Factors influencing the achievement of Year 12 physics students in Malang, Indonesia

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This thesis is submitted in fulfilment of the requirements for
the degree of Doctor of Philosophy

School of Education
Faculty of Arts
The University of Adelaide

November 2021

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ABSTRACT

Even though physics plays essential roles in human life in several aspects, there are still several challenges to overcome in physics education in Indonesia. The challenges can be seen from students' physics achievement in Indonesia based on the PISA or TIMSS dataset. In both studies, Indonesian students' achievement can be grouped into low-end ability students. This shows that there could be some issues that may influence students' achievement in physics.

In addition, this study can be said as the pioneer of the study with the main focus of Year 12 students rarely conducted in Indonesia. The more we can identify the factors influencing physics achievement, attracting new fresh students to physics or physics-related studies at university level will be achievable.

This study employed an embedded mixed-method design to investigate the factors influencing physics achievement of the students. A multistage random sample method was used that stratified the cohort of Year 12 students in Malang, Indonesia. Out of 473 students in total, 20 teachers and 19 school principals participated in this study. Furthermore, this study used convenience sampling to select the participants of the interview. Eight teachers and 20 students participated in the interview.

This study investigated and identified the extent of students' conceptual knowledge and understanding of students by using a diagnostic test adapted from the 2014 physics national examination. Furthermore, their understanding was linked to factors collected by using questionnaires. Moreover, this study proposed a model for investigating the effects of the factors on physics achievement.

This study found Dynamics, Kinematics, Fluid, Thermodynamics, Wave, and Temperature and Heat are difficult topics for students. It means that students generally could not handle abstract topics. It is supported by the finding that measurement can be considered as an easy topic, which is a concrete topic. Interestingly, both Dynamics and Kinematics are considered as both difficult and easy items which depend on the types of the problems.

This study also found that students' self-confidence significantly influenced physics achievement. Interestingly, other factors, including the frequency of physics homework assigned by the teacher and students' aspirations in their future education, also influenced physics achievement. This study also found that there was interaction between teachers' major education with the effect of students' self-confidence in influencing physics achievement.

In addition, this study found that the main objective of the teachers is to help the students facing the national examination. As a result, most of the teachers assigned paper-based homework. It is supported by the finding of student's interviews which showed that only students learning at School D assigned with project-based homework which is the most participants' favourite homework type. The interviews also revealed that the certification program did not show a direct effect on the quality of the education, but it is influenced by teachers' attitudes instead. In addition, students thought that physics is an important subject for their future studies, but they did not recognise the role of physics in their life.

DECLARATION

I certify that this work contains no material which has been accepted for the award of any degree or diploma in my name, in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. In addition, I certify that no part of this work will, in the future, be used in a submission in my name, for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and where applicable, any partner institution responsible for the joint award of this degree.

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Signed:

KHUSAINI

Dated: 25 August 2021

ACKNOWLEDGEMENTS

Bismillah wa Alhamdulillah. In the name of Allah SWT, I have written this thesis and thanks to Him. It happened because of Him. Prayers and peace be upon the best person in the world, prophet Muhammad SAW, his family and all of his companions who motivate me to learn and be better every day.

My best gratitude is for my parents and parents-in-law who always pray for me and my family. They also motivate me to achieve the highest levels. May Allah SWT grant them forgiveness and happiness as they cared me when I was a baby.

Thanks to my wife, Melly Selfita Diansari, who always gives me a smile and serves delicious food. Thank you for your prayer every day. I would also say thank you to Salsabila Nadhifah who always takes care of her sister and brother and helped her mother when I was busy, Kayla Nadhifah who is always happy, and my ‘anak ganteng’ Ksatria Cendikia; may Allah help all of you to be better than your parents.

I express my gratitude to my supervisory team who have always motivated and helped me during this project. My thanks to Dr I Gusti Ngurah Darmawan, the best supervisor ever, who is very patient and helpful. I hope I can always learn from and collaborate with you. My thanks to Prof John P. Keeves: you motivated me to grow and benefit others. I also extend my gratitude to Associate Prof (Adjunct) Chris Dawson, thanks for your help particularly during the last months of my PhD journey. You are the best for providing feedback on my thesis drafts, and made it happen.

I would also express my gratitude to LPDP Ministry of Finance, the Indonesia government for the scholarship, BPI (Beasiswa Pendidikan Indonesia). I will come back to Indonesia, and contribute to my beloved country, the Republic of Indonesia.

Thanks to Jurusan Fisika, FMIPA Universitas Negeri Malang and families there. I loved working with all of you. Thanks Prof Dr Markus Diantoro, Dean of FMIPA at that time and who motivated me to continue my PhD even though I had just completed my M.Ed. Thank you Dr Sentot Kusaeri and Dr Hari Wisodo who allowed me to continue my study. Thank you, my ‘former’ roommate, Prof Dr Sutopo, who always contacted me during my study. I am ready to continue our discussions to develop and enhance the quality of education in Indonesia. And, thanks to all of my friends in Jurusan Fisika.

Thanks to my friends Pakdhe Asep and Budhe Wati who will always be my friends whenever and wherever we are, people living in KCB, and MIIAS members. Thank you for your support.

I am also really happy to have Indonesian PhD friends, Mbak Yosita and Mas Abu. You always made me happy during my study. Thanks to my friends at level 6: Chin, Hninh, Fatimeh, Tinta, Nahwel and Ruby. I am so lucky to have you guys.

Thanks to Dr Diane Brown for copyediting my thesis in accordance with the current *Australian Standards for Editing Practice*.

CHAPTER 1

INTRODUCTION

Physics and educational issues

Physics is a natural science which describes the basic physical characteristics of nature such as motion, energy, force and sound (Hewitt, 2002). In relation to other natural sciences, such as astronomy, geology, biology, and chemistry, physics also provides fundamental knowledge (Serway & Jewett, 2004), for instance, understanding the physical properties of light and of lenses which developed optical astronomy.

Even though physics, as a basic science, plays essential roles in human life in several aspects, from understanding the creation of the universe to providing energy sources (Hawking, 2016; Serway & Jewett, 2004), this science still poses several challenges in educating and preparing physics teachers and physics-based professions. This is also the case in Indonesia, where the Indonesian government decided to implement physics as a compulsory subject for natural science students at senior high school level. Students' physics achievement in Indonesia is lower than in other countries based on both the Programme for international Student Assessment (PISA) or The Trends in International Mathematics and Science Study (TIMSS) dataset.

Physics in the modern age

Physics in the modern age can be seen from several aspects including developing various Information and Communication Technology (ICT) technologies, providing energy sources, and supporting economic growth. These are essential to human life in the modern age as people cannot be separated from these three aspects. It indicates that physics supports and facilitates human life in the modern era.

Providing better Information, Communication and Technology (ICT)

Physics-based technologies enhance the quality and type of telecommunication in society. As noted earlier, physics studies the physical characteristics of nature and helps advance ICT technology by providing research and development on both waves and particles to enhance internet connection speed and to support communication clarity through Wi-Fi connection and Fourth Generation (4G) technology (Ray & Misra, 2006). Both enhancement and support of ICT in the modern era reflect the advancement of technologies in telecommunication supported by physics-based research (Ray & Misra, 2006). It can be also seen that throughout the world, people are involved with ICT facilities provided by physics-based technology to communicate and share information (IOP, 2013).

The advancement of ICT technologies facilitated by physics-based technology using Fifth Generation (5G) technology allows us to communicate much faster than in the beginning era of telecommunication. In the era of the telephone, people were able to communicate with each other using the wired phone, which enabled them to communicate without any issues with physical distance. However, there are several weaknesses in relation to the wired phone. People could not communicate using the audio-visual facility, as it was audio communication only. The wired phone is also expensive as it provides the infrastructure for installing phones and other utilities. As a result, it was expensive for users to communicate. Furthermore, the wired phone requires the user to always be located in the area where the phone is located. Therefore, people need to consider when and where they communicate with their friends when they need rapid responses.

On the other hand, it is far different since the research and development of wireless phones began. People can now communicate easily with low-cost technology by using 4G and 5G that allows more capability than previous generations. Compared to previous telecommunication transfer ability that only allowed audio communication, nowadays people can communicate in both audio and visual transmission with technologies assisted by the advancement of internet connection. Transfer ability is supported by the development of smartphones and their applications such as WhatsApp, Zoom, and so on that allow better communication experiences using internet connection.

Internet connection not only allows audio visual communication, but it also costs less to ICT consumers compared to the beginning era of telecommunication. Telecommunication was introduced when it was much more expensive to communicate with others, particularly overseas. Thanks to internet connection that only charges for the data used during communication, the cost of making the world borderless, without any difference between international and national calls, is minimised.

Furthermore, physics roles in telecommunication technologies today are also apparent in smartphone development in terms of its practicality. Now we can carry and use our smartphones almost anywhere. The nanotechnology supported by physics allows phone producers to minimise phone size. Such minimisation enables users to catch up with each other. Therefore, people can communicate wherever they are by minimising smartphone size. In other words, it is easier to communicate when we need rapid responses.

Physics and energy issues

Energy is one of the most fundamental aspects of human life where people are dependent on energy sources to stay alive. People consume energy from cooking their food to communicating with friends and family. However, we still face challenges to fulfil energy demands. The issues of energy sources cannot be avoided where society is more dependent on energy in their life. This is evident when we use various technologies which need more energy for operating.

Energy dependency is not only an issue for people who live in developed countries but for those who live in developing countries in the modern age. Developed countries, assumed as high-income countries, have more reliance on energy compared to developing countries. Developed countries have greater GDP and better access to high technology facilities that require more energy. They have higher per capita electricity consumption and energy use per capita compared to developing countries (Ritchie & Roser, 2019).

However, developing countries also show an increased need for and access to energy. To show the increased need for energy, this study used Ritchie and Roser’s (2019) study, using the electricity ratio as the energy need indicator. The electricity ratio is defined by the percentage of people with access to electricity in a particular area that meets a minimum level specified by the International Energy Agency (IEA). They argued that the electricity ratio can be used to indicate improved living standards, economic growth, and poverty alleviation. The electricity ratio has been steadily increasing worldwidewide including in developing countries. In particular, this is indicated by the electricity ratio in Indonesia that increased from 62% in 1990 to 98% in 2016 (Ritchie & Roser, 2019). It can be concluded that Indonesia, which is a developing country, also needs more electrical energy per year indicated by higher access to electricity.

Increased energy consumption means that the availability of energy sources should be considered to fulfil the demand for energy consumption that increases steadily worldwide worldwide (Ritchie & Roser, 2019). Even though energy dependency increases steadily, we still face several issues in supplying energy including methods of transporting energy, attempts to gain new energy sources, the high cost for fossil fuel energy, and climate change (Beggs, 2009). To solve these energy issues, physics-based technology offers several solutions in providing highly efficient energy devices, offering renewable energy sources, and reducing the cost of exploring potential sources of gas or oil as major energy sources (Ritchie & Roser, 2019).

Physics-based research and development industries have found several technologies that can save more energy, for example, the application of Light Emitting Diodes (LED) used in TVs, computer monitors and lights. The use of LEDs could minimise electricity demand and save energy.

Furthermore, to deal with energy sources, physics-based knowledge helps to predict and explore more easily the availability of oil and other fossil fuels using technology based knowledge (IOP, 2013). The ability to identify and predict the availability of oil and other fossil fuels can reduce the cost to explore energy sources and to predict the period needed to explore and help the mining industry to consider future planning when exploring alternative energy sources.

Moreover, physics-based technologies provide several technologies to develop renewable energy sources such as sunlight, wind, waves, bioenergy and geothermal heat as more sustainable and environmentally friendly compared to fossil fuel energy sources thereby minimising carbon emission. It can be concluded that physics plays essential roles in meet consumers energy needs with better, greener solutions, providing renewable resources.

Physics and economic growth

Physics knowledge supports economic growth by supporting economic growth of countries worldwide to manage their development and stability. For example, the Institute of Physics (2013) published a report regarding the contribution of physics to the economy of the United

Kingdom. It was reported that physics-based business supported 8.5% of the economic output (more than £77 billion) and created employment for a million people in the UK. This report also revealed the roles of physics in driving industrial growth involving nuclear and offshore wind to supply energy and semiconductors to power computers. Besides its roles in solving energy sources issues, energy based industry is one of the largest economic sectors in the world (Beggs, 2009).

In addition, physics benefits the advancement of computer technology, flight technology, and agricultural technology, providing more job opportunities to support economic growth in many countries. Besides, the advancement of ICT helps people to communicate more easily, facilitates a new revolution industry, and provides new job opportunities such as online transportation, online hotel rental, and so on. this means that physics plays an important role in supporting economic sectors in the modern era.

The advance of telecommunication through 5G internet connection, as discussed in the previous subsection, also triggers the fourth industrial revolution that enables society to purchase or run their business online. This industrial revolution allows 24/7 business transactions and minimises cost and time during transactions. This telecommunication advancement in supporting the fourth industry revolution indicates vital roles of physics in the modern age, particularly in telecommunication advancement.

Physics still faces educational issues worldwide

Even though physics plays essential roles in supporting other natural sciences and helping people in providing ICT facilities, energy sources, and supporting economic growth in the modern age, physics still faces several challenges in relation to education. These challenges are evident in several areas, such as low physics enrolment in several countries where physics is an elective subject and low interest in learning physics.

Physics enrolments have been found to decline in several countries such as Australia (Lyons, 2006), Germany (Tobias & Birrer, 1999), and the United Kingdom (IOP, 2001), 2001). The enrolment issues in physics have also caused the closing down of physics departments at 24 universities in the UK due to reduced enrolment (Smithers & Robinson, 2006). This situation will, most likely, cause difficulty with the recruitment of high-quality physics teachers and physics graduates for physics-based industry employment (IOP, 2001).

Factors influencing enrolment issues have been investigated worldwide for a long time. Such issues can be caused by students' negative attitudes toward physics at school level, in relation to gender, the characteristics of physics as a subject, and father's education (Milner, Ben-Zvi, & Hofstein, 1987). Several studies suggested increasing student motivation and interest by providing new physics curricula (Milner et al., 1987; Oon & Subramaniam, 2013; Sheila & Frans, 1999), investigating teachers' views regarding physics enrolment issues (Oon & Subramaniam, 2010) and evaluating recent physics education practice (Dekkers & De Laeter, 2001; Sheila & Frans, 1999).

Thus, while the fundamental roles of physics need to be supported by high quality education that attracts and motivates students to learn and to apply physics in their lives, and move to physics-based careers, physics education faces a challenge in trying to increase enrolment in secondary high schools and universities, particularly in Australia, in northern European countries, and in the United States of America (De Laeter, Jennings, & Putt, 2000; Milner et al., 1987; Oon & Subramaniam, 2013; Sheila & Frans, 1999).

Physics education issues in Indonesia

However, physics education issues in Indonesia are somewhat different. There is no enrolment issue, but the issue is students' physics achievement. This can be seen in two international comparison studies, TIMSS and PISA, that Indonesian students' achievement is grouped into low-end ability students. This indicates there could be some issues that may influence such achievement, and which need to be investigated to improve Indonesian students' achievement in physics. However, there is limited information investigating Year 12 students' achievement in Indonesia. Furthermore, Year 12 student performance is not examined by either PISA or TIMMS. Therefore, it is important to investigate Year 12 students' achievement to offer additional information on student performance at senior high school level.

Another issue was student choice for the elective subject for the national examination. Compared to other natural science subjects, fewer Year 12 students chose physics as an elective subject in the 2016 national examination based on preliminary findings using interviews with physics teachers in Malang, Indonesia. For the 2016 national examination, Year 12 natural science class students could choose one of the natural science subjects (i.e., physics, chemistry, and biology). This low intention to choose the elective assessment subject showed there were issues with student attitudes toward physics. It may be affected by their views about physics, such as how to extend what they like or value about physics as a subject. It can also be affected by how the student showed self-confidence in learning physics. However, because students learn in the school environment, student attitudes on physics can be affected by teacher factors or school factors.

This study attempted to link low intention to choose physics as an elective subject and Year 12 performance. In other words, the study investigated the influence of potential factors on Year 12 students' physics achievement in Malang, Indonesia. Students' low intention can be concluded as one factor, and this study investigated other potential factors that were found to influence students' achievement in previous studies.

Statement of issues

Year 12 students are currently learning at senior high school level in the Indonesian education system, and this level equals ISCED3 in ISCED 2011 classification. In terms of their position, Year 12 is the highest level in senior high school in Indonesia. The highest level means that some of these students will continue their study at university level with their decision to choose a particular program to study based on their experiences and interests. Thus, the assessment of the reasons for Year 12 physics achievement will help physics teachers and policymakers consider physics delivery, particularly for Year 12 students, in order to increase physics or physics-based study enrolment at university level. As a result, the probability of getting better physics graduates could be increased to improve the beneficial use of physics in Indonesia. Therefore, it is important to investigate Year 12 student performance in physics and factors that may significantly influence performance.

However, there are limited studies of factors influencing the physics achievement of Year 12 students in Indonesia due to critical time to pass the national examination and to prepare the selection test at university level. This critical time can be viewed as the busiest period of students learning at senior high school level because they are learning physics while they do several final tests including school based and national examination tests.

Besides lacking studies with Year 12 students, the majority of physics education studies in Indonesia have mostly focused on four groups of issues, namely teaching strategies, assessment and evaluation methods, teacher professionalism, and teaching media in terms of their influence on physics performance of students. Most of these studies are quasi-experimental and experimental studies. However, any study investigating factors influencing student performance using a survey method is limited in Indonesia. The survey study investigates factors influencing physics performance to describe the real situation in the population before choosing and undertaking a particular strategy or policy to improve student performance in physics, particularly for Year 12 students. In addition, this study took a qualitative approach by employing interviews mixed with the survey method to provide additional information and to check the survey findings. Interviews can strengthen the conclusion regarding factors influencing physics achievement.

Because of limited studies with Year 12 students and survey methods, this study may be used to pioneer a new method to diversify research in physics education in Indonesia. The survey findings can capture the views of Year 12 students, physics teachers, and principals and finally, they can also be used by policy makers, including principals and the Indonesian government, to evaluate physics achievement and classroom experience in Indonesia.

Research questions

This study investigated the factors influencing physics achievement of Year 12 students in Malang, Indonesia, aiming to answer the following questions.

a) What is the extent of Year 12 students' conceptual understandings of physics?

b) What are the factors influencing physics achievement of Year 12 students?

c) How do these factors interact with one another to influence physics achievement?

d) How much of the variance in physics achievement is explained by student- and school-level factors included in this study?

e) What are students' views and teachers' views regarding factors influencing physics achievement of Year 12 students in Malang, Indonesia?

Aims of the study

This study aimed to investigate and identify the extent of students' conceptual knowledge and understanding of physics of Year 12 students in Malang, Indonesia. This conceptual understanding was tested using a diagnostic test adapted from the 2013 physics national examination. This diagnostic test then estimated item difficulties and student abilities.

The factors and variables that potentially influence physics achievement of Year 12 students were identified using previous studies. The potential factors or variables were then measured using the student questionnaire, teacher questionnaire, and principal questionnaire. These factors and variables were modelled into a hypothesised model by adapting the 3Ps learning model proposed by Biggs (1987) and a multilevel model proposed by Resnick (2010). This hypothesised model explains the interaction of potential factors or variables in influencing physics achievement. The interaction of these factors and variables was predicted using single level and multilevel analysis.

Within a single level, the direct and indirect effects of factors and variables on physics achievement were estimated. These direct and indirect effects were estimated by using Structural Equation Modelling (SEM). This analysis allowed the study to investigate the probability of variables as independent and dependent in affecting physics achievement.

The study also aimed to investigate the probability of cross-level interactions between specific variables in physics achievement at the student- and school-level within a multilevel model. These interactions were investigated through hierarchical linear model analysis to check the importance of a multilevel model, because the nature of data collected in this study is nested at different levels.

In addition, background information underlying the factors influencing physics achievement of Year 12 students in Malang, Indonesia was investigated. This study carried out interview and focus group discussion to investigate students' and teachers' views. These data provide additional and interpreting information to variables and factors studied in the survey. This additional information can also be used to check the data in quantitative findings.

Significance of the study

The Indonesian government has proposed several policies such as curriculum development, teacher training, and teacher certification program to improve students' academic performance and education quality, particularly in physics. These initiatives are also supported by physics teachers and principals in schools by providing academic situations which support and facilitate students learning in physics. However, there has been limited study to evaluate Year 12 student performance in physics comprehensively. The study evaluates potential factors influencing physics achievement stemming from student, teacher and school factors. Limited publications that focus on students' achievement in physics to investigate potential factors influencing physics achievement which not only focus on teaching strategies, but also other aspects indicated the need for a comprehensive study in physics education. Therefore, this study offers a new investigation in physics education studies about the potential factors influencing physics achievement of Year 12 students in Malang, Indonesia.

In addition, the majority of physics education studies examine physics achievement of year-10 and year-11 students with only limited attention on Year 12 students. Furthermore, even though the Indonesian government has participated in TIMSS and PISA, as international comparative studies to investigate and compare student performance and factors that may influence performance internationally, these comparative studies do not investigate the physics performance of Year 12 students. At senior high school level, the PISA study focuses on year-10 science, mathematics and reading literacy (15-year-old students). On the other hand, the TIMSS study examines students' achievement in mathematics and science at year-4 and year-8 levels. Therefore, this study will provide new information about students' achievement at the Year 12 level.

Furthermore, this study employed embedded mixed methods design, which combines both a quantitative and qualitative approach. The method hopefully will enrich research studies into physics education to give more comprehensive information about the population of the study, which may encourage other researchers, particularly in Indonesia, to employ a stochastical, as well as statistical procedure in the quantitative method. Both stochastical and statistical procedures employed in this study deal with physics educational studies investigating students as human beings who may change over time (Lindsey, 1996). This approach encourages the use of an integral method to view the factors influencing physics achievement as it happened in the real-life situation where student performance is influenced by complex environments. These environments include students, physics teachers, and principals who interact and influence one another.

This study can be a starting point to investigate potential factors influencing physics achievement within a single study in Indonesia. This study would examine the factors affecting students' achievement, but limited to physics education studies, particularly in Indonesia. The factors, divided into three different groups, were checked for their causal relationship in groups separately in a single level analysis. This analysis aims to check the causal relationship of factors measured in the student questionnaire, teacher questionnaire, and principal questionnaire on students' achievement. In addition to single level analysis, the interactions between factors and the integrated effects of students, teachers, and principals on education issues using a multilevel method of analysis, because the nature of the educational data is nested at a particular level. This comprehensive study may provide additional information to government as policymaker, to propose more effective policies and to consider real-life situations in the school environment in Indonesia.

This study provides recommendations and conclusions for the teaching of physics and the education of Year 12 students in Malang, Indonesia. Influential factors that were found in the study may help the government to take effective steps toward solving physics education issues. And because the factors were tested and identified from large-scale assessment data analysis, the real condition in the schools was captured. In addition, the study hopefully can provide additional information about Year 12 students' physics achievement in areas rarely investigated by physics education researchers.

Limitations

This study has a number of limitations. It employed survey and interview to obtain data regarding the physics achievement of Year 12 students in Malang, Indonesia. The mixed methods used in this study took a quantitative approach as the primary method embedded with a qualitative approach to investigate the background context of participants.

The survey employed here was conducted as a cross-sectional design. This design measures current variables (attitudes, opinions, or practices) and the needs of community, compares respondents within and between groups, and evaluates particular policies or programs in a short amount of time; however, this design cannot compare or investigate trends of the same respondents over a particular duration of time (Cohen, Manion, & Morrison, 2007; Creswell, 2012). This study investigated and reported physics achievement and factors influencing performance, significantly in 2018 when the data were collected in Malang, Indonesia.

The interviews were conducted one-on-one plus focus group interviews. One-on-one interviews were employed to obtain physics teachers' views and opinions regarding students' achievement. Furthermore, focus group interviews were employed to obtain students' views regarding physics and learning (Creswell, 2012). The interviews sampled respondents' opinions and gathered more data. They employed a semi-structured design which benefits by gathering data from similar questions, thus increasing the comparability of the response and the ability of policymakers to evaluate the instruments used in this study; however, this design allows for little flexibility during the process (Cohen, Manion, & Morrison, 2018). One-on-one interviews employed to gather teachers' views regarding physics teaching and learning may not be ideal for teacher participants who find interviews time-consuming and they may be hesitant to share their ideas, thus influencing the findings (Creswell, 2012). Another issue is that focus group interviews used to obtain students' views is a potential problem in distinguishing respondents' voices (Creswell, 2012).

A further limitation is that the area of research was only in Malang, Indonesia. Malang is an education city and the second largest city in East Java province. Compared to Indonesia as a whole, Malang is a small city. Therefore, the conclusions here only describe a small part of Indonesia. It can thus be seen as a pilot project to be followed up by further studies investigating the physics achievement of Indonesian students.

Structure of the thesis

This thesis presents the study and its findings in ten chapters. Chapter 1 introduces background information, particularly the importance of physics as a basic science subject. Chapter 1 also provides an overview of the gaps triggering the importance of the study. The study's aims and limitations are presented in Chapter 1.

Chapter 2 is the literature view, presenting previous studies to inform the reader about the factors investigated in the study. The studies are grouped into three categories, based on student-, teacher-, and principal-level factors. The proposed model examined in this study is also presented. The model was adapted from the 3Ps learning model proposed by Biggs and the multilevel model proposed by Resnick et al. (2007) and Resnick (2010).

Chapter 3 describes the research design employed in this study. The methods are described as mixed methods research with an embedded design. Chapter 3 also presents the theoretical framework for the study. The methods for data collection in the study that range from Confirmatory Factor Analysis to interview analysis are described in this chapter.

Chapter 4 reports Confirmatory Factor Analysis findings. The chapter presents the construct validity of indicators in investigating factors influencing physics achievement. These findings can indicate that the items used in the student questionnaire, teacher questionnaire, and principal questionnaire measured a single constructed factor.

Chapter 5 presents the Rasch analysis to validate and estimate the items difficulty and person ability. The items validated in this chapter are those used in the physics diagnostic test and those examining constructs validity in chapter 4. The findings in this chapter can be defined as valid items which can be used in subsequent analysis.

Chapter 6 discusses the nature of the study through descriptive statistics use. The chapter indicates the Mean, Standard Deviation, Skewness, and Kurtosis to check the data that can be used in subsequent analysis.

Chapter 7 presents the findings of Structural Equation Modelling in investigating the relationships among variables/ factors at three levels, namely student-, teacher-, and principal-level data. This chapter reports on the findings using diagrams and significance level within the three models.

Chapter 8 presents the Hierarchical Linear Model (HLM) for investigating the factors in a multilevel model. The chapter considers the use of a two-level model, that is, student-and school-level data. Consideration is based on the nature of the data where the majority of those at the school participating in this study have only one physics teacher.

Chapter 9 presents the findings of interviews with selected physics teachers and Focus Group Discussions (FGD) with selected students. The interviews are reported based on thematic analysis. This chapter can be used to check and provide additional information on quantitative findings.

Chapter 10 concludes the study based on the findings reported from Chapter 4 to Chapter 9. The findings from these five chapters are compared with previous research discussed in the literature review in Chapter 2. This chapter proposes several solutions for the Indonesian government based on the findings. Suggestions for further studies are also discussed.

Summary

Chapter 1 discussed background information underlying the significance of the study including the importance of physics, its roles in human life and issues related to physics education, particularly in Indonesia. The importance of studying Year 12 student physics performance is discussed at the highest level in senior high school in Indonesia which equals ISCED 3 in ISCED 2011 classification developed by UNESCO.

The factors influencing physics achievement of Indonesian students, as the most important consideration in this study, are discussed in this chapter. The factors predicted to influence physics achievement have rarely been investigated in Indonesia. Thus, this reality motivated the researcher to conduct this study.

An embedded mixed methods study was used to fill the gap regarding physics education studies in Indonesia to enrich research in Indonesia. This approach will encourage physics education researchers in Indonesia to apply various approaches and offer a new method for identifying issues tied to students’ achievement in physics. A mixed methods approach has rarely been employed in physics education studies in Indonesia. This method introduces the combination of qualitative and quantitative research that may be carried over into future physics education studies in Indonesia.

This study investigated factors using a multilevel model. Within this multilevel model, the factors were divided into two levels. These levels reflect the method used in this study to deal with the nature of the educational data nested at different levels. This method can be identified in the research questions and the aim of the study in this chapter.

Chapter 1 also revealed the limitations of the study. The limitations inform several weaknesses even though this study has strengths. These limitations show that this study exclusively investigated the factors influencing the physics achievement of Year 12 students in Malang, Indonesia. However, Malang is only a small part of Indonesia. Thus, this study should be considered as the first step in subsequent similar studies on physics education, and cannot be generalised as students’ achievement in Indonesia.

In addition, Chapter 1 also provided thesis structure containing a brief overview of what each chapter covered. This information guides the reader in relation to signposting the thesis.

CHAPTER 2

LITERATURE REVIEW

Introduction

Physics achievement, the central topic in this study as discussed in Chapter 1, has been addressed in several studies worldwide and particularly in Indonesia where the study has taken place. Generally speaking, the physics achievement of students is estimated by using a test administered by the teacher in the classroom (Ferris, 1960). This study used a similar physics diagnostic test to estimate students' performance in physics.

Furthermore, physics achievement can be influenced by several factors relating to students, teachers, and schools. These factors describe students' demographic background and their attitudes toward physics. Physics teachers can also influence physics achievement through their attitudes, teaching practice, teaching challenges, and their own characteristics including gender, educational background, and teaching experience. Furthermore, schools where students learn physics can also influence their achievement through principals who manage these schools, the facilities provided to help students learn physics, and so on.

This chapter introduces previous studies conducted worldwide and particularly in Indonesia to review factors influencing students' achievement. Previous studies are discussed to provide a general description of the factors potentially influencing physics achievement of Year 12 students in Malang, Indonesia. Many factors investigated in this study are grouped into student-, teacher- and school-level factors to simplify the discussion in this chapter.

A conceptual model is then proposed and examined. The conceptual model describes hypothesised interactions between variables in influencing physics achievement and provides the conceptual framework for the investigation undertaken in this study. The model combines the 3P model of learning (Biggs, 1987) and the multilevel model (Resnick, 2010). Factors are divided into three Ps (Presage, Process, and Product), also analysed in a multilevel model to examine the interaction of variables within and between levels. This model is proposed to answer the research questions in Chapter 1.

Physics achievement and physics education research

Students' physics achievement is an increasingly important study that can be indicated by the development of several international comparison studies such as PISA and TIMSS. Both studies examine students' achievement using diagnostic tests to check their ability on various topics in science, mathematics, and reading skills.

Furthermore, both PISA and TIMSS utilise a methodology that allows users to compare students' achievement studied among participating countries. These studies also provide important information about potential factors or background information measured through questionnaires. Furthermore, they allow both researchers and users worldwide to access data to examine the causal relationship between factors or variables indicated by respondents through questionnaires and students' performance scores.

In addition, physics achievement has also been investigated worldwide since the 1900s when a physics achievement test was administered (Pfeiffenberger & Zolandz, 1991). This is also the case in Indonesia where many physics studies focus on physics achievement as an indicator of academic performance of participants.

In line with students' achievement in physics education studies, many studies have also been conducted to examine the effect of several potential factors on physics achievement. These studies can be examined using both primary and secondary data. Primary data can be seen as experimental studies investigating particular teaching and learning methods and the effect of particular factors in affecting physics achievement (Deta, Suparmi, & Widha, 2013; Farrell, 2011; Lamba, 2006; Yance, 2013). For example, physics achievement was examined in a bilingual environment by Farrell (2011) who examined the effect of student language proficiency in English and Maltese on academic proficiency in Malta. This study found students who were proficient in English and Maltese tended to perform better in physics (Farrell, 2011).

In addition, several studies have also been conducted to investigate the effect of variables for predicting physics achievement using secondary data. The secondary data are provided by the two aforementioned international comparison studies, TIMSS and PISA. Factors influencing physics achievement has been investigated using a dataset provided by TIMSS (Khusaini & Darmawan, 2020; Mesic, 2012; Murdock, 2008). The majority of studies applied quantitative methods including Path Analysis and Hierarchical Linear Modelling (HLM) which examine causal relationships among variables within either single or multilevel analysis. Khusaini and Daramawan (2020), for example, examined the causal relationship of several variables influencing physics achievement using path analysis to examine potential factors including students' demographic backgrounds, homework and attitudes toward physics. Through this study they could show the direct effect of self-confidence in learning physics, liking of physics and homework on physics achievement, while gender difference, valuing of physics, and engagement in physics showed indirect effects on students' physics achievement.

Many studies regarding physics achievement have been conducted in Indonesia. These studies have been undertaken in four areas: (1) teaching and learning methods, (2) teaching and learning media, (3) assessment and evaluation, and (4) teacher professional development. In investigating teaching and learning methods, various pedagogical methods have been studied to investigate new approaches to delivering physics in the classroom and to correlating these methods with physics achievement (Deta et al., 2013; Lamba, 2006; Yance, 2013). Other studies in Indonesia have included both developing and applying new media to enhance students' physics performance (Sulistyani, Jamzuri, & Rahardjo, 2013; Viajayani, Radiyono, & Rahardjo, 2013; Wahyudin, Sutikno, & Isa, 2010). These studies have indicated the advancement and improvement of performance taught by such media in physics classes. Evaluation and measurement in physics education courses have also been conducted to investigate and identify effective methods to evaluate and enhance student performance in physics learning (Chodijah, Fauzi, & Ratnawulan, 2012; Istiyono, Dwandaru, & Rahayu, 2018; Kusairi, 2013; Susila, 2012). Furthermore, research on professional development has been conducted to identify professionalism of teachers in physics classrooms and laboratories (Agung, 2011; Djajadi, Sumintono, & Mislan, 2012; Suhandi, 2012; Yuliati, 2007).

In conclusion, students' achievement is an important topic in physics educational studies, particularly in Indonesia. Several previous studies, particularly in Indonesia, investigated four physics education aspects and examined the correlation or relationship of these studies with students' achievement. However, it is important to check the combination of such studies in a single study using primary data, which investigates the influence of factors on physics achievement. In addition, a limited number of studies have been conducted in Indonesia to investigate Year 12 students' physics achievement, as Year 12 is a critical point before students continue their study at university. Thus, it is important to undertake an integrated study in investigating several factors from various learning aspects that potentially influence Year 12 students' physics achievement in Indonesia.

Factors influencing physics achievement

Generally speaking, factors potentially influencing physics achievement can be categorised into three groups, (1) student-level, (2) teacher-level, and (3) school-level factors. These three groups have been examined in previous studies and are discussed in this chapter.

These previous studies pay more attention to physics or science education. This focus ensures the results discussed in those studies are relevant to the factors discussed in this study. However, if studies are rarely conducted in science or physics education, other related studies in other educational areas are discussed in this chapter, but the focus is to support the discussion on topics describing the factors examined and their effects on students' physics achievement.

Furthermore, these studies were taken from high impact journals, and in several cases, particularly in physics education issues in Indonesia, the studies were taken from credible journals published by several universities in Indonesia. These articles are selected from those credible sources to ensure that studies were well-conducted and are peer-reviewed by experts in related studies.

Student-level factors

Students are the main focus in this study, particularly in relation to physics achievement. Therefore, this study examines various factors or variables related to students that may influence their achievement. Factors or variables are then grouped into one level, which is the student level. The factors or variables discussed at this level are students' characteristics, attitudes toward physics, additional physics tuition and homework.

Students' characteristics

Students' characteristics discussed in this study involve gender, parents' educational attainment, future education aspirations, and age. The interactions of students' characteristics on physics achievement have been studied to examine their influence on student performance, particularly in international comparative studies (e.g., TIMSS and PISA). It has been concluded that student characteristics and teaching methods in the classroom influenced physics performance (Dunkin, 1978). Several students' characteristics including gender, parents' educational attainment, and age have indicated different influences on academic performance in science (Ma & Klinger, 2000; Scheiber, Reynolds, Hajovsky, & Kaufman, 2015). Thus, it is important to examine the effect of students' characteristics.

Gender

Gender is one topic examined in many studies in terms of its impact on students' achievement over time, particularly in western countries. This can be seen from the availability of studies that investigate the effect of gender on influencing students' achievement and factors that cause gender difference. However, studies on gender difference and its relationship with students' achievement, particularly in physics education, are still limited in Indonesia. The effect of gender on students' achievement in Indonesia can be found in several studies using international data taken from international studies such as PISA and TIMSS, but rarely conducted using primary data (Eminita, Notodiputro, & Sartono, 2020; Khusaini & Darmawan, 2020). Therefore, it is important to examine the effect of gender difference on students' achievement.

Arguably, there are several differences between female and male students when they learn physics. These differences were revealed in a study conducted by Hong et al. (2013)

and Cavallo et al. (2004). Hong et al. (2013) investigated the effect of gender in their method of learning science. Gender difference was found to influence students' thinking categories such as numbers and relationships, and the ability to make branches and cross-links (Hong et al., 2013). Furthermore, female and male students' ways of thinking when learning physics also influence students’ attitudes toward physics, learning styles and achievement in physics learning (Cavallo, Potter, & Rozman, 2004). Such gender difference needs to be considered by physics teachers if they intend to help all their students succeed in physics studies. In addition, the effect of gender difference on students’ achievement can be influenced by ethnicity and family background (Kamwendo, 2010; Parker, 2006; Stump, Hilpert, Husman, Chung, & Kim, 2011). Kamwendo (2010) found that the majority of participants thought that male students outperformed their counterparts based on several reasons, mainly to do with culture and socio-economic background where culture and socio-economic background allowed a special place for male students which influenced their motivation to achieve better in their studies.

Moreover, the effects of gender difference on students' performance were examined in international comparison studies including both the PISA and the TIMSS studies. It was concluded that gender influenced student performance in physics-based on the TIMSS and PISA studies (Eminita et al., 2020; Khusaini & Darmawan, 2020; Ma & Klinger, 2000; Pavešić, 2008). These studies examined the effects of gender difference on students' achievement using several methods based on secondary data provided. Khusaini and Darmawan (2020) examined the effect of gender using path analysis on the TIMSS 2011 dataset. They found that female Indonesian students outperformed their male counterparts. In this study, gender exhibited an indirect effect on physics performance. Gender difference influenced students’ self-confidence during learning physics which shows that gender influences students’ attitudes toward physics. This is supported by Pavesic (2008) who examined the TIMSS data in Slovenia and found that gender difference influenced both liking of physics and the experimental work of students. She also found that males outperformed their counterparts in physics.

However, several studies have indicated that gender difference does not significantly influence students’ achievement and its effect can be minimised (Else-Quest, Mineo, & Higgins, 2013; Friedler & Tamir, 1990; Quinn & Cooc, 2015; Shepardson & Pizzini, 1994). Shepardson and Pizzini (1994) and Else-Quest et al. (2013) found there was no significant difference in students’ achievement based on gender, but that students had different views on science activities. Else-Quest et al. (2013) also supported the view that gender difference did not have a significant effect on students’ achievement compared with ethnicity. In addition, a study conducted by Quinn and Cooc (2015) tended to minimise the effect of gender difference on students’ achievement by controlling students’ prior knowledge. students’ achievement

Parents’ highest education level

Another factor investigated at student level is parents’ highest education level. The education level of parents was examined for its impact on physics achievement because parents play an important role in supporting students to succeed in their study by providing a conducive home environment.

The literature on achievement showed the importance of parental education roles on student success in the education system through different routes: (1) transmission of parental beliefs and attitudes regarding the value and utility of the education, (2) transmission of parents’ cognitive competencies, and (3) increased opportunities for students (Brown & Iyengar, 2008). In addition, several studies asserted the positive effect of home environment on students' achievement which is influenced by parents' highest education level. It can be seen from the findings about students who were living in a family with better attitudes and beliefs about learning and schooling tended to perform better in science (Ma & Klinger, 2000; Young, Reynolds, & Walberg, 1996). In addition, parents' highest education level could also be used to predict students' future education aspirations (Dubow, Boxer, & Huesmann, 2009; Oon & Subramaniam, 2013). These two effects were considered for examining the effects of parents' education on physics achievement in this study. Nevertheless, a study conducted by Lawrenz et al. (2009) showed there was little effect of parental education background compared with students' attitudes and the physics curriculum.

For examining home environment affected by parents' education level on student academic performance, two studies were conducted by Ma and Klinger (2000) and Young, Reynolds, & Walberg (1996) using hierarchical linear modelling. Ma and Klinger (2000) examined several potential factors from the New Brunswick School Climate Study dataset that could influence students' achievement in mathematics, science, reading, and writing. They found a significant correlation between negative family attitudes and beliefs and low students' achievement at student level. Based on this finding the researchers suggested working with both parents and students to improve achievement. In line with this study, Young, Reynolds, and Walberg (1996) also conducted a study to check several factors guided by a theory of educational productivity proposed by Walberg (1981), employing a longitudinal study of tenth-grade public school students in the US. In their study, Young et al's home environment was a significant factor influencing student science achievement at student level.

Furthermore, a study conducted by Oon and Subramaniam (2013) found that parents also influenced students' choices regarding their future careers and future education aspirations in physics. It has also been argued that parents' belief in physics may contribute to students' attitudes toward physics and students' low intention to continue future physics-based careers (Oon & Subramaniam, 2013). Therefore, parents, who more frequently interact with students and who have an important role to play in influencing students' decisions in relation to Indonesian culture, should be examined for their influence on students' achievement in physics because educational attainment, which is hypothesised, has a strong influence on how parents think.

In terms of the effect of parents' highest education level on students' academic performance, Damayanthi (2018) conducting a hierarchical-linear-mixed model and found that parental education is an important factor in improving students' academic performance. The important effect of parents' education attainment can be seen from how it reduced the effect of additional tuition attended by students to improve their academic performance (Damayanthi, 2018), meaning that parents' highest education level has a positive effect on students' achievement. This important effect is also supported by Hill et al. (2004) who found that parents who graduated from a higher education level showed a positive impact on students' achievement and educational aspirations when parents were involved academically with their child's education. They also found that this is different from parents who graduated from a lower education level. This only influenced students' education aspirations because parents may not be comfortable with, or capable of, assisting their children with school work during their academic involvement (Hill et al., 2004).

Future education aspirations

This study examined future education aspirations at the student level. The importance of students' aspirations to continue their study can be seen in many studies that examine its effect on students' achievement. Such aspiration is described as students hoping to continue their future education based on their belief without any further calculation about their decision (Marjoribanks, 2002; Reynolds & Pemberton, 2001). This definition was used to analyse the effect of future education aspirations on students’ achievement and how this influenced physics.

Future education aspiration was predicted to influence student achievement in physics A study conducted by Khattab showed that students who exhibited higher education aspirations showed higher achievement than those with lower aspirations for future education (Khattab, 2015). This is supported by McCulloch (2017) who concluded that higher education aspirations can positively influence students’ achievement and enable students to make more educational progress compared to others with lower educational aspirations. Seginer and Valmust (2002) investigated the effect of students’ educational aspirations and family background on students’ achievement. They found that students’ aspirations had a positive effect on students’ achievement for all students from Arab and Jewish family backgrounds (Seginer & Vermulst, 2002). In addition, mathematics achievement was significantly influenced students’ education aspirations (Signer & Saldana, 2001). This finding was also supported by Jung and Zung (2016) who showed that future education aspirations positively influence academic performance of immigrant children in the US.

This positive effect can be demonstrated by several studies showing that students' education aspirations influence how they behave and their attitudes toward physics (Oon & Subramaniam, 2013; Woolnough, 1994; Young et al., 1996). Oon & Subramanian (2013) and Woolnough (1994) found there were many factors that influence students’ low aspiration to pursue physics-related studies. These reasons could be used to analyse the effect of future educational aspirations on physics achievement.

In contrast, Young et al. (1996), employing Hierarchical Linear modelling analysis on student science achievement, found that schools with higher students' aspirations to continue science related studies were lower in science achievement. This means that schools with bigger number of the students in average that intended to continue study in science or science-related studies performed worse than their school counterparts. However, based on their study, the school-level difference was relatively small (5%) compared to student-level difference (up to 50%) in terms of student science achievement.

Age differences

Another factor that can potentially influence physics achievement is student age when students learn physics in Year 12. Age is still controversial when it is correlated with academic performance. For example, the debate on the influence of age difference on student academic performance is evident in Choppin's earlier study conducted in 1969. The influence of age difference on academic performance causes different opinions in relation to how government allows the starting age to begin a formal school when a single cut-off date is applied and how to manage the class using the age difference as a consideration.

Several studies have focused on the effects of age difference on student performance in particular subjects (Amro, Mundy, & Kupczynski, 2015; Grissom, 2004; Hauck & Finch Jr, 1993; Nam, 2014). A study conducted by Grissom (2004), for example, compared academic performance of students in terms of their age differences from grade-2 to grade-11 using data collected on students enrolled in public schools in California. He found that older students at a particular year level, performed better in reading and mathematics, but this positive relationship disappeared when students reached year-10. This finding is also supported by Hauck and Finch Jr (1993) who found that the higher level of students learning at their schools, the less influence of age on academic performance in mathematics and reading. Grissom also noted that average students were starting school later, spent more time in transitional kindergarten or first grade, or were forced to repeat a grade. In addition, Amro et al. (2015) examined the effects of student demographics including age, gender, and ethnicity on student academic performance in face-to-face and online college algebra classes. They found that age influenced both face-to-face meetings and online classes differently. However, gender and other demographic characteristics influenced students' achievement in face-to-face classes but there was no significant difference in online courses.

Other studies also showed there was no significant difference between students of different ages at university level (De Paola, Ponzo, & Scoppa, 2013; Nam, 2014). Nam (2014) found that the influence of a student's age persists only on school age. However, students at higher degree levels experienced no effects of age difference. This finding is supported by De Paola et al. (2013). They concluded that there was no significant age difference for students at university level doing mathematics and language skills, but they found that students' achievement was affected by student ability and/ or school size.

Furthermore, even though there is no unambiguous finding that can solve the discussions about the influence of age difference on academic performance, Choppin (1969) focused on student personality and ability. This approach allows more flexibility to mix students in a class based on their abilities instead of their age.

Students' attitudes toward physics

The influence of attitudes has been investigated since the end of the 19th century and such studies grew in popularity in the 20th century in social psychology (Voinea, 2016). Voinea (2016) also argued that a major milestone in attitude study was Thurstone (1928) who claimed that attitude measurement is possible. Thurstones' argument created much interest in investigating the impact of attitudes on students' achievement in education studies.

Attitudes toward science have attracted a lot of interest regarding students' achievement, particularly in western culture (Osborne, Simon, & Collins, 2003) and this is certainly true of science education. Many studies in science education have investigated the effect of students' attitudes on science achievement (Civelek, Ucar, & Ustunel, 2014; Jansen, Schroeders, & Lüdtke, 2014; Landine & Stewart, 1998). Other studies have also investigated attitude as a factor influencing students' aspirations to learn physics (Barmby, Kind, & Jones, 2008; Woolnough, 1994). Several researchers also investigated the effects of students' attitudes on students' learning during instruction (Laukenmann et al., 2003).

Attitudes can be defined generally as the binding of mind and body (Voinea, 2016). Such binding indicates that attitudes are a decision based on sensorial and perceptive information, and this information is communicated to all parts of the body and mind. Furthermore, this study uses a definition proposed by Kind et al. (2007), that attitudes are based on three components of cognition, affect, and behaviour (Barmby et al., 2008). Kind et al. (2007) also defined attitudes as feelings a person has about the object (affective) based on his or her knowledge and beliefs about that object (cognitive) that may influence the person to take particular action. The process distinguishes attitudes from general effects, that is, moods and emotions as an evaluative judgement formed by regarding a particular object (Barmby et al., 2008). Based on this definition, students' attitudes toward physics can be defined as students' evaluative judgment based on their feelings and knowledge regarding all aspects of physics.

The current study investigated students' attitudes toward physics-based on this definition, focusing on whether the construct of three motivational beliefs (valuing of physics, self-confidence in learning physics, and liking of physics), influence physics achievement. These beliefs have been examined and show a positive impact on students' achievement in 26 countries based on TIMSS 2011 dataset (Liou, 2017). PISA 2006 tests also found that students with more positive attitudes performed better in science tests (OECD, 2007). In addition, Khusaini and Darmawan (2020), using the TIMSS 2011 dataset also reported the impact of eighth-grade students' attitudes, including liking of physics, valuing of physics, and self-confidence during learning physics as a motivational belief on physics achievement in Indonesia. This is different from other studies that found students' self-confidence negatively influenced physics performance, in which grade-8 students who were more confident in physics tended to perform worse than their counterparts.

Positive attitudes play a significant role in enhancing students' achievement and experiences during teaching and learning in physics (Cavallo et al., 2004; Häussler & Hoffmann, 2002; Labudde, Herzog, Neuenschwander, Violi, & Gerber, 2000). These attitudes also reduce adverse effects of students' backgrounds through the intervention of intended values (Miyake et al., 2010). Both student understanding of specific concepts in physics concepts and overall physics achievement were also influenced by students' motivational beliefs (Cavallo et al., 2004).

Valuing of physics as a part of attitudes described here refers to how students think about the benefits of physics in their life or their utility value (Liou, 2017). Woolnough's view (1994) on valuing physics is how students think about the attractiveness of a physics-based profession (e.g. salary, career opportunities, and job prospects) and how this in turn influences their decision to learn physics in future educational aspirations. Therefore, it is important to communicate the value of physics by providing potential jobs to attract promising students in learning and continuing their studies in physics (Semela, 2010; Woolnough, 1994).

Students also need interesting experiences to have a positive attitude and be motivated towards physics (Jansen et al., 2014; Josiah, 2012; Veloo, Nor, & Khalid, 2015; Woolnough, 1994). This positive attitude can motivate them to learn and in turn learn physics better (Veloo et al., 2015). Therefore, physics teachers and policymakers should consider providing a physics environment through the school climate and curriculum to trigger students' positive self-concepts in physics (Woolnough, 1994). With this in mind, Josiah (2012) also supported the importance of providing Computer Assisted Instruction (CAI) to motivate and assist students in learning physics, and results showed that CAI helped teachers minimise the effects of school location and gender.

Another factor is the liking of physics which encourages students to learn physics as part of their motivational belief. Liking of physics is categorised as an intrinsic value or how students feel when they learn physics (Liou, 2017). This should be encouraged by teachers because it has a positive impact on students' educational aspirations, particularly in choosing physics as their future education (Woolnough, 1994). However, the majority of students may not think physics is about understanding phenomena, but instead focus on learning to know the physical world and to reproduce knowledge during assessment (Prosser, Walker, & Millar, 1996).

Physics homework

When we focus on homework provided by teachers, several studies have correlated homework with preparing work-ready students in future (Corno & Xu, 2004; Damayanthi, 2018). Damayanthi (2018) concluded that homework facilitates students to prepare and develop their skills to work independently by providing “self-study hours”. The opportunity provided by the homework indicates that it helps the students to achieve the highest possible performance in their future careers because homework has a similarity in its necessary attitudes with their potential employment (Corno & Xu, 2004).

Other studies found that homework enabled learning and showed a positive relationship with students' achievement (Cooper, 2001; Coutts, 2004; Khusaini & Darmawan, 2020b; Maltese, Tai, & Fan, 2012; Trautwein, 2007). This positive relationship can be seen in the time spent doing homework where more time is spent on physics homework, so the student achieves better grades with physics (Khusaini & Darmawan, 2020; Núñez, Suárez, Cerezo, et al., 2015). This finding is supported by Maltese et al. (2012) and Ulrich (2007) who concluded that homework has a positive impact related to student frequency and behaviour on students' achievement, even though there was no stable significant relationship between time spent doing homework and students' achievement. Furthermore, Núñez et al. (2015) showed that effective time management provides a positive impact on students' achievement.

In addition, homework has positive effects if it meets several requirements (Corno & Xu, 2004; Coutts, 2004; Núñez, Suárez, Rosário, et al., 2015; Rønning, 2011) including (1) students, teachers, and parents have similar perceptions of homework and collaborate to achieve the same goals; (2) homework should integrate daily experiences, encourage proper knowledge, and be designed well; and (3) teachers provide feedback on student work.

Additional physics tuition

Additional tuition in physics or other subjects is a large industry in Indonesia, particularly for those students who will face the final examination or selection test (Nosek et al., 2009; Oktavianti, Wardi, & Marwan, 2018). Additional tuition is playing an increasing role worldwide including countries such as Sri Lanka (Damayanthi, 2018), Pakistan (Jamil, Syeda, & Khan, 2021; Suleman & Hussain, 2013), India (Santhi, 2011), and Ireland (Smyth, 2008). However, it is important to consider the objectives of additional tuition or extra physics classes before its effects and importance can be examined (Santhi, 2011; Smyth, 2008).

Additional tuition in Indonesia is conducted in both classical meetings conducted by an educational institution and private tutoring (Oktavianti et al., 2018; Wicaksono, 2017; Widodo, 2016) based on students' needs and allocated finance. However, there is limited information regarding the impact of additional tuition on physics achievement in Indonesia. Wicaksono (2017) found there was no significant correlation between year-11 students who received additional physics tuition with physics achievement. This study employed the Kolmogorov-Smirnov normality test and product-moment correlation coefficient test to check correlation of variables. This finding is supported by Smyth (2008) who found no significant effect of private tuition on students' academic performance.

Fransisca (2004), however, showed a significant positive correlation between additional tuition and students' achievement in the national examination. This study also showed that tutoring also had a positive effect on students' motivation to face the national examination. Furthermore, information regarding the effect of additional tuition can be found in mathematics (Jamil, Syeda, & Khan, 2021; Suleman & Hussain, 2013), showing the significant effect on students' achievement for those undertaking private tuition.

In addition, several studies found factors motivating Indonesian students to undertake additional tuition (Oktavianti et al., 2018; Widodo, 2016). These can be grouped into four factors including learning competition, motivational learning support, learning quality, and learning achievement (Oktavianti et al., 2018). Oktavianti et al. (2018) found that students undertook additional tuition classes for every class in their observation school. Interestingly, the majority were Year 12 students because they could sit the final examination and selection test at their university of choice (Oktavianti et al. 2018).

The effect of additional physics tuition will be examined in this current study as this plays a prominent role in Indonesia besides formal education at school. Many Year 12 students undergo additional physics tuition to prepare for their national examination and university selection test (Nosek et al., 2009; Oktavianti et al., 2018). However, limited studies showed the effect of additional tuition on students' achievement.

Teacher-level factors

Teachers play an important role in managing the learning process and helping students to learn physics in the classroom. It can be said that teaching is one of the most important aspects of the learning process. The important roles of teachers in influencing students' physics performance were found in a study conducted by Wright, Horn and Sanders (1997). They found that teacher-level factors significantly influenced on physics performance by students.

This study examined several such factors including teacher characteristics, class size, attitudes toward physics teaching and learning, teachers' collaboration, teaching challenges, and teaching practice. The characteristics of teachers examined in this study were major education level, major education, and teaching certification.

Teacher characteristics

This study examined the effect of teachers' characteristics on physics achievement. It has been concluded that teacher effects are dominant factors influencing students' academic gains (Wright, Horn, & Sanders, 1997). In other words, Wright et al. (2009) concluded that students of all achievement levels learn effectively with effective teachers regardless of the level of heterogeneity in their classroom. And vice versa, if teachers are ineffective during the teaching and learning process, students will achieve less in their studies.

However, before we continue to discuss the effect of teacher-level factors, it is also important to consider the findings of Cottar (2012), that is, it may be difficult to measure the effect of teachers' characteristics on physics achievement when it coincides with the increased motivation of low-ability students, but it can be measured easily on students' attitudes toward physics. Cottar's findings can be used to consider the effect of teachers on physics achievement.

The characteristics of teachers examined in this study were major education level, and teaching physics certificate. These characteristics can be considered as background information on physics teachers.

Major education level

This study examined the effect of major and level of education of teachers in affecting physics achievement. The effect of teacher education levels on students' achievement has been examined for a long time and still needs further study to explore the effect of both major subject(s) and level of education of teachers (Greenwald, Hedges, & Laine, 1996; Wayne & Youngs, 2003).

Greenwald et al. (1996) conducted a longitudinal study to compare and examine the effect of school resources, including teachers' education level, on students' achievement. They found that more educated teachers increased students' achievement. They also argued that the magnitude of teacher education and teacher experience effects on students' achievement was higher than other related teacher variables such as salary and teacher ability.

In addition, Sirait (2016) found that teachers' highest education level had a significant effect on several variables using multiple regression to examine the model of education production function for estimating students' achievement across Indonesia. He found that teacher education background influenced the effect of teaching certification examination scores on student performance. Sirait found that students' achievement was positively correlated with certification score when teachers graduated with a bachelor degree at secondary high school level. However, there was no significant effect of certification programs on students' achievement when the teachers teaching in junior high schools had not graduated with a bachelor degree. This study showed the importance of teachers' highest education level on students' achievement and certification programs.

Furthermore, teachers' highest-level education was examined for its effect on students' achievement (Gansle, Noell & Burns, 2012). They compared student outcomes using a three-level model to compare the effect of teachers who graduated from Louisiana's Teacher Preparation Program (TPP) on students' achievement (Gansle, Noell, & Burns, 2012). They found that there were different outcomes for students taught by different teachers who had graduated from different programs. They also found that students of Master degree teachers tended to perform better than those of graduates of other teacher preparation programs.

Another study examined the effect of student preparation programs on students' achievement using a hierarchical linear model (Boyd, Grossman, Lankford, Loeb, & Wyckoff, 2009). Boyd et al. (2009) found several findings regarding teacher education preparation on students' achievement including the features of the program, student characteristics, and content knowledge. A teaching preparation program that produces effective teachers in a subject will likely produce effective teachers in other subjects (Boyd et al., 2009). They also found that another factor that may influence the effect of the teaching preparation program is its capability to attract the input of students learning in the teaching preparation program. Another finding was that teachers who were prepared in teaching skills benefitted from their skills in the first year of teaching, and those who taught content knowledge performed better in their second year.

On the other hand, several studies have indicated no significant correlation with teacher's education level with teacher ability and students' achievement (Aaronson, Barrow, & Sander, 2007; Rivkin, Hanushek, & Kain, 2005). Rivkin et al. (2005), who examined the data of all public schools in Texas provided by the UTD Texas School project, found no evidence that having a Master degree improves teaching skills. Furthermore, this finding is supported by Aaronson who concluded that teachers' highest educational level did not have a significant influence on students' achievement in mathematics and English.

In addition, it is still difficult to determine the effect of education level without any consideration of the teacher's major education study or subject-related education degrees (Wayne & Youngs, 2003). Wayne and Youngs (2003) compared several studies examining the effect of teacher education levels, and they concluded that a significant relationship was evident between student performance with teacher education level when mathematics and science teacher major education was included in data analysis. They also suggested conducting further studies to examine the effect of teacher subject-related study on students' achievement.

Teaching physics certificate

The teacher certification program in Indonesia is conducted to ensure that physics classrooms are managed by high quality and well-trained teachers (Abubakar, 2016; Masruroh, 2010).

The role of teachers is important to control the quality of the teaching and learning process inside the classroom in order to meet education standards.

It has been asserted that teacher certification and professional development are more strongly correlated with students' achievement compared to other variables such as knowledge of teaching and learning, and teaching experience (Darling-Hammond, 2000; Goldhaber & Brewer, 2000; Wayne & Youngs, 2003). This is because teaching certification ensures that the teacher certificate combines content knowledge and pedagogical skills.

In addition, Wayne and Youngs (2003) conducted a literature review of various studies to compare the influence of several teacher characteristics including college ratings, degrees and coursework and certification status on students' achievement. In their study, Wayne and Youngs used three electronic databases and most printed material excluding dissertations and conference papers. They found that students learnt more mathematics from certified teachers in mathematics and graduated with degrees related to mathematics in the US.

What about the certification program in Indonesia? The certification program was started by the Indonesian government following the implementation of law number 14 2005 aimed to enhance the quality of education and provide an additional allowance for certified teachers. In order to measure effectiveness of the certification program, Abubakar (2016) investigated the impact of teaching certification programs on religion-based high school quality in Kendari, Indonesia. High school quality was measured using several aspects including certified teacher roles on planning and implementing school programs, enhancing the teaching and learning process, improving other teacher competencies, and the use of certification allowance. Abubakar (2016) employed a survey and interview method to examine the effect of certification programs on school quality and found that the certification program showed positive effects on all aspects except for the incorporated certification allowance. This was because the majority of certified teachers used their certification allowance for individual needs such as buying vehicles, houses, and so on. The uptake of the certification allowance was also supported by the interview data which showed that a significant effect of the certification program is the increase in teachers' financial ability to purchase their daily needs and facilities needed for teaching in the classroom (computers, smartphones, etc). The reason why the majority of certified teachers used their certification allowance for individual needs is that the majority of these Indonesian teachers were living on, or even under, the minimum wage (Ikhsan, Zakso, & Wahyudi, 2013; Masruroh, 2010).

Siswandari and Susilaningsih (2013), however, conducted a study in Surakarta, Indonesia to investigate the effect of teaching certification on teaching quality in the classroom. They found that when the students taught by certified teachers explored their views regarding teacher clarity in delivering topics, only 37% of certified teachers could deliver the topics clearly. Another interesting finding is that only 30% of certified teachers could use media and teaching technology in their classes. Furthermore, only 32% of certified teachers were categorised as less than good or good enough in terms of their Continuing Professional Development (CPD). The majority of teachers (70%) also tend to collaborate with other teachers within the school to develop their professional skills compared to other activities such as research, training skills, or writing an article. Furthermore, the teaching certificate influences how teachers meet the requirements to receive their certification allowance (Ikhsan et al., 2013).

Class size

The effect of class size has been discussed since the 20th century and beyond (Bourke, 1986; Greenwald et al., 1996; Howley & Howley, 2004; Hoxby, 2000). These researchers focused on the optimum number of students learning in the classroom to help them learn effectively and achieve their best during the study. Another aim was to examine how class size influenced students’ achievement (Bourke, 1986).

Class size is still an issue in Indonesia where there is a lot of debate about how to improve students’ achievement, particularly in physics, by reducing class size. The importance of class size has encouraged schools in Indonesia to change their policy regarding the maximum number of students learning in the classroom. However, it is important to consider the research findings regarding the effect of class size in previous studies. The findings that may benefit the creation of appropriate policies regarding class size should be considered. Thus Bonesrønning (2003) concluded there is no certain effect of class size on students’ achievement. Rather it depends on the characteristics of subgroups where interaction between students and teachers happens. There were stronger effects of school size when teachers practised hard grading and provided incentives for students’ efforts. De Paola et al. (2013) examined the effect of class size on student learning at university level. They found different findings for students learning mathematics and language courses, where class size has a significant effect on students’ achievement in mathematics, where lower ability students would gain more benefit from a smaller class.

Although the effect of class size varies at different educational levels, several studies have examined the significant effect of class size on students’ achievement (Blatchford, Bassett, & Brown, 2011; Bourke, 1986; Fan, 2012; Greenwald et al., 1996; Rivkin et al., 2005). The effect of class size on students’ achievement was examined by Bourke (1986) using path analysis. In his study, Bourke examined several factors that potentially influence students’ achievement and concluded that instead of influencing students’ achievement directly, class size influences students’ achievement indirectly through teaching practice.

Class size influenced the pattern of teaching practice, and it was concluded that students learning in smaller classes tend to achieve better because teaching practice is more effective to help students learn in the classroom. The positive effect of school size can be seen when smaller classes allow students to interact more intensively with their teachers (Blatchford, Bassett, & Brown, 2011; Fan, 2012), and smaller class also helped teachers spend less time managing the class (Fan, 2012). In addition, another longitudinal study conducted by Greenwald et al. (1996) found that class size influences students' achievement where the smaller the size of the class, the better student performance in their subjects. Moreover, Rivkin et al. (2005) also found that class size reduction showed a positive effect on students' achievement although the effect was minor and varied at different levels. However, class reduction includes more expenditure, building requirements, and teacher numbers.

On the other hand, several studies have concluded that class size has no significant effect on students' achievement (Asadullah, 2005; Borland & Howsen, 2003; Hoxby, 2000; Wright et al., 1997). Borland and Howsen (2003) modelled various variables that may influence academic performance of primary students. They found that class size showed no significant effect on students' academic performance compared with students' ability, teacher experience, level of income and increased competition within education sectors. They also concluded that the attempt to reduce class size may incur additional costs but there is no association with students' achievement gain. Borland and Howsen's findings are supported by Hoxby (2000) and Asadullah (2005). Hoxby (2000), for example, found there is no significant effect by reducing class size on students' achievement at various levels in elementary-high school students. Hoxby (2000) conducted a longitudinal study by isolating the random component of the natural variation of the population and exploiting discontinuous changes in class size to measure the effects of class size changes on students' achievement within the US context, where class size is between 10 and 30 students. In addition, Asadullah (2005) investigated the effect of class size on students' achievement in the Bangladesh context. He found, for secondary grades, that it is not efficient to reduce class size in a developing country (Bangladesh) and also concluded that school competition showed a significant effect on improving students' achievement. Moreover, Wright et al. (1997) found that class size had relatively little influence on academic gain compared to teacher effects. Wright et al. found that class size showed a significant effect on students' achievement in only three out of 30 analyses when they conducted the longitudinal study.

Teacher's attitudes toward physics teaching and learning

Another important factor examined in this study is teachers' attitudes toward physics and learning. Teacher's attitudes play an important role in helping students learn physics. It is important to examine the attitudes because the quality of teachers is significantly correlated with teachers' ability regardless of the quality of students (Aaronson et al., 2007). In other words, teachers will perform well in any situation and conditions when they showed a good attitude toward physics teaching and learning to help the students.

Teachers' attitudes describe the way teachers think and view their students and their capability to teach physics in the classroom. Teachers' attitudes are evident in how they feel confident to inspire students and help them appreciate the value of physics by adapting their teaching methods to engage students' interest, making physics relevant, doing experiments, and using inquiry methods during teaching and learning. Teachers' attitudes toward Information, Computer, and Technology (ICT), for example, plays an important role in assisting teachers to deliver physics concepts (McFarlane & Sakellariou, 2002; Park, Khan, & Petrina, 2009; Wan, 2011). ICT may support or replace the offline meeting, but it can also help students to become more science-oriented through facilitating online discussion and providing access to broader information with further support from teachers' positive attitudes towards ICT (McFarlane & Sakellariou, 2002; Wan, 2011). Despite this, the most common uses of ICT in teaching usually involved administration and classroom interaction (Suduc, Bîzoi, Gorghiu, & Gorghiu, 2011), rather than enhancing content. These common uses could be considered to optimise effects and to develop favourable attitudes towards ICT, for example, by capturing the physic experiment activities or findings using smartphone and play them whenever we need them, using animation or simulation programs to attract students learning physics and understanding the physics concepts easily, accessing and discussing physics topics through internet communication (McFarlane & Sakellariou, 2002; Park et al., 2009; Wan, 2011).

Teacher’s attitudes could also be seen in their confidence to help students improve and achieve, students’ achievement and the enhancement of students' physics concepts particularly in connecting their lesson with daily life (Sanders, Wright, & Horn, 1997). Furthermore, the influence of teachers’ attitudes on students’ achievement is essential to improve the understanding of struggling students and provide challenging tasks for high achievers. Teachers' self-efficacy, which involves both general teaching efficacy and personal teaching efficacy, has a positive relationship with students' achievement and influences teacher interaction with each student (Ross, 1992). Another study also indicated that teacher motivation and Pedagogical Content Knowledge (PCK) can improve students' cognitive and affective outcomes (Keller, Neumann, & Fischer, 2017).

Teacher collaboration

Teachers’ collaboration is another factor that may potentially influence students’ achievement in physics. Teachers’ collaboration was one of the main focuses of the Indonesian government when the teaching certification program was initiated, and it was frequently done by 70% of the certified teachers to improve their professional development in Surakarta, Indonesia (Siswandari & Susilaningsih, 2013). Therefore, it is important to check the effect of teachers' collaboration to develop teacher professionalism and to support students' academic performance.

It has been asserted that teachers' collaboration can be used to improve teaching quality effectively for better student learning outcomes for their success in future studies and careers with an effective cost (Fulton & Britton, 2011; Vangrieken, Dochy, Raes, & Kyndt, 2015). They also found that teachers' collaboration has positive effects on Science, Technology, Engineering and Mathematics (STEM) teachers, indicated by their better understanding of mathematics and science content and they are more prepared to teach their subject in their class when learning in a professional learning team (Fulton & Britton, 2011). They also concluded that a group of teachers (at least three) who work and learn together are able to create a successful culture to improve students' achievement and school performance.

In addition, Vangrieken et al. (2015) undertook a systematic review regarding teachers' collaboration. They noted that besides the fact that teachers' collaboration positively influences students' performance, it also changes the school culture to become more innovative, improves teachers' job performance, and benefits them at a personal level. However, they also found the probability of negative effects of teaching collaboration such as forming exclusive groups within the schools which isolate the teachers should be avoided.

Teacher challenges

If we talk about teaching challenges, it is usually correlated with teacher turnover. Teacher turnover was frequently caused by student demographics and working conditions (Johnson, Kraft, & Papay, 2012; Ladd, 2011; Loeb, Darling-Hammond, & Luczak, 2005). It was found by Loeb et al. (2005) that the effect of student demographics becomes weaker when teachers' perceptions about working conditions were added. In other words, the challenges faced by teachers in relation to their working conditions show a significant correlation with teacher turnover.

Likewise, Johnson et al. (2011) also examined factors that potentially influence teacher turnover, but they paid more attention to the effect of working conditions on teachers' satisfaction with their jobs and career plans rather student demographics. They found that instead of physical facilities or modern instructional technological access, social conditions in the positive school culture, including teacher relationship and principal leadership, are the most important aspect for teachers. Furthermore, Ladd (2011) examined teachers' perceptions of their working conditions at three different school levels: elementary school, middle school and high school level. They found that principal leadership had a strong correlation with working conditions.

Teachers' challenges could also be used to predict student performance. Teachers who teach within favourable working conditions could positively predict student academic growth. This finding is supported by the TIMSS 2011 study where minimum challenges faced by teachers would positively influence students' achievement (Hooper, Mullis, Martin, & Fishbein, 2015). The TIMSS 2011 study found that teachers tended to spend more time helping their students to learn physics, and keeping up-to-date with the curriculum, and administrative tasks. These three challenges should be resolved to help students achieve better in physics because a manageable workload will help teachers work productively and thus significantly improve students' academic progress (Johnson et al., 2011).

Teaching practice

Teaching practice is another important factor which were investigated in this study. Teaching practice can be defined as how teachers deliver physics in the class or instructional quality of teachers (Goe & Stickler, 2008). Therefore, it is important to consider teaching methods besides teachers' background regarding students' achievement in physics (de Zeeuw et al., 2014).

The importance of teaching practice can be seen from its role to help students learn effectively in class. Teaching practice enabled students to achieve high-performance levels when teachers used an inquiry-based learning method and accommodated students' feedback in their physics classroom (Gess-Newsome et al., 2019). This is supported by Cottaar (2012) who underlined the importance of student feedback. He found that by considering feedback during teaching and learning in the class, teachers could match their teaching practice with students' needs and enable them to learn more effectively, particularly for low-capability students in learning physics (Cottaar, 2012).

In addition, there are other aspects that influence teaching practice. A study conducted by Bourke (1986), for example, showed that the teaching practices of the teachers interacted with student ability and class size in influencing student performance on Mathematics. This interaction showed that the teaching practices were correlated with the student abilities and the number of the students learning in the class. In this study, Bourke (1986) also found that the excellent teaching practices, class size, and student ability significantly influenced student achievement on Mathematics of year-5 students. Therefore, the influence of teaching practice cannot be separated from other factors including student abilities and class size.

School-level factors

This study examined the effects of school differences on students' physics achievement. In examining the influence of school-level factors, this study focused on two groups including characteristics of participant schools (school type, location, principal education level, the availability of physics laboratory and library) and school academic emphasis on academic success.

School characteristics

School characteristics were examined for their impact on physics achievement of Year 12 students. They included type and location of schools, experience of principals, education level of principals, availability of both science laboratory and library, and school enrolment.

School types

It has been argued that school types influence students' achievement (Epple & Romano, 1998; Gamoran, 1996; Sander, 1999). The type of school influenced how school funding is managed to facilitate student learning and to improve students’ achievement (Epple & Romano, 1998). In relation to this study, it is a common belief in Indonesia that public schools are cheaper, and they have better quality than private schools, but there is no evidence about physics achievement of Indonesian students based on school types. This limited evidence in investigating school types, particularly in physics, would be investigated in this study.

School location

School location is an interesting issue in terms of its influence on students’ achievement. He and Giuliano (2017), for example, found that school location is one of many factors which influenced parents’ decision making to choose a school closer to their home location. Parents chose a school based on its location, quality, and other school features (He & Giuliano, 2017). Furthermore, they also found that the quality of a school encouraged students to travel further which related to students’ motivation to learn in a better-quality school rather than choosing a school located closer to home. Therefore, it is not surprising that school location might also influence parental choices when they select the location of their house (Ely & Teske, 2014).

It has been asserted in a number of studies that concluded that there is a correlation between school and students' achievement (Papa, Lankford, & Wyckoff, 2002; Saadia, 2012; Veloo et al., 2015). The reason for the effect of school location on student achievement can be determined by several reasons. It was concluded by Veloo et al. (2015) who identified students’ attitudes toward physics argued that students living in rural areas in Malaysia tend to think that physics is more difficult. The principal factor may also affect the quality of schools. Papa et al. (2002), for example, studied the effect of school location and school principals. Papa et al. (2002) found that urban schools are much more likely to be managed by less experienced principals or principals who graduated from lower-ranked colleges in New York City. This was caused by the difference in salaries provided by the schools. This difference in principal leadership quality which may affect student achievement.

This can be seen from different perspectives including school quality, school facilities, and parental involvement. Home location also influenced student--teacher interaction, parental involvement, and self-concepts (Gavidia-Payne, Denny, Davis, Francis, & Jackson, 2015). A student’s home located in an urban location encouraged greater parental involvement. This also influenced students' achievement in Pakistan (Saadia, 2012). Saadia concluded that students who live in urban areas performed better and potentially had better motivation in learning mathematics.

However, a study conducted by Josia (2012) found that school location did not affect student performance in physics. He found that Computer Assisted Instruction (CAI) could minimise the effect of school location and resulted in no significant difference in academic performance of the students learning in CAI classroom in a different school location. Josia’s study showed that we can minimise the effect of school location on student performance by controlling learning qualities.

Principal's education level and experience

The principal plays an important role as school leader. Successful schools were managed by principals who could lead both people and programs effectively, as their main responsibility is to facilitate teaching and learning (Bottoms & O'Neill, 2001; O'Donnell & White, 2005).

In addition, the influence of principal leadership experience can be seen by its effect on student achievement because principal experience can be used as an important indicator of effective and successful principal leadership (Papa et al., 2002). In their study, Papa et al. (2002) found that low performing schools were led by less experienced principals and who had attended less competitive colleges. It is also supported by a study showing a positive effect of principal leadership on student achievement when the principal showed positive leadership in instructional activities and conflict resolution but it was not for other leadership skills (Eberts & Stone, 1988). Effective principals who facilitate and support the teaching and learning process can improve the teaching behaviour of their teachers and indirectly can improve student achievement at both elementary and secondary schools (Firestone & Wilson, 1989).

Physics laboratory

The laboratory is an integrated facility that should receive an intention during physics teaching and learning. It is because physics is a sort of natural science that need practical works and theory to describe physics concepts. The practical work and theory here are adapted from the terms used by Donnelly (1998). The practical work in Donnelly's study means that the students are doing laboratory work individually or within a small group. But, theory can be defined as student activities within the classroom indicated by learning on written material.

It has been argued, and tends to be a common belief, that practical works in the laboratory has a superior position to learning in the classroom (Donnelly, 1998). Therefore, Donnelly (1998) found that science teachers in English and Wales identified their teaching strategies, other than practical works, as a traditional teaching strategy which they believed was inferior to the practical works. However, he found that most of the science teachers in English and Wales felt anxiety when doing practical work because they were unable to effectively manage and consider their timetable and teaching strategies.

In addition, in terms of the effect of laboratory work on student achievement, Freedman (1997) conducted a study to measure the effect of a hands-on laboratory program on student achievement and attitude toward science. He compared student achievement using a post-test-only control group design. The study employed a one-way analysis of variance (ANOVA) to compare student achievement on science and attitude toward science. He found that students doing practical work in the laboratory performed significantly higher on achievement and exhibited more positive attitudes toward science.

Libraries

Several studies have been conducted to identify the effect of libraries on student achievement over 40 years of research (Haycock, 2011). Research evidence from Australia, Canada, and the US show that school libraries equipped with high-quality resources and managed by a qualified librarian can help the students succeed on their standardised test (Barrett, 2010; Haycock, 2011).

A study conducted by Haycock (2011) linked the standardised test scores of the students with library resources in the schools in British Columbia, Canada. He examined the library resources in terms of their accessibility, staffing, teacher partnership, usage, networked information technologies, collection, scheduling and funding. He concluded that students who learnt in schools facilitated by well-equipped libraries and supported by motivated and qualified professional teacher-librarians tended to experience high-quality learning in their schools, showed higher ability as a reader, were more information literate, and performed better in their study compared to students in other schools where these conditions did not exist.

The important question is how the library can influence student achievement? To answer this question, Scott and Plourde (2007) argued that most important is creating the academic life within the school libraries. They proposed the design of a particular curriculum to help students learn and discuss, which is not only to just retrieve information there but also to understand deeply the information as the effective users. In their study, Scott and Plourde (2007) suggested creating the library as a warm place in student learning centres with a particular curriculum and collaboration among the teacher-librarians to create consistent library goals, assessments, and activities. It is supported by Oberg (2002) who argued that the role of the library to improve student performance is not only by providing a well-equipped library and a professional teacher-librarian, but student achievement could be improved significantly by combining the library factor with other factors including the classroom teachers. In her study, Oberg also noted several benefits of the school library to improve student achievement at the elementary school level. She found that collaboration between classroom teachers and librarian teachers can improve student achievement because the classroom teachers can identify student weaknesses and the librarian teachers can provide any helps needed to develop student skills based on the findings of the classroom teachers. She also concluded that students who learnt with the collaboration between classroom teachers and librarian teacher could reach 81% mastery on the reading comprehension and 95% mastery on the reference portion of the tests compared with other students learning without any collaboration and a low material circulation who could reach 52% and 19% mastery on the reading comprehension and the reference portion of the test, respectively.

School enrolment

Enrolment or school size has been examined for its impact on students' achievement for a long time. The common belief is that students' achievement will decrease when the number of students learning increases (Egalite & Kisida, 2016). However, it is still important to examine the enrolment effect on physics achievement because there is limited information about the effect of student enrolment on physics achievement in Indonesia. A study in Indonesia was conducted by Sirait (2016) who used a production model to examine the effect of several factors including school size and teaching certification. He found that student enrolment influenced students' achievement in senior high school and junior high school in a particular subject (English at senior high school, and English and mathematics at junior high school).

Sirait's finding is supported by Egalite and Kisida (2016) who conducted a longitudinal study to examine the effect of enrolment on students' achievement. They examined a dataset provided by the Northwest Evaluation Association describing students' achievement from elementary school to secondary school of more than one million students in four states in the US. They found that students' achievement in reading and mathematics decreases when school size increases. They also concluded that the negative effect of higher enrolment showed a greater impact at higher levels (grades 6 to 10).

The effect of school size on students' achievement was also found by Eberts, Schwartz, and Stone (1990) who compared the achievement of students in three different groups of school size. They concluded that school size significantly influences students' achievement, and concluded that the smallest school size showed the best achievement. Therefore, it can be concluded that enrolment significantly influenced students' achievement. However, limited study in Indonesia examines the effect of enrolment on students' academic performance.

School emphasis on academic success

Besides demographic background, another important factor in emphasising students' academic success is the school environment. This environment is conceptualised as a new, latent construct, academic optimism, and where all school components, including teachers, parents and students, feel confident that students will succeed academically (McGuigan & Hoy, 2006; Wu, Hoy, & Tarter, 2013). Such academic optimism is predicted to minimise the negative effects of demographic background, such as low socioeconomic status, frequently associated with teaching challenges that potentially influence teacher turnover and impact students' achievement (Johnson et al., 2012; McGuigan & Hoy, 2006). In other words, academic emphasis shows the extent of the school environment to make students' achievement the main purpose (McGuigan & Hoy, 2006).

Academic environment examined in this study was adapted from TIMSS 2015 study which proposed both a new construct and school emphasis on academic success, based on studies conducted by Hoy, Tarter and Hoy (2006), McGuigan and Hoy (2006), and Wu, Hoy, and Tarter (2013) as well as the effect of school demographics on students' achievement (Hooper et al., 2015). This study measured perceptions of principals in regards to potentially influencing students' achievement, examining three aspects including (1) students' desire to perform better, (2) parental involvement to support students' achievement, and (3) teachers' expectation for successful physics curriculum implementation and students' achievement

(Hooper et al., 2015; Johnson et al., 2012). These principals' perceptions were examined because they can organise and manage schools to create an educational environment that focuses on students' achievement (McGuigan & Hoy, 2006).

Students' desire to achieve

Students are the main actors when we talk about achievement. Therefore, one out of three indicators of school emphasis on academic success is the desire of the students to focus on achievement. This desire is indicated by showing high motivation to achieve the intended curriculum and showing respect to other students who perform at high levels of achievement (Wu et al., 2013).

Furthermore, principals as school leaders play an important role in improving students' desire to achieve at high levels because emphasis is placed on academic success as potential factor influencing students' achievement at school level. Principals could increase students' desire to perform at high levels by providing challenging coursework and rewarding outstanding performance, and in turn, it can have a positive effect on students' achievement (McGuigan & Hoy, 2006).

However, these findings depart from Dodeen, Abdelfattah, Shumrani, & Hilal (2012). They found that students' desire to do well exhibited a different correlation in regard to students' achievement in Saudi Arabia and Taiwan (Dodeen, Abdelfattah, Shumrani, & Hilal, 2012). They examined the correlation of several variables with students' achievement and compared the findings of Saudi Arabia and Taiwan using the TIMSS 2007 dataset. They found that students' desire to achieve better in their mathematics showed a significant correlation with students' achievement in Taiwan but not in Saudi Arabia. They found that several contextual variables where the studies had taken place influence the effect of students' desire to achieve on student achievement.

Parental involvement and support

Parental involvement to support student achievement is another aspect of school emphasis on academic success. Parental involvement can be categorised as an important aspect to motivate the students to succeed in their studies. It can be seen from students’ views about their motivation to achieve better in their study, and what they desire to achieve is to please their parents and family (Daniels & Arapostathis, 2005). This is supported by the findings of Dodeen et al. (2012) who investigated the teacher contextual questionnaire using TIMSS 2007. They found that while many variables indicating school environment did not show a significant correlation with student mathematics achievement, parental support for student accomplishments showed a significant correlation with achievement. Therefore, greater parental involvement could be encouraged to improve the academic success of the students, and discussion between school and parents could be developed to improve the academic climate of the school (Cabus & Ariës, 2017; Hampden-Thompson & Galindo, 2017). Likewise, Cheung and Pomerantz (2012) examined the role of parent-oriented motivation on student achievement. They investigated the difference of parent involvement on student achievement in the US and China. The students were given a set of questionnaires four-times approximately 6 months apart from when the students entered a new school at seventh grade to the end of eighth grade. The study found that parent-oriented motivation was positively associated with all children’s reasons for doing well in school in both China and the US. The study also found the positive effect of parental involvement on higher achievement, and the role of parent-oriented motivation is to mediate the effect of parental involvement on student achievement.

The effect of parental involvement was also investigated in new immigrant families in the US. The study was conducted by Jung and Zhang (2016) using the New Immigrant

Survey. The study used structural equation modelling and CFA to analyses the data. The study found that parental involvement showed direct and positive effects on student achievement, cognitive development, and English ability.

The effect of parental involvement can also be seen in homework support. Parental involvement might also create a greater parental vision regarding the homework particularly to help the students in their academic success. Both parents and teachers could develop positive attitudes and behaviour towards the homework of the students (Coutts, 2004). The collaboration of both parents and teachers can encourage students to do more effective homework thereby supporting students' academic success (Epstein & Van Voorhis, 2001).

Teacher expectation for successful curriculum implementation and students' achievement

Teacher expectation is another aspect of school emphasis on academic success. Teacher expectation here is classified into collective efficacy where all teachers work together to help students with learning.

Within the school environment where principals focus on students' achievement, they not only provide a supportive environment, but also encourage and emphasise the collaboration between teachers and parents to make decisions about homework policy and tutoring to develop positive attitudes toward homework (Epstein & Van Voorhis, 2001; McGuigan& Hoy, 2006). In addition, with school leadership being a part of school emphasis on academic success, principals provide an environment to engage Professional Learning Communities (PLC) or teachers' collaboration (De Neve & Devos, 2017; McGuigan & Hoy, 2006). In PLC, teachers collaborate with teaching and learning activities, and beginning teachers can develop their careers. If teachers can positively collaborate and develop their careers, they will experience a supportive school environment which can minimise teacher turnover and increase students’ achievement (Johnson et al., 2012).

Interaction of the factors on influencing physics achievement

This study proposed a theoretical model to explain the interaction between factors in influencing physics achievement of Year 12 students in Malang, Indonesia (J. M. Epstein, 2008). The theoretical model for this study was adapted from both the 3Ps learning model and multilevel model. Furthermore, factors were modelled in the theoretical model using previous studies described in the previous subsection. (The model can be seen in Figure 2.4.)

The factors potentially influencing physics achievement in this study were proposed into a two-level model. The factors are divided into two levels namely: school- and student-level, as shown in Figure 2.3. Each level consists of several factors that were predicted to interact with each other as seen in Figure 2.4 using the 3Ps learning model and the multilevel model. In the multilevel model, this study proposed that the school-level combines both teacher factors and school factors, while the student-level includes only student factors and physics achievement.

Before the theoretical model can be discussed, this subsection discusses both the 3Ps learning model and multilevel model used to design the proposed model for this study. The description of the model includes a general description of the interaction of factors in the study followed by the proposed model used in this study.

3Ps learning model

This study used the 3Ps learning model as one of its theoretical frameworks. The model proposed by Biggs (1987) was adapted for this study (see Figure 3.1) proposes three components of Ps showing causal interaction between factors. This model was used to divide potential factors influencing the physics achievement of Year 12 students based on the findings from previous studies into three groups.

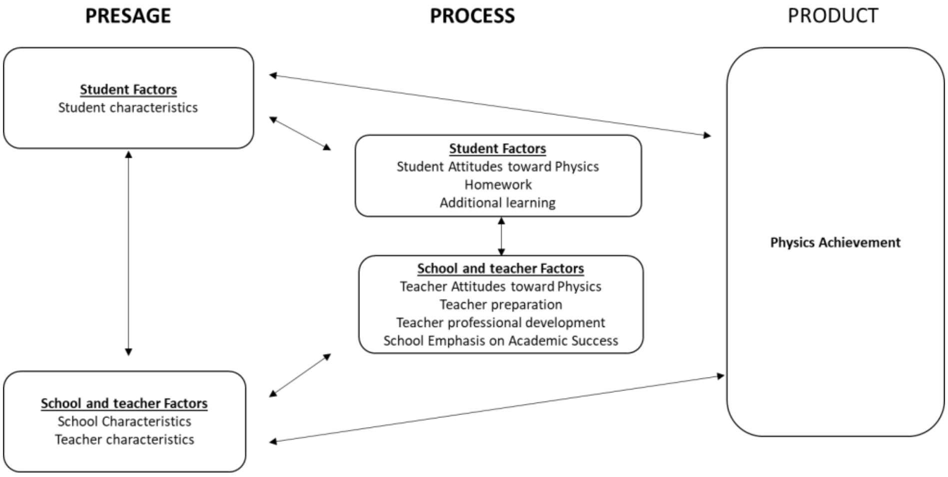


Figure 2.1 The 3Ps learning model in this study (adapted from Biggs, 1987)

The 3Ps learning model used in this study was employed to group and identify factors or variables based on the questionnaire data including situational and personal variables (Presage), learning approaches (Process) and learning outcomes (Product). Presage variables have an effect on students' values which influence their behaviour or attitudes during the learning process as indicated by student learning approaches (Process). As a result, learning outcomes (Product) can be influenced by both Presage and Process variables.

The conceptual model indicates three aspects of Ps using variables described based on the literature review. Presage in this study is indicated by students', teachers' and school characteristics. These factors were hypothesised influence other factors or variables in other groups. The characteristics of students, teachers, and principals were collected via student, teacher and principal questionnaires. (The description of instruments can be seen in Chapter 3.)

The second group is Process which indicates factors actively influencing learning approaches used by students. The group consists of students' attitudes toward physics, teachers' attitudes toward physics teaching and learning, schools' emphasis on academic success, teaching preparation, and the frequency of physics homework assigned by the teacher. These factors are hypothesised as those that indicate the process of how students learn in the physics classroom.

The third group, Product, is the outcome of the learning process. This is shown by students' performance in physics measured by a physics diagnostic test undertaken during data collection. The test was adapted using the 2013 physics national test.

Multilevel model

This study also adapted a multilevel model of school system performance proposed by Resnick et al. (2007) and Resnick (2010) (see Figure 2.2). It is different from the 3Ps learning model which shows the interaction between variables within a single level, while the multilevel model divides factors into different levels. This multilevel model adapted a controlling feedback system within the manufacturing process which describes a framework for effective management in promoting the performance of the school system (Resnick, Besterfield-sacre, Mehalik, Sherer, & Halverson, 2007; Resnick, 2010).

In the multilevel model proposed by Resnick et al. (2007) and Resnick (2010), there are two processes influencing educational products, which are a production process (at classroom-level) and a leadership and management process (a combination of school- and district-level). This model proposes that the education process is a combination of multilevel factors at classroom level as a production process and a shared leadership and management process at school level and district level to evaluate students' performance as outputs.

In addition, the multilevel model was also employed in the PISA 2015 study. The model was used to investigate the effects of factors within a multilevel model consisting of student-, school- and system-level (OECD, 2016). This multilevel model used in the PISA

2015 study indicates that the nature of educational data is nested into several levels or groups. Therefore, this study proposed a multilevel model to explain the interaction of factors at student- and school-level to deal with the nature of the data as part of the educational data.

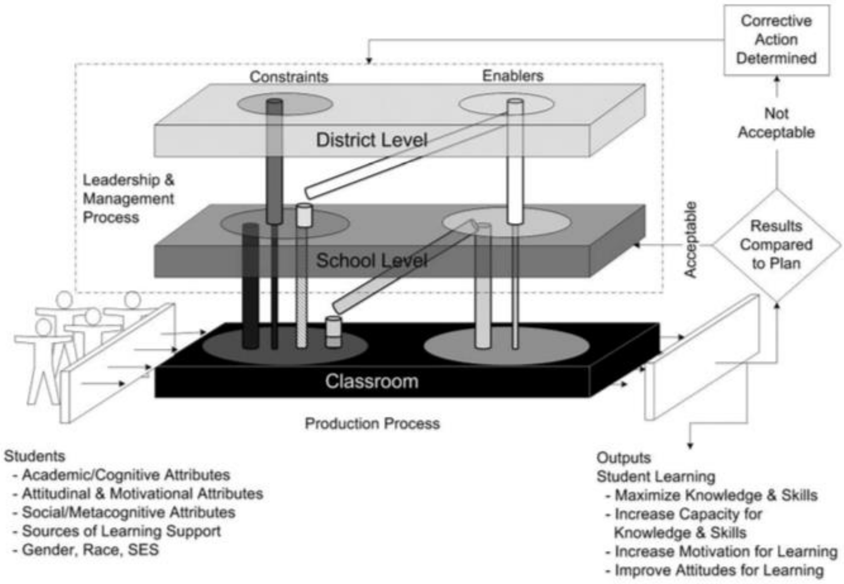


Figure 2.2 Multilevel model proposed by Resnick et al. (2007) and Resnick (2010)

In adapting the concept of the multilevel model proposed by Resnick et al. (2007) and Resnick (2010), this study used a two-level model. The proposed model combines factors at both teacher and school level into a single level, which is school level. This is because majority of schools only had one teacher participating in this study, except one school that had two teachers. The school level in this study describes leadership and management within the production process. This level indicates both principal and teachers' leadership in the physics classroom. The principals play a role in deciding the school climate, parental involvement in school management, and other policies to support and facilitate academic success of students during their learning process. Furthermore, physics teachers manage the teaching and learning process in the classroom. The teachers as classroom managers have an important role in helping students learn physics effectively.

Furthermore, this model also proposed a student level. The second level indicates the production process, described by factors examined based on the data collected in the student questionnaire. The students checked their factors including demographics and attitudes toward physics during the learning process as a production process. In addition, to measure the product of the education process, this study proposed students' achievement as an educational product. The model evaluates school system performance in educate students by using physics performance through the physics diagnostic test.

Conceptual model

The factors investigating causal interaction in influencing physics achievement in this study are modelled as a multilevel interaction (see Figure 2.1). The figure shows that teacher factors correlate with principal factors, and grouped into a single level, the school level. This same level proposes that similar characteristics for the students nested in a single school. In other words, within a single school the students are taught by the same teacher; thus, students share the same characteristics at school level. These factors interact with those at the student level in influencing the physics achievement.

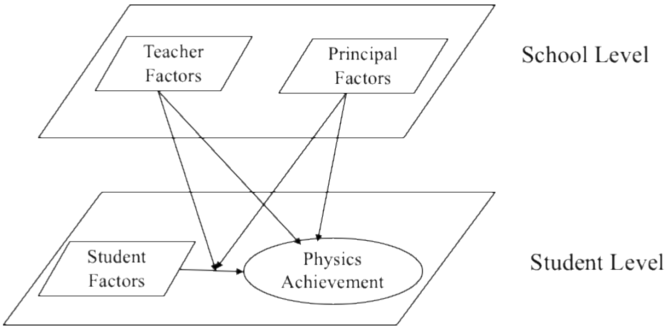


Figure 2.3 Factors investigated within multilevel data

The proposed multilevel model as shown in Figure 2.1 combines hypothesised factors in regard to their influence in explaining Year 12 students' physics achievement in Malang, Indonesia. As previously mentioned, this model is designed based on the 3Ps learning model proposed by Biggs (1987) and a multilevel model proposed by Resnick et al. (2007) and Resnick (2010). The proposed model combines both models to investigate the effects of the factors at both student and school level on physics achievement.

This study proposed a conceptual model describing the physics achievement of Year 12 students in Malang and influenced by several hypothesised factors. The conceptual model combined both the 3Ps learning model and the multilevel model (see Figure 2.3 showing the grouping factors investigated in the study).

The model proposed factors grouped at both school and student level, which shows the location of factors from the conceptual model. This makes it possible to describe interactions between factors on different levels as an educational process to produce students' performance as product. The factors were briefly constructed using characteristics of the respondents, teachers' professional development, attitudes of physics teachers and Year 12 physics students, role of homework in motivating students learning, and school academic climate in promoting academic success.

School-level data are related to factors that may influence physics achievement of the students learning in the same school or different schools. This level emphasised the influence of schools and teachers on students’ performance. The effects reflected by school characteristics and school academic climate aimed to support and emphasise students’ academic success. School characteristics are partly represented by school type and school location. Another factor would be school emphasis on academic success by describing how the school facilitates students' learning through its policy on teachers, students, and parents. In addition, teachers show the influence of related teacher factors within the physics classroom. This level consists of teachers’ characteristics, attitudes, and preparation. Teachers' characteristics are indicated by their gender, education level, and teaching methods.

Teachers' attitudes are another factor that can influence students' achievement. The other factor is how teachers prepare for teaching in the classroom. This factor can be indicated by teachers' activity in cooperating with their colleagues to improve the quality of teaching physics in the classroom.

The student level investigates students' physics achievement. Related student-level data includes students' characteristics, attitudes toward physics, and homework. Characteristics include gender and background. Attitudes toward physics and homework are also investigated with respect to their effects on students' achievement in physics in Malang, Indonesia.

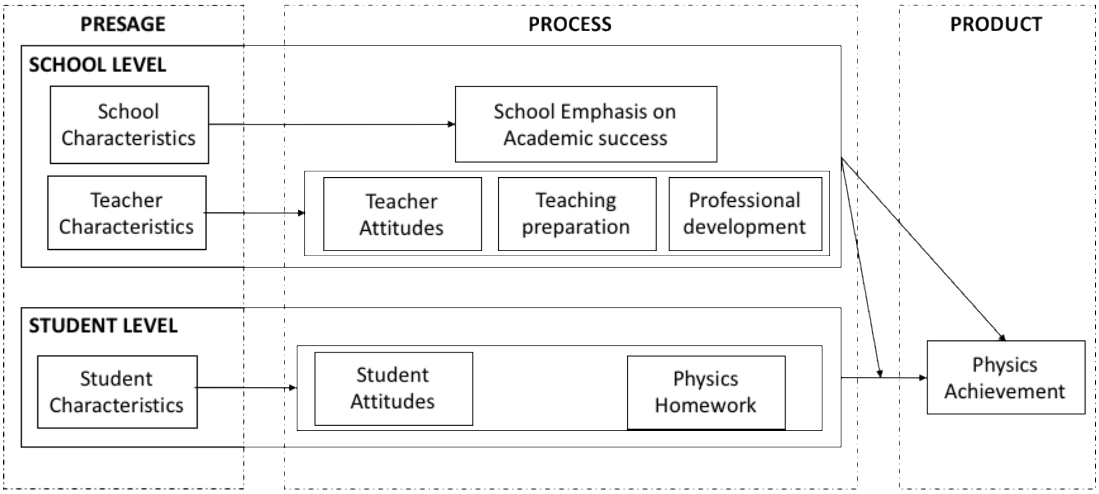


Figure 2.4 Conceptual model of the influence of Presage, Process and Products variables

Summary

Chapter 1 presented the main issues and research objectives of this study. This chapter discussed the importance of physics achievement as the main focus in this study. It can be seen in this chapter that physics achievement is one of the important topics in physics education studies. The importance of physics achievement can be seen from the main focus of the physics studies conducted using both primary and secondary data focusing on assessing students’ physics achievement. This is also supported by the international comparison studies, including PISA and TIMSS, providing data regarding students’ physics/ natural science achievement and survey findings about potential factors potentially influencing such achievement.

Potential factors that may influence physics achievement in this study were introduced in this chapter. The factors were examined based on previous studies. This study examined the causal interaction of potential factors within an integrative study by combining potential factors that may influence physics achievement of Year 12 students. The factors were divided into three groups including student-, teacher-, and school-level factors.

To examine the influence of the factors on physics achievement, this study proposed a theoretical model which explained the causal interaction of factors. Causal interaction between variables was formulated into a proposed model using the 3Ps model proposed by Biggs (1987) and a multilevel model proposed by Resnick et al. (2007) and Resnick (2010). The proposed model was examined using mixed methods (to be described in Chapter 3).

Chapter 3 will present the design carried out to evaluate the model regarding factors influencing physics achievement of Year 12 students in Malang, Indonesia. The methodology and research design for conducting this study, including sample selection, population descriptions, and analysis methods, will also be discussed.

CHAPTER 3

RESEARCH DESIGN, INSTRUMENTATION AND METHODOLOGY

Introduction

This study aims to answer research questions regarding potential factors that could influence physics achievement of Year 12 students in Malang, Indonesia. using mixed methods design, combining quantitative and qualitative approaches.

To investigate the impact and influence of factors on students' physics performance, this study employed embedded mixed methods design. In this design, a quantitative approach (survey) was used as a primary method for collecting and analysing the data, and a qualitative approach (semi-structured interviews and Focus Group Discussions (FGD)) supported the quantitative aspect of the study.

In this chapter, the overall design of the study, sampling framework, procedures employed during the pilot study, and methods used to collect and analyse the data will be discussed.

Research design

Research is concerned with ways of knowing and understanding the world, which can be carried out through various investigations, such as collecting and analysing data to obtain answers to research questions and drawing conclusions based on evidence. Prior to conducting research, an appropriate design must be selected that allows the researcher to organise the data collection and analyses as well as interpret findings. In order to achieve the aims of this study, the mixed methods design was applied. In mixed methods design, both quantitative and qualitative data are collected in a single study or series of studies (Creswell, 2014). Combining statistical measurement (quantitative data) and personal experiences of participants (qualitative data) provides a better understanding of the research problem under investigation than employing a single approach (Creswell, 2014). In a nutshell, mixed methods design allows the researcher to use various data collection tools or multiple approaches in order to identify research problems comprehensively, and to answer research questions that cannot be addressed using a single approach. Two or more methods complement each other in relation to strengths and weaknesses and allow for complete analysis of the research problem. For instance, weaknesses of the quantitative method can be complemented by strengths of the qualitative method and vice versa.

In this study, a mixed methods design was carried out to combine survey and interviews/ Focus Group Discussion (FGD) for data collection. A survey method was used for collecting and capturing Year 12 student performance in physics in Malang, Indonesia, which is the target population in this study. This survey method describes trends, opinions and attitudes of Year 12 students, physics teachers, and principals in Malang, Indonesia. In terms of research questions, this survey method answers descriptive questions, relationship questions, and predictive relationship questions (Creswell & Creswell, 2018). These question types were investigated in this study in Chapter 1. However, this survey method cannot be used to gain in-depth understanding of respondents' views which can be achieved through interview or FGD. The information collected via the survey can be explained further by hearing the background information from respondents using interviews in natural settings. Therefore, such a mixed methods approach can answer more complex research questions compared to a single research design.

The mixed methods applied in both survey and interviews/ FGD in this study help to generalise the findings using quantitative survey data and provide a greater understanding of participants' background and context taking a qualitative approach through the views of teachers or students (Creswell & Creswell, 2018; Cohen, Manion, & Morrison, 2018). Mixed methods design employed in this study shares and discusses both quantitative and qualitative views rather than seeing them as different ways of interpreting the world (Cohen et al., 2018). In other words, interviews and/or FGD conducted in this study are used to check, or provide more information regarding factors identified in the survey.

Instead of separating qualitative and quantitative approaches, this research design answers the research questions that cannot be answered separately by combining both methods. This mixed methods design answers the research questions about Year 12 students' physics achievement by identifying factors that may influence such achievement (quantitative) and exploring the views of physics teachers and students regarding potential factors investigated in questionnaires (qualitative). In sum, mixed methods design benefits the study by investigating potential factors influencing physics achievement.

Embedded mixed methods design

Embedded mixed methods design was carried out for this study. The survey was carried out first, and both semi-structured interviews and FGD were embedded. The design for this study was adapted from Creswell (2012) (see Figure 3.1).

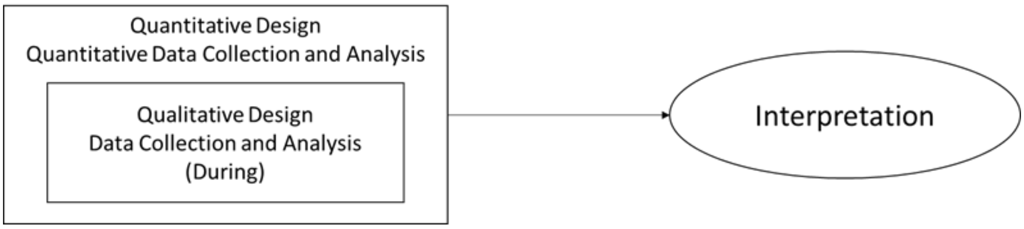


Figure 3.1 Embedded mixed methods (adapted from Creswell (2012))

During application of embedded mixed methods design, this study used a definition proposed by Creswell and Clark (2018). They defined mixed methods study based on previous descriptions by combining philosophy, methods, and methodology. They characterised mixed methods design as: (1) collecting and analysing both qualitative and quantitative data rigorously, (2) mixing or integrating the data and results, (3) organising the procedures into specific research design, and (4) framing the procedures within theory and philosophy (Creswell & Clark, 2018).

In line with the four characteristics proposed by Creswell and Clark (2018), this study applied embedded mixed methods with a particular time framework and background theories. This study used stratified random sampling for the survey (quantitative) and purposive random sampling for interviews and FGD (qualitative). Both sampling frameworks were used within a particular timeframe and were integrated into a single method to select participants.

In applying embedded mixed methods design, both qualitative and quantitative data processes were undertaken simultaneously during the study (Creswell, 2012). This study focused more on the quantitative method via the survey administered to Year 12 physics students, physics teachers and principals. At the same time, interviews with selected physics teachers and focus group discussions with selected students were conducted to provide background information (qualitative method) to support the survey data. The data collected were integrated to examine potential factors influencing physics achievement.

In examining the data, this study used five different data analyses which were selected based on the characteristics of the data. Quantitative data, for example, were examined using Confirmatory Factor Analysis (CFA), Rasch analysis, Structural Equation Modelling (SEM), and Hierarchical Linear Modelling (HLM). Furthermore, qualitative data collected in both interviews and FGD were analysed using thematic analysis which fits the characteristics of the data. However, even though data analyses were conducted separately, the findings were incorporated into a mixed analysis because the approaches were carried out to examine the same factors or issues with different ways of viewing them. In other words, different approaches were mixed integrally to examine the same factors influencing physics achievement.

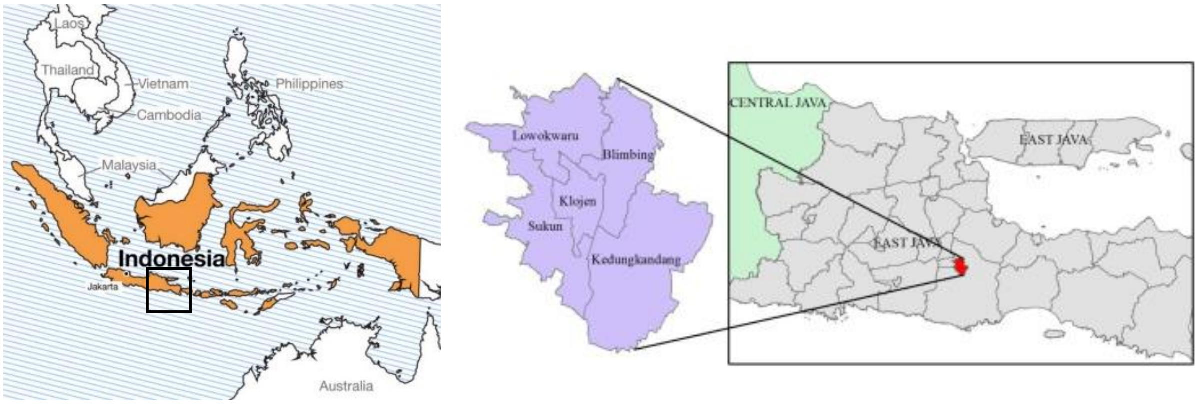
Sampling framework

The sampling framework plays a significant role in determining the quality of the research findings. Thus, this study decided to choose a sampling framework that could address the research questions more accurately. This study considered Kish (1987) in identifying strategies, particularly in the quantitative studies. The three strategies included (1) representativeness, how the sample represents the target population, (2) realism, how the project investigates the sample in the real situation, and (3) randomisation, how to ensure the investigation is a reliable study. These three strategies were considered during the process of developing the sampling framework and selecting participants.

Two different sampling frameworks were used in this study to select the participants. The selection of survey participants employed a statistical sample framework to ensure each Year 12 student in Malang, Indonesia, had a similar probability of being chosen as a participant in this study. In addition to the survey sampling method, interview respondents were selected based on school type using purposive random sampling. The techniques used in inviting participants to take part in the study are described below.

Senior high school in Malang, Indonesia

The study was conducted in Malang, the second-largest city in East Java province, Indonesia. Malang is one of three cities in greater Malang (see Figure 3.2). In terms of school quality, Malang can be viewed as an educational barometer in East Java province alongside Surabaya. The quality of schools in Malang is evident as students achieved the best average scores in East Java province in the 2019 national examination (Yohanes, 2019).



(a) (b)

Figure 3.2 (a) Indonesia Map (http://theconversation.com/indonesia-72878) (b) Malang City (Nugroho, Hasyim, & Usman, 2018)

Stratified random sampling

This study employed multistage stratified random sampling to ensure samples selected represent the population investigated in this study (Kish, 1987; Taylor et al., 1998). The sampling method stratified the population, including students, teachers, and principals, into four groups in terms of their school type, and each group member had the same chance of being selected randomly during sample selection (Cohen et al., 2018; Creswell & Creswell, 2018).

There were 53 senior high schools delivering physics in Malang. This represents a large number compared to other cities. This is because generally, on average, one public school is available in each sub-district in Indonesia. In addition, these schools can be classified into four types, including public and private schools and religion-based public and private schools (see Table 3.1).

Table 3.1 School selection

	School Type	**Available**	**Selected**
	Public	11	6
	Private	17	7
Religion-Based	Moslem public	2	2
	Moslem private	15	2
	Catholic private	4	1
	Christian private	4	1
	Total	53	19

Stratified random sampling used in this study was a three-stage design. At the first stage, the school type was used as primary characteristic to draw the samples. All schools were stratified and categorised into four groups, namely public and private schools, and religion-based public and private schools. School principals were invited to participate based on their school types. At the second stage, physics teachers working at the school where the principals had elected to join this study were selected to participate in this study. At the third stage, all students studying in the selected physics teachers' classes were invited to participate in this study. All participants selected to participate in this study received questionnaires.

The sample selection framework can be seen in Figure 3.3. Firstly, the population of senior high schools in Malang (53 schools) were stratified into four school groups. As a result, at the first stage, 36% of total available schools stratified based on school types (19 schools) were selected to participate. At the second stage, teachers working at the participating schools (20 physics teachers) were selected to participate. At the third stage, students learning in the selected teacher classes (473 students) were invited to participate.

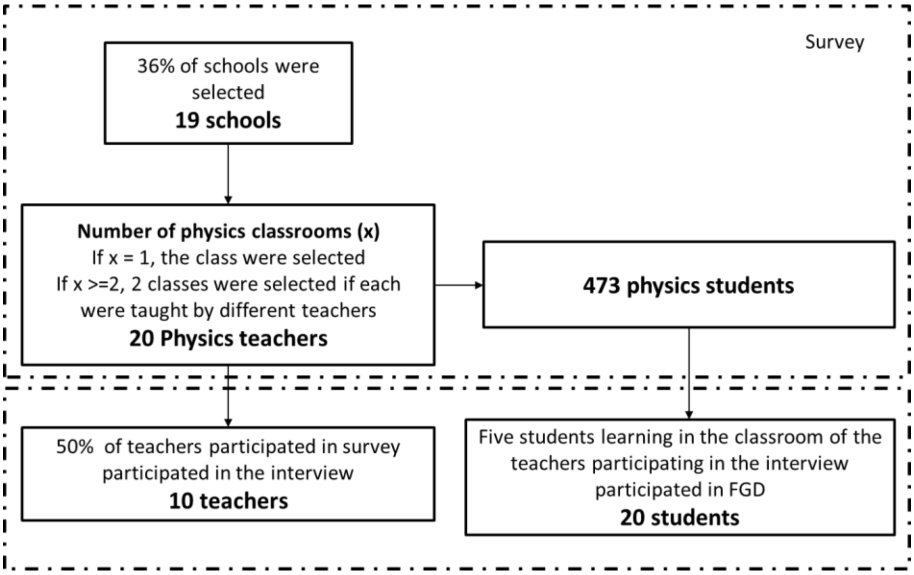


Figure 3.3 Sampling framework employed in this study

Convenience sampling

This study used a convenience sampling method to select teachers and students to participate in the interview. Those who participated in the survey were selected to participate in the interview and group discussion based on their school types. At least one teacher and a group of five students were selected from each school type. This study selected participants who were more easily contacted and showed high motivation to be included in interviews when the survey was conducted. In addition, school type was still considered for selecting participants. School type was considered during the sample selection to ensure that the interview could explore the views of all teachers and students from all school types.

The sampling framework for the interview process can be seen in Figure 3.3. A total of 50% of teachers participating in the survey were selected for interview. Furthermore, 20 students who were selected for FGD were students in the physics teachers' classes who participated in the interview. Five students were selected to participate in FGD from each school type. This selection allowed the study to triangulate and investigate further information from students regarding teacher views about physics classes. In other words, the interview findings could be used to check the survey data and to provide additional information regarding factors investigated in the questionnaires.

Ethics approval

Before the study was conducted, ethics approval was obtained from the Research Ethics Committee, The University of Adelaide, Australia, with approval number H-2017-224 (see Appendix F). Ethics approval ensures the study protects participants from potential risks such as discomfort and inconvenience considered a risk.

This study also received permission from the Ministry of Education and Culture of the Indonesian government (see Appendix F). This permission enabled researchers to undertake research in senior high schools in Malang, Indonesia.

Operationalisation and instruments

All principals, physics teachers, and students who participated in this study shared their views regarding physics education issues using survey and interview methods. To examine potential factors influencing physics achievement, this study used questionnaires for students, teachers and principals. The questionnaires were administered in the Indonesian language. Furthermore, interviews were conducted to obtain the views of students and physics teachers. The study selected interviewees from each of the selected samples using school type as the selection base.

This study undertook the survey using structured questions adapted from TALIS 2013, TIMMS 2015 and PISA 2015 questionnaires, due to their greater validity and reliability in international studies regarding students' achievement and influencing factors. The questionnaire included scales based on several adaptations with respect to the language of choice for relevance. The questionnaires administered were adapted to physics as a subject and to the real situation in Malang, Indonesia. The survey was used to investigate the factors influencing students' outcomes. Furthermore, semi-structured interviews and focus group discussion to investigate teachers’ and students’ views on particular topics such as homework, physics learning, and attitudes toward physics (see Appendix D and Appendix E) were conducted. The interviews contained detailed information regarding factors such as respondents' culture, habits, and other background information.

Student-level variables

As discussed in Chapters 1 and 2, this study focused on the effects of students' characteristics, students' attitudes toward physics, physics homework and additional physics tuition on students’ physics achievement. Student questionnaires collected data about these variables (see Table 3.2). In addition, the interview focused on students’ experiences and views regarding future education aspirations, physics homework, and attitudes toward physics to triangulate and provide additional information on the factors investigated in the survey. The guidance of the questionnaire and interview can be seen in Table 3.2 and Attachment 3, respectively.

This study investigated the effect of students' characteristics on physics achievement. The characteristics investigated in the questionnaires were identified through background information on relevant factors such as gender (Hong et al., 2013; Kamwendo, 2010; Khusaini & Darmawan, 2020; Parker, 2006; Stump et al., 2011), parents’ highest education level (Dunkin, 1978), age difference (Amro et al., 2015; Grissom, 2004; Hauck & Finch Jr, 1993; Nam, 2014), and future education aspirations (Oon & Subramaniam, 2013). In addition, subject preferences of students were investigated during FGD (Oon & Subramaniam, 2013; Woolnough, 1994) which could then be used for comparison with survey data.

Furthermore, both survey and FGD investigated how students' attitudes toward physics potentially influence physics achievement. The survey investigated whether students like physics, how they value this subject, and students' self-confidence in learning physics (Liou, 2017; Miyake et al., 2010; Woolnough, 1994). In addition, FGD explored background information about the degree of physics compared to other natural science subjects, the importance of physics in student life, and their elective subject on their national examination.

Other variables included in these student-level factors/variables are homework and additional physics tuition. Homework in this research study was examined to identify physics homework provided to enrich students' knowledge. The effect of physics homework was examined based on the frequency with which teachers set physics homework (Chang, Wall, Tare, Golonka, & Vatz, 2014; Cheema & Sheridan, 2015; Flunger et al., 2015; Keith, 1982; Khusaini & Darmawan, 2020; Núñez, Suárez, Cerezo, et al., 2015). In addition, this study also examined students' attendance and motivation to study with additional physics tuition or tutoring, and how this influenced students' achievement. This was done because the majority of Year 12 students in Indonesia receive additional tuition or tutoring to prepare for the national examination or university selection test (Oktavianti et al., 2018). Furthermore, FGD was carried out to investigate roles and types of physics homework assigned by teachers and their students' views. Students' views about their favourite homework types were also investigated in FGD.

School-level variables

School-level variables were examined using the teacher and principal questionnaires. The school variables were a combination of both teacher- and school-level variables as discussed in Chapter 2. This study proposed a two-level model where teacher-level variables were combined with school-level variables.

This study investigated five teacher-level factors or variables including teachers' characteristics, teachers' attitudes toward teaching physics, teachers’ collaboration, teaching challenges and teaching practice. Teachers’ characteristics were highest education level, major study in teacher educational background, class size and teaching certificate. Teachers’ collaboration was examined via professional learning collaborations conducted by teachers within and between schools. Collaboration was identified in terms of types and purposes to improve teaching quality and professional development. Teachers' attitudes toward physics classrooms were gathered by asking questions regarding what teachers thought about the delivery of physics and their views on students' activities. Teaching practice in the physics classroom was also examined to identify the effect of teaching strategies. In addition, teaching challenges were also identified to check how teachers deal with difficult situations. Challenges were examined from several aspects including students, parents, and principals’ views.

In addition to teacher-level factors or variables, this study also examined the effect of school-level factors or variables. These were school emphasis on academic success and school characteristics, including school types and location, experiences of principals, education level of principals, availability of both science laboratory and library, and school enrolment. School types here were identified as public schools, private schools, and religion-based public or private schools, chosen to accommodate school types already established in the Indonesian context. School leadership was investigated via educational background of principals and their experiences in running a school. School location was investigated and effects on the difference between school location and students' motivation to learn and facilities provided in each classroom. Another variable, school academic climate, was assessed at the school level. The school was evaluated regarding its policies encouraging teachers, parents, and students to be involved actively to do their best. Teachers' understanding of school policies, and how teachers implement them and work cooperatively, could inspire students' learning and enhance achievement. Parental involvement was also investigated to examine policy to maintain school--parent relations. Moreover, academic climate was also assessed regarding student motivation to learn and succeed in physics.

As previously mentioned, questionnaires used in this study were adapted from the TIMSS 2015, PISA 2015 and TALIS 2013 questionnaires. Several items were modified to fit the Indonesian context. The instrument developed used guidance detailed in Table 3.2.

Table 3.1 Instrument guidance to create questionnaire instruments

Level	**References**	**Questionnaire**
Student level	Student Characteristics	
	Gender difference (Cavallo, Rozman, and Potter, 2004; Dimitrov, 1999; Young& Fraser, 1994; Parker, 2006)	TIMSS (1A, 2, 9A, 9B, 10A)
	Students' socio-economic background (Dunkin, 1978)	PISA (ST 123)
	Students' attitude toward Physics (Miyake et al., 2010; Carvallo et al., 2004; Haussler& Hoffman, 2002; Labudde et al., 2000; Chang& Cheng, 2008; Singh, 2002; Stewart, 1998).	TIMSS 24, 26, 27
	Homework (Cooper& Valentine, 2001; Maltese, 2012; Corno& Xu, 2004; Cooper, 2001; Coutts, 2004).	TIMMS (28A, 28B, 29 A, 29B)
School level	Teacher Characteristics: Gender, education level, experiences (Aikaterini, Belias, & Athanasios, 2016; Antecol, Eren, & Ozbeklik, 2015; Cho, 2012; Darling-Hammond, 2000; de Zeeuw et al., 2014; Goldhaber & Brewer, 2000; Rockoff, 2004; Spilt, Koomen, & Jak, 2012)	TALIS (1, 4, 5, 6, 7, 12, 13, 15) TIMSS (6)
	Teacher attitude toward physics teaching and learning, ICT use, professional view (Bophy, 1986; McFarlene & Sakellariou, 2002; Park et al., 2009; Ross, 1992; Wan, 2011)	
	Teacher preparation & professional development (Darling-Hammond, 2000; H. C. Hill, Rowan, & Ball, 2005; Park et al., 2009; Sanders et al., 1997; Wan, 2011)	TIMSS (10, 12, 18, 19) TALIS (20, 30, 21, 31, 33, 19)
	School characteristics School type (Epple & Romano, 1998; Gamoran, 1996; Sander, 1999); School location (Ely & Teske, 2014; Gavidia-Payne et al., 2015; He & Giuliano, 2017; Saadia, 2012)	TIMSS (25, 26,27, 7, 8B, 15A, 15B, 16)
	School emphasis on academic success	TIMSS 16
	Parental involvement (homework), teacher appraisal, professional learning communities, (Cabus & Ariës, 2017; Coutts, 2004; De Neve & Devos, 2017; J. L. Epstein & Van Voorhis, 2001; Hampden-Thompson & Galindo, 2017; MacNeil, Prater, & Busch, 2009)	

Data collection

This mixed methods study employed a survey and interviews to collect quantitative and qualitative data. The study, which investigated a large sample, administered questionnaires because they offer standardised responses to a range of intended factors within questionnaire items (Cohen et al., 2018). All selected participants received questionnaires consisting of closed questions with a range of prescribed responses regarding the factors hypothesised as influencing physics achievement.

The survey in this study was cross-sectional. Data was collected at one point in time to examine current attitudes, opinions, views, and practice in Year 12 physics classrooms. This survey type offers several benefits, which are time saving with regard to data collection, by collecting data at one time which enables appropriate inferences relating to the population of interest (Creswell, 2012). However, this study could not provide information regarding change over time because that would require a longitudinal study (Creswell, 2012). This drawback will be considered during the discussion and interpretation of findings.

This study also employed standardised open-ended interviews. This interview type has the advantage of comparability and reducing interviewer bias (Cohen et al., 2018). The interviews were semi-structured questions to provide the opportunity to examine participants' views and to compare participants' views. Interviews, as an important data collection method, also have a role in identifying respondents' interpretation of their point of view regarding physics education and students' achievement and providing a greater understanding of context.

Interview data was used to triangulate survey data to obtain integral findings regarding the factors influencing physics achievement of Year 12 students in Malang, Indonesia. Interview protocols were designed to contain similar topics in students' and teachers' questionnaires. The topics investigated focused on the views or background information underlying response in the questionnaires.

Pilot study

A pilot study was conducted before the researchers collected the final data to ensure the instruments administered in this study were valid and reliable. The pilot study was undertaken in a single public school in Malang, Indonesia, to ensure consistency of the instruments used in measuring variables investigated. Furthermore, it was important to check instrument validity in terms of content because questionnaires were adapted from the TIMSS 2015, PISA 2015 and TALIS 2013 questionnaires, and also translated into Indonesian.

This study employed an internal consistency method using Cronbach's alpha coefficient to assess internal reliability of the student questionnaire. This method was employed because limited time was available in the pilot class. Thus, this internal consistency was preferred to test-retest reliability.

Cronbach's alpha coefficient plays an important role in ensuring the internal reliability of items administered before conducting construct validity to check that items are effectively working in measuring intended constructs (Field, 2018). The coefficient has a value range between 0 and 1 with a higher value indicating more reliable items in measuring research variables (Pallant, 2016). A cut-off value used in this study was 0.7 indicating the items are reliable in measuring variables, as proposed by Kline (1999), although Nunnally (1978) suggested the 0.5 value is enough for an early stage of a research project (Field, 2018). The 0.7 value ensured that questionnaire items and physics diagnostic items were reliable enough to measure students’ physics performance and the factors that influence Year 12 students’ physics achievement.

The study found that physics test items were sufficiently reliable, as indicated by Cronbach’s alpha coefficient with more than the cut-off value (0.7) (Kline, 1999). Students’ responses during the pilot project also showed that items needed several minor adaptations before data collection. The pilot study showed that physics diagnostic test items had a coefficient of 0.755, meaning that the items tested in this study exhibited good internal reliability to check students’ performance in physics. Furthermore, questionnaire items used in this study had a Cronbach’s alpha coefficient of 0.820. This coefficient is bigger than the cut-off value of 0.7. this means that questionnaire items were reliable and could be administered in this study.

In addition, discussions were conducted with two physics teachers, a principal, and physics education experts at a public university in Malang, Indonesia, to ensure content validity of the questionnaires. The discussions also addressed the language used, Indonesian, and its ability to measure intended factors. The pilot study found that questionnaires should be revised (i.e. several sentences) and should provide additional information to support questions that that apply to the Indonesian context. The revisions helped the respondent to understand the questions and answer appropriately.

Data analysis

Participants’ responses were subsequently analysed using both statistical and stochastical procedures for quantitative data analysis. This study estimated statistics based on the data in the questionnaires. In analysing the questionnaire data, we should consider the study aims to provide a stochastical model proposed by Fisher (1955) (Lindsey, 1996). In line with Fisher’s idea regarding the stochastical model, this study conducted several stochastical aspects including (1) the study investigated the factors supported by the previous theoretical framework and empirical information, (2) the study selected the participants by specifying the probability distribution of all observations, (3) the study estimated the unknown constants as parameters, (4) the study enriched the previous findings by the newly collected data without any contradicting purposes in any relevant way. Fisher's ideas for conducting statistical analysis are called stochastical procedures.

This stochastical model can be seen within Confirmatory Factor Analysis (CFA), Structural Equation Modelling (SEM), and Hierarchical Linear Modelling (HLM). These analyses examined the proposed model described in Chapter 2 using both statistical and stochastical procedures. Data analyses were conducted to examine the proposed model using previous studies as the base. These analysis methods aimed to enrich previous studies using data collected in Malang, Indonesia. Furthermore, statistical procedures examined the factors or variables in the model.

This study employed thematic analysis for interview data. To provide more detail from interviews, NVivo 12 was used as part of qualitative data analysis to manage and code interview data.

Scale validation

Before carrying out further data analyses, it was necessary to establish the reliability and validity of the research instruments. In this study, the instruments used were adapted from TALIS 2013, TIMMS 2015 and PISA 2015 questionnaires. Although it is implicit that adopted instruments had already been validated and reported by the publishers or authors, it was important to re-validate the instruments used to ensure their suitability for the Indonesian context, so that meaningful data interpretation and valid research findings could be drawn.

In the context of this study, the validation of instruments was achieved by establishing construct validity. A construct is a theoretical concept underlying the various indicators shown by respondents (Brown, 2015). The indicators can be measured using items in the student, teacher and principal questionnaire. An example of the construct is students' attitudes toward physics: to measure these attitudes, this study used 26 items to cover valuing of physics, liking of physics, and self-confidence in learning physics. The result of CFA provided evidence of the convergent and discriminant validity of students' attitudes/ theoretical construct (Brown, 2015). Convergent validity shows that indicators within the same factor measure a single construct, and discriminant validity indicates that theoretically distinct constructs have no inter-correlation.

Two analytical approaches validated the scales included in this study: Factor and Rasch analyses. The former approach was used to examine construct validity of scales and the latter to investigate properties of each item included in each of the scales. Thus, CFA was employed to examine underlying structure of the scales, examining their dimensionality measured by items included in the questionnaire. Once validity and dimensionality of the scales were confirmed, Rasch analysis verified whether the items fitted well with the Rasch model. When two or more subscales were identified during CFA analysis, a multidimensional scale approach was used in subsequent Rasch analysis. The use of both forms of measurement modelling can be considered as validation techniques or types of test validation that are complementary. Explanation of CFA and Rasch models are presented in the following sections in more detail.

Confirmatory Factor Analysis (CFA)

Since the 1960s, Confirmatory Factor Analysis (CFA) has been shown to advance the development of factor analysis. Factor analysis was initially developed and applied in psychology and then used in other disciplines (Spearitt, 1997). Spearman (1904) was the first psychologist who tested it and proposed the concept of factor analysis technique to simplify variables into a single function (Spearitt, 1997). He found that the single factor could reflect all mental activities into his mental activity theory. Spearman's work was tested and continually developed by other psychologists such as Thomson, Pearson, Thurstone and Caroll. In the 1960s, Karl Joreskog fully developed the first software program to calculate CFA (Schumacker & Lomax, 2016).

Since this study investigated various indicators in questionnaires that can be interpreted by a single factor based on previous studies or theories in the proposed models, CFA was carried out to simplify indicators found in the data collected in questionnaires. In analysing the data, CFA tested indicators in the proposed model based on theories or previous studies (Brown, 2015; Wang & Wang, 2012). Thus, CFA tested whether observed variables (indicators) in questionnaires indicated a good fit to define factors (Schumacker & Lomax, 2016).

Furthermore, this study used CFA to identify valid models selected by using two possible approaches: the strictly confirmatory approach and the alternative model approach. For student and principal scales, the alternative model approach was used to decide the final model where four alternative models were examined for their factor loadings and fit indices. In addition, for teacher scales, the final models of the teacher scales were examined their best model using the strictly confirmatory. The best models in this strictly model which was used in the subsequence analyses were decided based on the factor loadings.

Model evaluation

To recap, this study evaluated the best model using both the strictly confirmatory approach and alternative model approach and application is decided by the possible factors constructing the model. The strictly confirmatory approach was used when the models were constructed by only one possible factor based on previous studies. Therefore, this approach focuses exclusively on fit indices and factor loading to choose the best final model.

Alternatively, the alternative model approach was used when the factors were theoretically constructed by more than one alternative model. CFA evaluates the best model using alternative model comparisons using fit indices and factor loading values. When using this approach, this study chose one out of four alternative models.

The alternative model approach evaluated four alternative models to find the best fit model, including a single factor, orthogonal, correlated, and hierarchical model. The single factor model examined a factor reflecting the indicators in participant responses to questionnaires. The orthogonal model examined the possibility of more than one factor reflecting indicators, but where factors are uncorrelated. The correlated model checked the possibility of factors being correlated when describing indicators. The hierarchical model checked the possibility of a single factor reflecting other factors in a hierarchical structure. These models were proposed on the basis of previous studies or theories investigating physics achievement.

Fit indices and factor loadings

These proposed models were evaluated using several goodness-of-fit indices and factor loading to check the validity of the data collected in measuring intended factors. The evaluation used several goodness-of-fit indices to compare the sample data with the proposed model. The models were evaluated as to their fit on three fit indices, namely absolute fit index, fit adjusting to the model parsimony, and comparative fit. The best fit models evaluated in this CFA were used in subsequent analyses using quantitative data analysis methods.

The first index is χ^2, which is the classic goodness-of-fit index. This index measures the model fit to the absolute level. This index focuses on the degree to which the model estimated (**Σ**) differs from the model measured (**S)** without any account of other aspects. This fit index is looking for the model that has a bad fit with the estimated model. χ^2 is highly sensitive to the sample size, where the large sample used in the study is more likely to reject the model investigated (Wang & Wang, 2012). Instead of looking for the perfect fit or goodness-of-fit (small χ^2), this index desires a non-significant χ^2 for not rejecting the null hypothesis. Because of this sample size sensitivity, it is important to also employ other fit indices.

The second fit index is Root Mean Square of Error Approximation (RMSEA) as a parsimony fit index which shows how well the model fits a population. This index measures the error approximation of the hypothesised model to the population. The values of RMSEA are interpreted as a perfect fit (0), close fit (<0.05), fair fit (0.05-0.08), mediocre fit (0.08-0.09), and poor fit (0.10) (Wang & Wang, 2012). A cut-off value between 0.05 and 0.08 indicates that the model fits the population (Brown, 2015; Hair, Black, Babin, & Anderson, 2018; Wang & Wang, 2012).

The third indices are the Tucker Lewis Index (TLI) and Comparative Fit Index (CFI) as a part of incremental/relative/comparative fit indices which show the improvement of model fit by the specification of related multi-factor constructs. These indices compare the null model with the final model, where it is assumed that the null model has the worst fit compared to alternative models (Wang & Wang, 2012). In other words, this study compared fit indices of the final model with the nested baseline model in which covariances are fixed to zero (Brown, 2015). The indices from this category have found the best model to indicate the fit of the model to the data that have been introduced in the literature (Brown, 2015). The cut-off value used in this index is 0.90, and the recommended value is 0.95 (Brown, 2015; Hair et al., 2018; Wang & Wang, 2012).

Besides checking fit indices, it is also essential to check factor loadings. Factor loadings are the coefficients that link the items used in questionnaires with the factors intended to be measured during the study to show their relationship (Wang &Wang, 2012). There are two recommended cut-off values used to evaluate items indicating factors which are 0.3 and 0.4, but the most important consideration of acceptable indicators is that factor loadings of indicators are statistically significant (Wang & Wang, 2012). This study used 0.3 as the cut-off value of factor loadings accepted as a significant relationship between indicators (items measured in questionnaires) and factors measured in the study.

Rasch analysis

After construct validity of items measured in questionnaires was checked, the data were analysed using Rasch analysis. The main focus of Rasch analysis is how well the data fit the Rasch model. During Rasch analysis, several concepts are introduced, such as Logit scales, Wright map, and Differential Item Functioning (DIF). In addition, Rasch analysis offers benefits to deal with several science education measurement issues that cannot be solved by classical test theory (Boone, 2016; Boone & Scantlebury, 2006). The benefits and use of Rasch analysis are discussed in the next subsection.

Rasch analysis and its use

Rasch analysis was proposed by George Rasch (1960) and expanded by subsequent researchers to utilise a model for developing tests and to calculate participant responses (Adams, Wu, & Wilson, 2012; Bond & Fox, 2015; Boone & Scantlebury, 2006). Rasch is a probabilistic model which describes the probability of a person with a particular ability (θ) succeeding on a particularly difficult item (δ) by providing a table describing the expected response based on ability (θ) (Bond & Fox, 2015; Wu & Adams, 2007). The model predicts the probability of student performance in physics and can be completely determined by item difficulty (Wu & Adams, 2007). The greater a person's ability, the greater the probability of solving the items (Bond & Fox, 2015).

Rasch analysis as a part of IRT involves three basic ideas: the relativity principle, probability principle, and measurement principle (Keeves & Alagumalai, 1999). The relativity principle joins item difficulty with student ability. Therefore, users can compare and correlate students' ability with item difficulty. The second principle, probability, explains that a students' response in an educational context is influenced by several factors such as carelessness and guessing. The last principle, measurement, is when the interval scale is employed to make describing students' ability and item difficulty easier. Thus, the Rasch model can be seen in equation 3.1 below to accommodate these three basic ideas:

$$p = P(X = 1) = \frac{\exp(\theta - \delta)}{1 + \exp(\theta - \delta)} \tag{3.1}$$

Source: Wu and Adam (2007)

Where, p, P = the probability of the person to response

θ = person's ability

δ = item difficulty

Logit scale

One of the measurement issues in science education is the use of raw scores in calculating student performance (Boone, 2016; Boone & Scantlebury, 2006). The issue of raw score use can be seen when the researcher calculates students' achievement directly by totalling the number of correctly answered items on the test without any consideration on item difficulties.

Thus, the researcher who compares different abilities of the students can draw incomplete or incorrect conclusions (Boone, 2016).

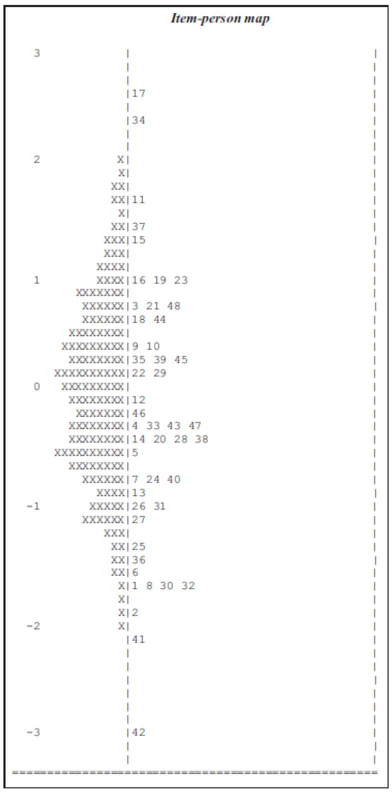
The use of raw scores in assessment results causes incorrect and/or incomplete information on student performance because these scores cannot offer invariant scales in measuring student performance to compare distance between students (interval measurement) on the ability scale (Boone, 2016; Boone & Scantlebury, 2006;Wu, Tam, & Jen, 2016). Raw scores cannot describe the nonlinear relationship at the lower and higher end of ability scales and can only order students on ability scales (ordinal measurement) (Boone & Scantlebury, 2006; Wu et al., 2016). As a result, students have different gaps in items with different difficulties for student performance in raw scores.

In addition, it is essential to provide information independent of item difficulty, which shows students' ability in a particular topic. To deal with weaknesses in the use of raw scores in measuring students' performance in physics, Rasch analysis using logit scales were used instead of raw scores. These scales can be calculated using raw scores or students' outcomes on the physics test. The logit scores have equal intervals or invariant intervals which can perform both interval and ordinal measurement (Boone, 2016). This logit scale feature allows the researcher to investigate and compare students' physics performance with various abilities that do not have raw scale drawbacks.

Wright map

The Rasch model can show the order of person abilities and item difficulties through a person-item map, as proposed and developed by Ben Wright (Bond & Fox, 2015; Boone, 2016). The map honours Wright's work and contribution to measurement. The map displays and locates each item difficulty and the person ability position easily using the same linear scale in a logit unit (Bond & Fox, 2015; Boone, 2016). This map is provided by the ConQuest 2 program used in this study.

The Wright map helps researchers evaluate and identify the order of person abilities and item difficulties vertically. Student abilities are indicated on the left-hand side and item difficulties on the opposite side of the map. Person abilities are shown by the symbol “X”. The higher the student’s position, the better students’ performance. Furthermore, the number shown on the map indicates item difficulties. The higher the item position, the more difficult the items on the map (see Figure 3.4).



Item-person map

```
 3            |                                  |
              |                                  |
              |                                  |
              |17                                |
              |                                  |
              |34                                |
              |                                  |
              |                                  |
 2           X|                                  |
             X|                                  |
            XX|                                  |
            XX|11                                |
             X|                                  |
            XX|37                                |
           XXX|15                                |
           XXX|                                  |
          XXXX|                                  |
 1        XXXX|16 19 23                          |
       XXXXXXX|                                  |
        XXXXXX|3 21 48                           |
        XXXXXX|18 44                             |
      XXXXXXXX|                                  |
     XXXXXXXXX|9 10                              |
      XXXXXXXX|35 39 45                          |
    XXXXXXXXXX|22 29                             |
 0   XXXXXXXXX|                                  |
      XXXXXXXX|12                                |
       XXXXXXX|46                                |
      XXXXXXXX|4 33 43 47                        |
      XXXXXXXX|14 20 28 38                       |
    XXXXXXXXXX|5                                 |
      XXXXXXXX|                                  |
        XXXXXX|7 24 40                           |
          XXXX|13                                |
-1       XXXXX|26 31                             |
        XXXXXX|27                                |
           XXX|                                  |
            XX|25                                |
            XX|36                                |
            XX|6                                 |
             X|1 8 30 32                         |
             X|                                  |
             X|2                                 |
-2           X|                                  |
              |41                                |
              |                                  |
              |                                  |
              |                                  |
              |                                  |
              |                                  |
-3            |42                                |
              |                                  |
              |                                  |
==================================================
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Figure 3.4 Wright map (Wu et al., 2016)

Weighted Likelihood Estimate (WLE) and W-score

This study employed a Weighted Likelihood Estimate (WLE) and W-score to estimate and provide a reference point for student ability and item difficulty. WLE scores were proposed by Warm (1989) to minimise item bias on the Maximum Likelihood Estimate (MLE). Furthermore, W-score were proposed by Marshal Dahl and Richard Dahl by transforming the item difficulty score and person ability estimate from Rasch analysis (Benson, Beaujean, Donohue, & Ward, 2018). W-score used in this study were simply a transformation of the WLE score using the equation 3.2 below:

$$W = 9.1024\,(WLE) + 500 \qquad (3.2)$$

where W is the W-score, WLE is the WLE score, and 500 is an arbitrary constant to reduce the probability of having a negative value. This constant value is mostly used in international studies such as PISA and TIMSS as a set value interpreting the ability of a child of 10 years 0 months or a beginning fifth grade student (Benson, Donohue & Ward, 2018). The W-score used in both studies determine a value of 500 on a scale describing the international average of students' achievement in OECD countries or participating countries with a Standard Deviation of 100 originally (Foy & Yin, 2015). The 500 value can also be stated as the average achievement of a beginning fifth-grade student or a 10-year-old child in determining the W-score (Benson et al., 2018).

As a reference point, this departs from raw scores which only show particular scores when the student answers the item test correctly. Both WLE and W-scores show the difference in scores based on item difficulties and person ability estimates. Students who successfully answer difficult items will achieve a higher WLE score compared to students who answer easier items. In terms of person ability, students who have high physics ability will achieve better compared to lower ability students as indicated by higher scores.

The subsequent analysis in this study, SEM, used the W score. The W score converts items and ability scores that come from fitting a Rasch model to the test or questionnaire data and were originally developed by Richard Woodcock and Marshal Dahl in 1971 (Benson et.al, 2018). In this study, W scores transformed WLE scores describing students' attitudes toward physics, and physics achievement test scores.

Fit statistics

The primary purpose of Rasch analysis shows item validity of test items and questionnaire items, to order people based on their ability, and to order items based on their difficulty (Bond & Fox, 2015). The benefits of Rasch analysis are only present when data examined in this study fit the Rasch model (Gómez, Arias, Verdugo, & Navas, 2012). The model describes the effect of a latent trait (person's ability) underlying responses or infers a person's ability based on measurement variables as stated in equation 3.1 above (Bond & Fox, 2015). Therefore, it is important to examine how well the data fit the model.

To check the extent to which data fit the Rasch model, the study carried out an assessment of the model fit to compare observed data with the Rasch model. If the items fit the Rasch model, the probability of Year 12 students succeeding in a physics test will be determined completely by students' ability (θ) and item difficulty (δ). If Rasch model assumptions are violated, there will be other factors influencing students' achievement in physics including guessing, item dependency, differential item functioning (DIF) and others (Wu & Adams, 2007).

During the model-fit assessment, fit statistics were used to compare the observed item score and expected item score based on the Rasch model. Wu et al. (2016) suggested applying residual-based fit statistics compared to Chi-square goodness-of-fit tests, and exploratory and nonparametric tests. Wu argued for the importance of this fit statistic because these two Chi-square ratios (infit and outfit), are usually provided by Rasch analysis programs, particularly ConQuest 2, used to conduct Rasch analysis in this study. These ratios are the mean square of Chi-square statistics divided by degrees of freedom (Bond & Fox, 2015).

Criteria for fit statistics have much flexibility. Wu et al. (2016) focus on the cut-off score of the mean-square value when deciding the fit model. To decide to what extent the item violated this, the study used 1 as the cut-off value where an item showed a misfit if it had a mean square less or more than 1 as the standard score. In addition, this study used fit t statistics as a fit index. Fit t statistics can be regarded as a transformation of the fit mean-square value with the value of variance and the mean of the fit mean-square statistic. The indication of t statistics fit the Rasch model if the t value is inside the -2.0 to 2.0 range. However, t statistics are sensitive to sample size, where fit items can be evaluated as a misfit to the Rasch model when the sample size becomes larger (Wu & Adams, 2007).

Other fit statistics frequently used are Unweighted MNSQ (outfit) and Weighted MNSQ (infit); however, this study used only infit MNSQ to assess the degree of fitness of items to the Rasch model because this score had been weighted using the variance of item response. Compared to unweighted MNSQ which is more sensitive to outliers, weighted MNSQ (infit) is more sensitive on items that have difficulties close to students' ability (Planinic, Boone, Susac, & Ivanjek, 2019). This means that the variance will be larger in well-targeted observations and smaller for off-target observations which provides more information about the targeted person or item compared to unfit MNSQ (Bond & Fox, 2015; M. Wu et al., 2016). When comparing an item with the model, the misfit item can be interpreted as less than 1 (over-fit) and more than 1 (underfit).

Differential Item Function (DIF)

One of several measurement issues is the problem of using a biased test item. To check for biased test items on instruments carried out in this study, Rasch analysis used Differential

Item Function (DIF). DIF indicates different responses in respondents with the same ability due to different experiences or other factors. The DIF that exists on test items may be caused by specific characteristics and knowledge of respondents as unique individuals (M. Wu et al., 2016). DIF cannot be detected based on the overall difference score between groups of participants, but students' response within each item is considered when detecting the existence of DIF.

In examining biased items in the instruments used in this study, the researcher tested each item in terms of gender difference. Each item was separated into male and female student responses and identified as possibly exhibiting DIF. The researcher concluded that DIF exists on test items when the estimated difference is more than 0.5, based on Scheuneman and Shubiyah (1998) (Bond & Fox, 2015). In terms of its effect on size, the magnitude of DIF can also be classified into three groups depending on size: small (difference < 0.426), intermediate (0.426 < difference <0.638) and large (difference > 0.638) (Chen et.al, 2013). As a result of DIF analysis, the items with possible DIF were removed from further analysis before computing students' mean scores (W. J. Boone & Scantlebury, 2006). By deleting these items, physics performance could be compared between students and avoid biased items.

Point Biserial Index

Another aspect considered was the concept of item discrimination. Rasch analysis also offers a concept provided by traditional statistics analyses to indicate item discrimination by a Point Biserial Index (r_{pb}) (Boone & Scantlebury, 2006). This index indicated how items used in this study discriminated against students' ability when the correct answer had an index higher than 0.2 (Ebel & Frisbie, 1991; McGahee & Ball, 2009; Penn, 2009).

Rating Scale Model (RSM)

Items used to investigate the views of students, teachers, and principals used a Likert scale in the questionnaires which provided more than two alternative responses for each item ranging from strongly disagree to strongly agree. Given the response of items is more than two, another Rasch measurement model was used.

To analyse these questionnaire items, the Rating Scale Model (RSM) was used. This decision is supported by several reasons such as the design of items similar to alternative responses, and size of the dataset (Oliveira, Fernandes, & Sisto, 2014). To check fit indices of items, this study used infit indices proposed by Linacre (2002) where values between 0.5 and 1.5 fit the model, but values between 1.5 and 2.0 show moderate misfit, and values above 2.0 are considered misfits and should be reviewed (Linacre, 2002; Oliveira et al., 2014).

In addition, Rasch analysis converted the raw score to unit logit. The interpretation of the unit is that the more positive the value, the greater disagreement of the respondent on the item, while the more negative the value, the greater the agreement on the item (Pey Tee & Subramaniam, 2018).

Structural Equation Modelling (SEM)

After conducting Rasch analysis, Structural Equation Modelling (SEM) was carried out to check item validity. SEM offers capabilities to analyse data in non-experimental studies (Ramlall, 2016). As a non-experimental study, a survey to collect responses via questionnaire was employed. The data obtained in this study were collected without the introduction of controls and treatment class. Therefore, it was important to choose a method to analyse the data correctly, and in this case, SEM was appropriate.

SEM does not refer to a single statistical procedure but combines two approaches to analysing variables within the measurement model (factor analysis) and structural model (path analysis) (Kline, 2016; Ramlall, 2016; Schumacker & Lomax, 2016; Wang & Wang, 2012). Thus, SEM allows flexibility and powerful analysis in both approaches, integrating the ability to validate measurement variables by constructing factors investigated and seeking a causal relationship among factors. SEM can also be defined as a powerful multivariate tool to analyse interrelationships among both latent and observed variables in representing, estimating, and testing specified theory/models compared with study findings (Ramlal, 2016). Furthermore, Schumacker and Lomax (2016) focused on the ability of SEM to depict the correlation among observed latent variables, and to hypothesise and test models of variables.

SEM analysis offers a broader investigation compared to other familiar statistical analysis methods such as Analysis of Variance (ANOVA), multiple regression, and principal factor analysis. SEM analysis thus offers the ability to estimate relationships among variables and allow variables to be independent, dependent, or both (Hoyle, 2012). This benefit encouraged the use of SEM in this study to provide a broader description of the population.

SEM analysis used the findings of CFA (Chapter 5) and investigated the causal relationship among factors found by CFA. This study examined several factors influencing physics achievement in student, teacher, and principal questionnaires.

Significance of SEM in this study

SEM is more powerful compared to regression analysis in investigating variables. Such modelling offers the ability to deal with indirect, multiple, and reverse relationships (Ramlal, 2016). SEM also provides information regarding measurement errors that cannot be shown on regression analysis with perfect analysis assumed (Ramlal, 2016).

Some benefits of SEM over regression analysis include (1) regression analysis does not control for measurement errors and can merely deal with one dependent variable at a time, (2) SEM controls measurement errors, (3) SEM can handle several dependent variables, (3) SEM allows several independent variables without causing multicollinearity problems.

Regression analysis assumes that observable proxies are exact measures of theoretical constructs, which may not be correct due to measurement errors. Alternatively, regression analysis deals only with observable variables but not latent constructs. Assumptions of regression analysis can easily be violated. However, under SEM, the normality distribution required by maximum likelihood can be achieved by a normal score transformation (Ramlal, 2016).

Thus, the method used to analyse data in this study is SEM, proposed by Bollen and Long (1993) as cited by Wang and Wang (2012). Five steps were used including (1) model formulation, (2) model identification, (3) model estimation, (4) model evaluation, (5) model modification.

The first step, model formulation, was conducted to specify models estimated in the study. The formulation step can be done easily using a path diagram proposed by Wright (1934) that allows the researcher to formulate the estimated model (Wang & Wang, 2012) (see Figure 3.2 below).

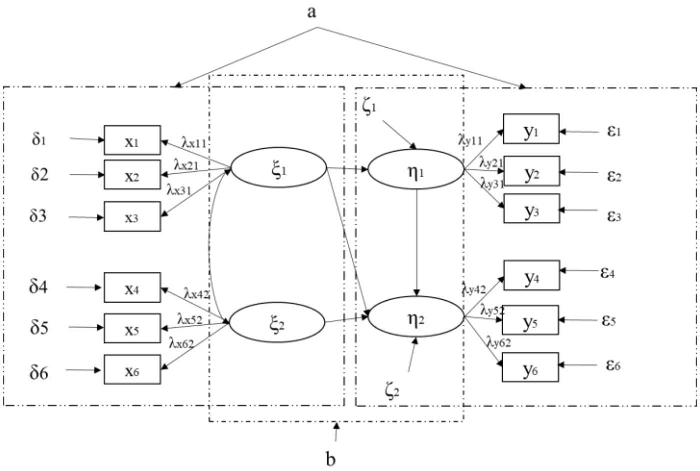


Figure 3.5 A hypothesis path diagram integrates measurement model (a) and structural model (b)

Figure 3.5 shows the variables clearly and easily using boxes (observed variables), circles or ovals (latent variables/ factors), and lines (direct relationships) (Wang & Wang, 2012). The lines are then divided into two types, one with a single arrow describing the direct effect of a variable on another variable indicated by the arrow, and one with bidirectional arrows indicating relationships or associations (Wang & Wang, 2012). As previously described, SEM incorporates a measurement model and a structural model.

SEM modes can be formulated into three basic equations. These equations describe the models included in SEM. The first equation describes the structural model indicated by an endogenous variable (η). This endogenous variable (η) is affected by the effects (**B**) given by exogenous variables (ξ), the effects (**Γ**) given by other endogenous variables (η), and residual regression terms (ζ). Second and third equations describe measurement models indicating exogenous indicators (x) and endogenous variables (y) affected by factor loadings (Λ) and measurement errors (ε and δ).

$$\eta = \boldsymbol{B}\eta + \boldsymbol{\Gamma}\xi + \zeta$$

$$Y = \Lambda_y \eta + \varepsilon$$

$$X = \Lambda_x \xi + \delta$$

The second step, model identification, is fundamental in specifying an SEM model because it concerns estimating unknown parameters from observed variables (Wang & Wang, 2012).

The third step, model estimation, minimises residual discrepancy between variance/covariance of the samples and the model (Wang & Wang, 2012). The perfect model fit is indicated by the zero value of the fitting function.

The fourth step, model evaluation, evaluates how well the hypothesised model fits the sample indicated by the variance and covariance matrix. Model evaluation employs fit indices to check the discrepancy between measured samples and the estimated model. This suggests model modification, whether essential or not.

The fifth step, model modification, modifies the estimated model based on fit indices in model evaluation. This step is encouraged to obtain a final model that closely fits the data statistically and has a meaningful interpretation with a theoretical basis (Wang & Wang, 2012).

Fit indices

SEM tests fit indices of models using three fit index groups as carried out in CFA. Those used in this study were absolute fit indices, parsimony fit index, and comparative fit index.

The first index χ^2 compares the model fit to the absolute level. This index calculates the discrepancy of the model estimated (**Σ**) with the model measured (**S**) without any account taken of other aspects. This fit index is looking for the model that has a bad fit with the estimated model. This index is a badness fit test where a non-significant Chi-square value (χ^2) or not rejecting the null hypothesis is desired, instead of looking for the perfect or good fit.

The second fit index is the Root Mean Square of Error Approximation (RMSEA) used to check error approximation of the hypothesised model to the population. This index provides more population information than the absolute index. A value between 0.05 and 0.08 is considered to indicate that the model fits the population (Brown, 2015; Hair et al., 2018; Wang & Wang, 2012).

Both the Tucker Lewis Index (TLI) and Comparative Fit Index (CFI) are a part of incremental/comparative fit indices which show the improvement of model fit by the specification of related multi-factors constructs. The cut-off value is 0.90, and the recommended value is 0.95 (Brown, 2015; Hair et al., 2018; Wang & Wang, 2012).

Hierarchical Linear Model (HLM)

The structure of the data in this study is naturally nested in nature, which is quite common in educational studies. The student data are nested within schools which provide students with contextual characteristics. Students' characteristics, attitudes, and behaviours are likely to be affected by their social contexts (school, teacher or class). The relationships between these variables are important due to their influence on physics achievement (Snijders & Bosker, 2011). Thus, it was necessary to analyse the data with an appropriate method to deal with the nested data in this study by using Hierarchical Linear Modelling (HLM) (Goldstein, 2011; Raudenbush & Bryk, 2002; Snijders & Bosker, 2011)

Furthermore, most educational studies focus on two significant variable types, estimating students' variables (compositional) and group variables (contextual) (Keeves & Sellin, 1997). These variable types indicate that students cannot be separated from their social context (contextual) as they form natural conditions when describing physics achievement or factors influencing that achievement (Goldstein, 2011; Hox, Moerbeek, & Van de Schoot, 2017; Ramlall, 2016). The social context then influences the probability of clustering students into a group randomly and identifying similar students' characteristics within different groups (Keeves & Sellin, 1997). This study enables variability between schools and explains different achievements among students within different schools. Thus, the HLM overcomes single-level statistical analysis barriers by addressing the complexity of relationships between variables, and appropriateness of measurement and analysis in nested data (Dixon & Cunningham, 2006).

Given this study collected the data from natural situations using a survey method, without any treatment given by the researchers, the statistical control must be assessed through regression and related procedures to check both compositional and contextual variables (Keeves & Sellin, 1997). Thus, these variable types also encourage a data analysis method that can deal with multilevel data. This method can be carried out by using Hierarchical Linear Modelling (also called multilevel modelling or multilevel regression modelling) to distinguish the position of the variable relative to students and prevent biased findings.

HLM analysis is one of the Ordinary Least Square (OLS) multiple regression extensions to be used under specific circumstances such as nested data within an identifiable context. HLM has several approaches to analysing such as nested data that cannot be carried out by regular OLS (Bickel, 2007). HLM recognises individual student data nested within broader contextual data (school data) (Cohen et al., 2018). Thus, HLM is carried out to prevent false inferences (ecological fallacy) about variable relationships and to understand the social context behind the sample studied (Cohen et al., 2018). In conclusion, Bickel (2007) argues that HLM analysis is required to be carried out due to three considerations: nested data, OLS is limited in determining violation and measurement error, and development of regression analysis.

Data aggregation

As previously described, HLM as statistical analysis offers the ability to analyse variables within different levels, investigate the interaction of factors within and between levels, and the effect of school-level on student performance in physics (contextual analysis). Since the factors of participants are generally described at both student and school level, it is assumed that variables have values at both levels. Thus, it is important to aggregate variables from student-level into school-level.

The idea of data aggregation involves constructing school-level variables (contextual) by combining information about student-level and where Year 12 physics students were learning in schools (compositional) (Darmawan & Keeves, 2009; Diez Roux, 2002; Woltman, Feldstain, MacKay, & Rocchi, 2012). The aggregation approach in creating new variables combines data from students, or lower-level data, by calculating the mean value to create higher-level data/criterion variables (Keeves & Sellin, 1997). In this study, all student variables (compositional) have been aggregated into school-level variables (contextual). The average values of school variables, including gender, socio-economic background, age, future education aspirations, parents' highest education, students' attitudes toward physics, physics homework, and additional learning outside school time have been calculated using the software program SPSS version 26. The scores calculated using SPSS 26 were aggregated variables (contextual). These values indicate the mean value of physics classes regarding variables at student level. Original variables indicating variability of participants at student-level is described as compositional, and their aggregated variables (i.e. mean value of original variables), are interpreted as contextual variables indicating character of the group formed by physics students within each school unit.

Aggregation data used in this study decomposes variables into different levels due to the ability to deal with group and individual effects on outcome variables rather than data disaggregation (Woltman et al., 2012). This data aggregation predicts the effect of aggregated variables at different levels due to intraclass correlation between variables. This allows the researcher to assess the best individual or group variable, to provide a meaningful presentation (Dixon & Cunningham, 2006).

Furthermore, it is important to consider compositional and contextual effects during the use of aggregated variables (Darmawan & Keeves, 2009; Diez Roux, 2002). The compositional effect is associated with aggregated student-level variables that vary as school-level units influence students' physics performance, and the contextual effect is associated with school-level variables where student-level variables are aggregated on individual physics achievement. The compositional effect can be seen from the difference in students' physics performance at different schools due to different student compositions. Furthermore, contextual effect can be seen in the differences in students' physics performance affected by the school where they study physics.

HLM application

As mentioned before, the main reason for undertaking HLM analysis in this study was to identify nested data in particular groups. These nested data can be seen through interclass correlation among variables between levels as indicated by the interclass correlation coefficient (ICC) in the null hypothesis model. This coefficient is a statistic that measures dependence among variables or the resemblance/dependency degree of variables at student level within the same school level (Bickel, 2007; Snijders & Bosker, 2012). Further analysis in HLM can be carried out if the coefficient is not zero or negative (Garson, 2013). In this study, the ICC describes the variability of factors influencing physics achievement available in the model.

The ICC can be calculated through the equation below.

$$\rho = \frac{\tau_{00}}{\sigma^2 + \tau_{00}}$$

This equation shows the proportion of variance (ρ) known as ICC that compares school-level variance (τ_{00}) with total variance in the unconditional model. This total variance is calculated as the sum of student-level variance (σ^2) and school-level variance (τ_{00}).

A further step in HLM analysis is to formulate the final model, consisting of a level-1 model (student-level model) and a level-2 model (school-level model). The final model examines the effect of potential variables on Year 12 physics achievement. The variables have been added into the null model as an exploratory variable. The study examined significant effects of variables on physics achievement.

This study also informed explained variance at both student- and school-level. This information indicates the opportunity to conduct further study on other potential variables and how the effect of potential variables on physics achievement is explained. Furthermore, HLM also examined the interaction effects of variables at both student- and school-level on physics achievement. These interaction effects show the importance of HLM analysis to be conducted in this study.

Interview data

This study used semi-structured interview and focus group discussion (FGD) as an additional method providing further information that is limited in statistical analysis (Horton, Macve, & Struyven, 2004; Longhurst, 2003; Vogt, Gardner, Haeffele, & Vogt, 2014). The semi-structured interview was employed to investigate teachers' views about teaching strategies, attitudes toward physics, the teaching certification program and teachers’ collaboration. Furthermore, FGD was conducted to determine the students' opinion about both the importance and difficulty level of physics and the role of homework to help students learn.

Both semi-structured interview and FGD were carried out due to the ability to adapt to the situation during the interview process, even though interview protocols had been determined. Both interview methods allow interviewees a degree of freedom to express their views, highlight significant factors, and respond in-depth to particular topics (Horton et al., 2004; Longhurst, 2003). Furthermore, the FGD was chosen to optimise the time and expense spent in capturing Year 12 students’ views regarding physics in Malang, Indonesia (Longhurst, 2003).

In addition, the protocols used during both interview and FGD (Focus Group Discussion) were prepared in discussion with supervisors, a physics teacher and physics education experts. These protocols guided the interview process, helped to ensure the interview data could address the research questions, and allowed the interview to flow smoothly (Leech, 2002). (The protocols can be seen in Attachment 5.)

All interviews were recorded by using a smartphone to ensure accuracy of reporting. All interviews records were transcribed in the Indonesian language, and essential points of view were coded and translated into English.

Thematic analysis was undertaken to identify students' and teachers' views regarding factors influencing physics achievement of Year 12 students in Malang, Indonesia. In order to simplify the coding and reporting process, this study used the software program NVivo 12.

Summary

This chapter described embedded mixed methods design used in this study to answer the research questions from Chapter 1 and to examine the proposed model in Chapter 2. In applying mixed methods design, this study employed a survey using three different questionnaires to collect the views of students, teachers, and principals. An additional collection data method used interview or Focus Group Discussion (FGD) embedded during the survey method to check the context of samples and provide additional information regarding the views of students and teachers on several potential factors.

This chapter presented two different sampling methods for conducting the survey and interviews. The first method is stratified random sampling to collect survey data. Nineteen school principals were selected to participate in this study based on their school types. Twenty physics teachers working in schools led by these principals were then selected. Students of selected teachers were invited to participate in the study. In addition, the second method utilised convenience sampling to conduct interviews and FGD. Eight interview participants were teachers invited to participate after the survey. Furthermore, 20 students taught by four teachers who participated in the interviews from four different school types were invited to participate in FGD.

This study employed five data analysis methods to answer the research questions. The construct validity of the questionnaire data was evaluated using Confirmatory Factor Analysis (CFA) to examine how well items constructed a single factor. The study then used Rasch analysis to examine item difficulty, person ability, and differential item functioning (DIF). Such analysis also converted raw scores provided by survey data and a physics diagnostic test into a W-score to was used in subsequent analysis. In addition, this study employed Structural Equation Modelling (SEM) to analyse causal relationships among factors within a single level. Furthermore, to deal with educational data nested into different levels, Hierarchical Linear Modelling (HLM) was carried out to integrate and investigate potential factors within different levels. Moreover, thematical analysis was employed to explore interview findings with physics teachers and FGD with groups of students.

Chapter 4 describes Confirmatory Factor Analysis (CFA). This chapter examines how well items used in student, teacher, and principal questionnaires constructed the intended factors to be measured in this study.

CHAPTER 4

CONFIRMATORY FACTOR ANALYSIS (CFA)

Introduction

Several potential factors influencing physics achievement investigated in this study cannot be directly measured, such as students' attitudes toward physics, teaching challenges, teaching practice, and so on. These multiple questions adapted from TIMSS 2015, PISA 2015, and TALIS 2013 studies were used to reflect unobserved or latent variables.

Even though these variables were adapted from international studies validated previously, it was important to check construct validity of scales to measure factors influencing Year 12 students' achievement. This process helps to confirm the structure of questionnaires (observed variables) when measuring latent variables.

Confirmatory Factor Analysis (CFA) examined construct validity of scales used in questionnaires. In the student questionnaire, the construct validity of students' attitudes toward physics (ATTITUDES), including Value (VAL), Self-confidence (SELFCON), and Like (LIKE), was examined. In the teacher questionnaire, the construct validity of four scales was examined including teaching practice in physics class (TEACHING), teachers' attitudes toward physics (ATTITUDE), teaching challenges (CHAL), and teachers' collaboration (COL). In the principal questionnaire, the construct validity of the scale measuring principals' views on School Emphasis Academic Success (SEAS) was validated.

The MPlus version 7 program developed by Muthén and Muthén (1998-2017) was used to analyse alternative CFA models. MPlus 7 is a user-friendly program with several strengths such as the ability to provide various outcomes from continuous to a combination of different variable types, the ability to handle incomplete data, non-normality, and complex survey data, and the ability to implement various advanced models (Multilevel models, SEM with Bayesian/exploratory analysis, etc.) (Wang & Wang, 2012).

In addition, this study employed two different approaches (i.e. confirmatory and alternative model) to check construct validity of the scales. For student and principal latent variables, the alternative model approach was used to examine the best model, while teacher latent variables were examined as their best models using the strictly confirmatory approach, because teacher latent variables were constructed by a strong background theory. Alternative models (i.e. one-factor) including orthogonal-factors, correlated and hierarchical models, were examined with respect to their fit indices and factor loadings to find the best model. All alternative models were hypothesised based on possible interactions between measurement variables in interpreting latent or potential factors, and possible interactions were models from the literature review in Chapter 2.

Student latent variables

Construct validity using CFA analysis was used to estimate students' attitudes toward physics (ATTITUDE) in the student questionnaire. This is because attitude scales are constructed by several indicators, and it is important to validate their constructs. Indicators are items used in the questionnaire to measure students' views about their attitudes toward physics. Other variables, however, such as physics diagnostic scores and demographic data do not need their construct validity checked because these variables were not constructed into different dimensions.

The items used in measuring students' attitudes toward physics were adapted from the 2015 context questionnaire in TIMSS 2015. This questionnaire measured students' attitudes using three factors including the extent to which students like physics, how students value physics as a subject at senior high school level, and students' self-confidence in learning physics. Therefore, the attitudes toward physics (ATTITUDE) scale was validated by three potential factors including students' thoughts about whether they like to learn physics as a subject at senior high schools (LIKE), students' values on physics (VAL), and students' self-confidence on learning physics (SELFCON).

This study labelled items investigating how students value physics in student questionnaires. Students' values on physics (VAL) were investigated using nine items including physics helped students in their daily life (VAL1), physics is needed to learn other school subjects (VAL2), physics is needed to learn at future study (VAL3), physics is needed students' future job (VAL4), future job preference involving physics (VAL5), physics needed to go ahead in the world (VAL6), learning physics provided more job opportunities (VAL7), the importance of physics achievement (VAL8), and parents' views on physics (VAL9).

Students' self-confidence in learning physics (SELFCON) was examined using eight items including doing well in physics (SELFCON1), physics as the easy subject (SELFCON2), physics as students' strengths (SELFCON3), learning quickly in physics topics (SELFCON4), feeling good at working out difficult physics problems (SELFCON5), the teacher told the students that they can do physics well (SELFCON6), physics as the easiest subject (SELFCON7), and physics never making me confused (SELFCON8). Four out of eight items were negatively worded, and before CFA was conducted, item codes were reversed to avoid a negative correlation between items and factors.

Nine items used to measure student liking of physics (LIKE) included enjoying learning physics (LIKE1), wishing to learn physics (LIKE2), boring to learn physics (LIKE3), learning many interesting things in physics (LIKE4), liking physics (LIKE5), looking forward to learning physics in school (LIKE6), physics showing students how the world works (LIKE7), liking to conduct physics experiments (LIKE8), and physics as the favourite subject (LIKE9). There were two items examining liking physics that were negative statements, LIKE2 and LIKE3. Therefore, both code items were reversed to prevent a negative correlation between items and factor.

CFA for examining construct validity of items was the alternative model. In applying this approach, the study proposed four alternative models that compared factor loadings and fit indices to decide the best models to describe the data.

One-factor model

This model proposes only one factor, ATTITUDE, which simplified the 26 observed variables or items measured on the student questionnaire. In terms of the relationships between the indicator and underlying factors, it can be seen in Table 4.1 that most measured variables have factor loadings more than the cut-off value (0.3) and only physics showing the students how the world works (LIKE7) was deleted from the model, because it exhibited factor loadings below the cut-off value (λ=.233). This deletion means that LIKE7 did not highly relate with other items to measure students' liking of physics.

In addition, it can be seen in Table 4.1 that all measured variables had factor loadings more than the cut-off value (0.3) after LIKE7 was deleted from the model. This this means that all items used in the student questionnaire, except LIKE7, can be used to measure students' attitudes toward physics (ATTITUDE). It can also be concluded that the lowest factor loading is .409 indicated by VAL2, and the highest factor loading is .756 on LIKE9.

Furthermore, this study checked the extent of model fit of the data using multiple fit indices. It can be seen in Table 4.2 that the model exhibits CFI (0.723), TLI (0.698), and RMSEA value (0.105). Furthermore, χ^2 (5467.278), degree of freedom (df) (300), and χ^2/df 18.22.

Three-orthogonal factor model

The second alternative model examined was the three-orthogonal factor model which proposes three underlying factors for students' attitudes toward physics. This model proposed that students' attitudes toward physics (ATTITUDE) were measured by three different factors, which are liking physics (LIKE), valuing physics (VALUE), and self-confidence in learning physics (SELFCONF). The model divided 26 measured variables into three groups, nine items in LIKE, nine items in VALUE, and eight items in SELFCON as variables divided in the TIMSS 2015 study. In this model, three factors are uncorrelated or separated in measuring students' attitude toward physics.

In general, the majority of measured variables exhibited factor loadings greater than the cut-off value (λ=0.3). It can be concluded that the majority of variables exhibited acceptable relationships with the three underlying factors. Furthermore, the three-orthogonal model also showed factor loadings below 0.3 for physics showing students how the world works (LIKE7, λ=.250), as found in the one-factor model. Therefore, this model also deleted LIKE7 from the three-orthogonal factor model, and it can be concluded that LIKE7 showed low correlation with other items to measure liking of physics.

The model also exhibited different factor loadings with the one-factor loading. These factor loading changes can be seen in Table 4.2. These factor loading changes also influenced goodness-of-fit indices of the model. Furthermore, this study checked the extent of the model fit of the data using multiple fit indices. It can be seen in Table 4.2 that the model exhibits CFI (0.752), TLI (0.729), and RMSEA value (0.099). These fit indices showed the model fit better with the data compared to other previous models. Furthermore, χ^2 (5467.27), degree of freedom (df) (300), and χ^2/df are the same with the one-factor model.

Three-correlated factor model

The third model examined was the three-correlated factor model which was developed based on the three-orthogonal model. The model correlates the three factors, VALUE, SELFCON, and LIKE, to identify Year 12 students' attitudes toward physics.

In terms of factor loadings, it can be seen in Table 4.1 that the correlation of these factors influenced factor loadings between measured variables and factors. The majority of measured variables exhibits factor loadings more than the cut-off value (0.3). As in the previous two alternative models, only physics showing students how the world works (LIKE7) exhibited factor loadings below the cut-off value (λ=.207). Therefore, LIKE7 was deleted from this model because this item was not highly correlated to measure students' liking of physics.

Furthermore, this study checked the extent of the model fit of the data using multiple fit indices. It can be seen in Table 4.2 that the model exhibits CFI (0.939), TLI (0.939), and RMSEA value (0.51). Furthermore, χ^2 (577.52), degree of freedom (df) (261), and χ^2/df decreased from the previous models.

Hierarchical-factor model

The last alternative model to validate the construct of the attitude scale in the student questionnaire was the hierarchical-factor model. This model proposed ATTITUDE as the higher level formed by three factors. ATTITUDE was proposed as the second-order factor of VALUE, SELFCON, and LIKE in a hierarchical structure. this means that students' attitudes toward physics (ATTITUDE) are reflected by the other three latent variables (VALUE, SELFCON, and LIKE).

This model exhibits accepted factor loadings for the majority of measured variables and revealed that only one variable, LIKE7, exhibited factor loading below the cut-off value

(0.3), which is 0.206. Therefore, LIKE7 was deleted in this model as likewise deleted in the other three alternative models.

In terms of fit indices, the hierarchical-factor model exhibited CFI (0.938) and TLI (0.929) more than the cut-off value (0.90). The model also exhibited good fit indices on RMSEA (0.51) and χ^2/df (2.230812). It can be concluded that the model exhibits a good fit for the data.

Final model of students' attitudes toward physics

This study examined both factor loadings and fit indices to decide on the final model to was used in subsequent analysis. Factor loading values showed how well observed variables indicated latent variables (Byrne, 2010). This factor loading examination is one of the main objectives in conducting CFA to check the strength of regression coefficients of factors to observed variables. In addition, fit indices were evaluated to compare the fit of alternative models. This comparison was conducted after the factor loading value comparison was carried out. Fit indices were used to check the best model fit from the data collected in the student questionnaire.

Factor-loading comparison of alternative models of students' attitudes toward physics

Factor loading values of student scales were examined and compared among alternative models to choose the best fit model. The comparison of factor loadings can be seen in Table 4.1. The higher value of factor loadings from the cut-off value (0.3), the stronger relationship between indicators and factors.

Table 4.1 Factor loadings of alternative factor models of students' attitudes

Item	Loading				
	1-factor	3-orthogonal factor	3-correlated factor	Hierarchical	
	ATTITUDE	VALUE			ATTITUD
VALUE					0.726
VAL1	0.451	0.422	0.433	0.433	
VAL2	0.409	0.445	0.436	0.437	
VAL3	0.594	0.753	0.696	0.696	
VAL4	0.632	0.790	0.742	0.742	
VAL5	0.717	0.769	0.791	0.792	
VAL6	0.478	0.568	0.582	0.581	
VAL7	0.506	0.709	0.686	0.687	
VAL8	0.676	0.752	0.781	0.781	
VAL9	0.489	0.599	0.607	0.607	
		SELFCON			
SELFCON					0.898
SELFCON1	0.587	0.471	0.584	0.584	
SELFCON2	0.462	0.620	0.519	0.515	
SELFCON3	0.701	0.748	0.798	0.779	
SELFCON4	0.557	0.696	0.696	0.623	
SELFCON5	0.656	0.673	0.712	0.703	
SELFCON6	0.510	0.537	0.575	0.568	
SELFCON7	0.456	0.643	0.493	0.489	
SELFCON8	0.538	0.694	0.556	0.557	
		LIKE			
LIKE					0.986
LIKE1	0.725	0.740	0.756	0.756	
LIKE2	0.504	0.522	0.511	0.521	
LIKE3	0.546	0.614	0.574	0.582	
LIKE4	0.514	0.569	0.518	0.515	
LIKE5	0.773	0.845	0.830	0.830	
LIKE6	0.581	0.577	0.577	0.575	
LIKE8	0.363	0.420	0.395	0.395	
LIKE9	0.756	0.765	0.795	0.794	

Note : 🟨 same as the nearest previous model ⬜ decreased from the nearest previous model

It can be seen in Table 4.1 that all factor loadings are more than the cut-off value (0.3) where items can be considered acceptable to interpret latent variables once LIKE7 was deleted, as discussed in the previous subsections. Therefore, all items investigated in student questionnaires, which are listed in Table 4.1, can be considered acceptable for use in the final model.

In the first comparison, the three-orthogonal factor model was compared with the one-factor model. The three-orthogonal factor model indicates that most variables increased their factor loadings except on two variables, VAL1 (decreased from .451 to .422) and SELFCON1 (decreased from .587 to .471). Although both VAL1 and SELFCON1 decreased their factor loadings, both values are still greater than the cut-off value and are therefore acceptable to measure factors. Thus, it can be concluded that the three-orthogonal factor model is considered a better comparison to the one-factor model.

In the second comparison, the three-correlated factor model was compared with the orthogonal model. There were three types of value change on factor loadings of this model. Firstly, 12 variables have lower factor loadings (VAL2, VAL3, VAL4, VAL7, SELFCON2, SELFCON7, SELFCON8, LIKE2, LIKE3, LIKE4, LIKE5, LIKE8). Secondly, 10 variables, which are VAL1, VAL5, VAL6, VAL8, VAL9, SELFCON1, SELFCON3, SELFCON5, SELFCON6, LIKE1 have higher factor loadings. Thirdly, only two variables indicated the same factor loadings with the three-orthogonal factor model. Even though several variables exhibited decreased factor loadings compared to the three-orthogonal factor model, these variables exhibited better factor loading compared to the one-factor model. Therefore, it can be concluded that the correlated model is better and can be selected as the final model for students' attitudes toward physics. Furthermore, the three-correlated factor model also exhibited better factor loadings on 10 variables compared to the three-orthogonal model. Therefore, it can be concluded that both models could be considered for the final model.

In the third comparison, the hierarchical model was compared to alternative models. The hierarchical model indicated three trends in factor loading changes as indicated in the second comparison. The first trend, 10 variables (VAL6, SELFCON2, SELFCON3, SELFCON4, SELFCON5, SELFCON6, SELFCON7, LIKE4, LIKE6, and LIKE9) decreased factor loadings. Eight variables (VAL1, VAL3, VAL5, VAL8, VAL9, LIKE1, LIKE5, LIKE8) showed the same factor loading as the three-correlated factor model, meaning that more variables have no changes from the three-correlated factor model. Furthermore, six factors (VAL2, VAL5, VAL7, SELFCON8, LIKE2, LIKE3) increased factor loadings. This hierarchical model also shows new factor loadings between VALUE and ATTITUDE, between SELFCON and ATTITUDE, and between LIKE and ATTITUDE .726, .898, and .986 respectively. As the loadings of these three factors were more than the cut-off value (0.3), the hierarchical model could also be considered as the final model, though a little different compared to the three-correlated factor model. Therefore, to select the final model, it is important to consider fit indices of alternative models.

Fit comparison of alternative models and final structure for students' attitudes toward physics

The final model to be used in this study was based on fit indices. As described in Chapter 3, the final model was selected based on values of the classic goodness-of-fit index (χ^2, χ^2/df), the parsimony fit index (RMSEA), and comparative fit indices (CFI and TLI). Fit index comparison can be seen in Table 4.2 below.

Table 4.2 Model fit comparison for attitude

No.	Model	χ^2	df	χ^2/df	CFI	TLI	RMSEA
1	One-factor model	5467.27	300	18.22	.723	.698	.105
2	Three-orthogonal factor model	5467.27	300	18.22	.752	.729	.099
3	Three-correlated factor model	577.52	261	2.21	.939	.930	.051
4	Hierarchical factor model	582.24	261	2.23	.938	.929	.051

Fit indices recorded in Table 4.2 show that the three-correlated factor model (CFI=.939 TLI=.930 RMSEA .051) and hierarchical factor model (CFI=.938 TLI=.929 RMSEA .051) differ in their goodness-of-fit indices. Both models have similar values of CFI and TLI with a difference of .001, which can be considered as very little difference. Therefore, the three-correlated model was decided as the best model describing factors underlying students' attitudes toward physics. This model was therefore used in subsequent analysis.

Three-correlated-factor model: final model

The final model was the three-correlated factor model. This was considered the best model based on factor loadings and fit indices comparison. The correlated model indicates that students' attitudes toward physics were described as liking physics (LIKE), valuing physics (VALUE), and self-confidence in learning physics (SELFCONF). Even though these three variables are different factors, they are correlated in describing students' attitudes toward physics.

In addition, the final model showed the majority of items used in the questionnaire can measure students' attitudes toward physics at the student level, as the majority of items showed exhibited loadings more than the cut-off value (0.3). The only exception was whether physics showed students how the world works (LIKE7) which exhibited factor loadings less than the cut-off value and was therefore deleted from the model. This means LIKE7 was not highly correlated with other items to measure students' liking of physics.

Teacher latent variable

The teacher scales examined four potential factors that may influence physics achievement, teachers' attitudes toward physics teaching and learning (ATT), challenges faced during physics delivery in the class (CHAL), collaboration among physics teachers (COL), and teaching practice in the class (TP).

These factors were chosen based on previous research findings and the real situation in Malang, Indonesia. The attitudes have been chosen to reflect issues that may be influenced by government policies such as certification, curriculum, national examination, etc. Furthermore, challenges during teaching and learning physics at Year 12 level (CHALL) were investigated to check the real differences in challenges faced among teachers who were teaching diverse backgrounds, particularly different school types. In addition, teachers' collaboration (COL) was studied because it is an activity done frequently by certified teachers in Indonesia. The last factor, teaching practice (TP), was studied to investigate current physics teaching practice.

The scales in the teacher questionnaire employed here were adapted from TIMMS 2015 and PISA 2015 studies. CFA analysis checked the construct validity of items on identifying teacher factors. In addition, because only 20 physics teachers participated in this study, it will not give good fit indices compared to student scales where the number of students was more than 400 (Shi, Lee, & Maydeu-Olivares, 2019; Wolf, Harrington, Clark, & Miller, 2013). Therefore, this model evaluation focused on factor loadings exhibited by the items which showed that loadings less than the cut-off value (0.3) were deleted from the model.

Attitudes toward physics teaching and learning (ATT)

Teacher's attitudes scales were examined using the one-factor model. This is different from students' attitudes constructed by different groups including liking physics, valuing physics, and self-confidence. Teachers' attitudes toward teaching and learning physics were constructed by a single factor, their confidence in teaching physics. Thus, in deciding the final model, it was examined using the strictly confirmatory approach where factor loading values of each item were checked. The model was considered to measure teachers' attitudes toward physics when all items indicated factor loading values more than the cut-off value (0.3).

These factor loadings can be seen in Table 4.3. It can be seen that all items exhibited factor loadings more than the cut-off value (0.3). The highest factor loading is indicated by ATT4 (adapting my teaching to engage student interests). The item that exhibited the second-biggest relationship was ATT5 (helping students appreciate the value of physics).

Table 4.3 Factor loadings of the one-factor model of teachers' attitudes toward physics teaching

First-order factor	Item	Loading
ATTITUDE	ATT1	.561
	ATT2	.568
	ATT3	.533
	ATT4	.879
	ATT5	.793
	ATT6	.647
	ATT7	.719
	ATT8	.741
	ATT9	.649
	ATT10	.437

In terms of model fit, as can be seen in Table 4.7, both CFI and TLI values are below the recommended value of 0.9. The value of RMSEA is 0.193, above the recommended value of 0.07. χ^2/df, indicated a good fit. Even though these fit indices did not exhibit a perfect fit, this model was used in subsequent analysis because the factor loadings are good enough to be used to measure teaching practice in teaching physics. Furthermore, the number of teachers participating in this study were 20; therefore, this model can be used (Shi, Lee, and Maydeu-Olivares, 2019; Wolf et al., 2013).

Challenges (CHAL)

Challenge scales in the physics classroom (CHAL) in this study focused on various challenges faced by teachers in their class. Challenges were examined using nine scales including number of students (CHAL1), physics topics covered in the class (CHAL2), teaching hours (CHAL3), time preparation (CHAL4), time needed to do students' assistance (CHAL5), parental pressure (CHAL6), keeping up with curriculum change (CHAL7), and administrative tasks (CHAL8).

For deciding the best model for teaching challenges in class, the scales were examined using two steps, as they were used in teachers' attitudes toward physics teaching (ATT). The first step was examining factor loadings of observed variables, and the second step was examining model fit.

To validate the item construct, factor loadings were examined as seen in Table 4.4. CHAL4 was deleted because the factor loading was 0.182, which is below the cut-off value (0.30) to be used as a valid item. After CHAL4 was deleted, other variables showed factor loadings more than the cut-off value.

Table 4.4 Factor loadings of the one-factor model of teachers' challenges in physics class

First-order factor	Item	Loading
CHAL	Chal1	.750
	Chal2	.683
	Chal3	.557
	Chal5	.421
	Chal6	.551
	Chal7	.657
	Chal8	.424

*chal4 deleted

At the second step, fit indices for this model were examined. These fit indices in Table 4.7 show that χ^2/df had a goodness-of-fit model. Furthermore, both CFI and TLI show a goodness-of-fit index, supported by RMSEA, which is below 0.05. Therefore, this model can be used for measuring teachers' challenges in physics class. Even though these fit indices did not exhibit a perfect fit model, this model was used in subsequent analysis because the factor loadings are good enough to be used to measure teaching practice in teaching physics. Furthermore, the number of teachers participating in this study were 20; therefore, this model can be used (Shi, Lee, and Maydeu-Olivares, 2019; Wolf et al., 2013).

Based on CFA, it can be concluded that there are seven types of challenges faced by physics teachers including number of students (CHAL1), physics topics covered in the class (CHAL2), teaching hours (CHAL3), time spent to do students' assistance (CHAL5), parental pressure (CHAL6), keeping up with curriculum change (CHAL7), and administrative tasks (CHAL8).

Collaboration (COL)

The collaboration scale for teachers was examined using the one-factor model because the items measure the same factor in different ways. Teachers' collaboration was measured through collaboration in discussing a particular physics topic (COL1), planning and preparing instructional materials (COL2), sharing teaching experiences (COL3), visiting another physics classroom (COL4), working together to try out new ideas (COL5), working together on implementing the curriculum (COL6), and working together with other teachers from other grades (COL7).

To decide the best model for teachers' collaboration, items were examined by using two steps including teachers' attitudes toward physics teaching (ATT) and teachers' challenges (CHAL). At the first step, factor loadings of observed variables were examined to check the correlation of indicators to factors. In addition, at the second step, fit indices were examined to check how well the model fits the data.

This study examined factor loading values exhibited by all items. The model showed that all items indicated bigger factor loading values than the cut-off value (0.3). Therefore, all items could be considered as good indicators of teachers' collaboration with other physics teachers.

Table 4.5 Factor loadings of the one-factor model of teachers' collaboration in physics class

First-order factor	**Item**	**Loading**
col	col1	.665
	col2	.765
	col3	.824
	col4	.607
	col5	.773
	col6	.721
	col7	.477

In terms of model fit (see Table 4.7), CFI is 0.9, and TLI is 0.85, which is close to the recommended values (0.9). Both values indicate that the model is quite good for modelling the data: RMSEA is 0.139, which is above the recommended value (below 0.07) and χ^2/df value indicated a good fit. Even though these fit indices did not exhibit a perfect fit model, this model was used in subsequent analysis because factor loadings are good enough to be used to measure teaching practice in teaching physics. Furthermore, the number of teachers participating in this study were 20; therefore, this model can be used (Shi et al., 2019; Wolf et al., 2013).

The final model shows that all construct validation was examined and all items could be used to measure teachers' collaboration. Such collaboration could be measured by using seven items, including collaboration, in discussing a particular physics topic (COL1), planning and preparing instructional materials (COL2), sharing teaching experiences (COL3), visiting another physics classroom (COL4), working together to try out new ideas (COL5), working together on implementing the curriculum (COL6), and working together with other teachers from other grades (COL7).

Teaching Practice (TP)

The teaching practice scale was examined using the one-factor model because scales measured only a single factor with various aspects. For measuring teaching practice, 13 items were measured including observing natural phenomena and describing what students' see (TP1), listening to me explain new science content (TP2), watching me demonstrate an experiment or investigation (TP3), designing or planning experiments or investigations (TP4), conducting experiments or experiments (TP5), presenting data from experiments or investigations (TP6), interpreting data from experiments or investigations (TP7), using evidence from experiments or investigations to support the conclusion (TP8), reading their textbooks or other resource material (TP9), having students memorise facts and principles (TP10), using scientific formulas and laws to solve routine problems (TP11), doing fieldwork outside of class (TP12), and taking a written test or quiz (TP13).

For deciding the best model for teaching practice in their class, the items were examined by employing two steps as they were used in teachers' attitudes toward physics teaching (ATT) including teachers' challenges (CHAL), and teachers' collaboration (COL). At the first step, factor loadings of the observed variables were examined to check the correlation of the indicators to the factors. In addition, at the second step, fit indices were examined to check how well the model fitted the data.

This study examined factor loading values exhibited by all items. The model showed that all items had bigger factor loading values than the cut-off value (0.3). Therefore, all items could be used to measure teaching practice in the physics class.

Table 4.6 One-factor model of teaching practice on physics teaching

First-order factor	Item	Loading
TP	tp2	.412
	tp3	.799
	tp4	.645
	tp5	.828
	tp6	.931
	tp7	.890
	tp8	.860
	tp9	.540
	tp10	.455
	tp12	.466
	tp13	.344

In terms of model fit (see Table 4.7), both CFI and TLI were below recommended values (0.9), which were 0.801 and 0.721, respectively. Both values indicated that the model did not fit well with the data. RMSEA is 0.243, which is above the recommended value (below 0.07). χ^2/df value indicated a good fit. Even though these fit indices did not exhibit a perfect fit model, this model was used in subsequent analysis because the factor loadings are good enough to be used to measure teaching practice in teaching physics. Furthermore, the number of teachers participating in this study were 20; therefore, this model can be used (Shi et al., 2019; Wolf et al., 2013).

The final model shows that all construct validation was examined. All items can be used to measure teaching practice. Teaching practice can be measured by using 11 items including listening to me explain new science content (TP2), watching me demonstrate an experiment or investigation (TP3), designing or planning experiments or investigations (TP4), conducting experiments or experiments (TP5), presenting data from experiments or investigations (TP6), interpreting data from experiments or investigations (TP7), using evidence from experiments or investigations to support the conclusion (TP8), reading their textbooks or other resource material (TP9), having students memorise facts and principles (TP10), doing fieldwork outside of class (TP12), and taking a written test or quiz (TP13).

Fit indices of teacher scale

Fit indices of teachers' latent variable models can be seen in Table 4.7 below. These models were explained in previous subsections.

Table 4.7 Fit indices of teacher scale

No.	Model	χ^2	df	χ^2/df	CFI	TLI	RMSEA
1	Teachers' attitudes	140.440	45	3.12	.726	.648	.193
2	Teaching challenges	42.959	21	2.04	1.00	1.058	.000
3	Teachers' collaboration	19.436	14	1.38	.900	.850	.139
4	Teaching practice	72.804	44	1.65	.778	.723	.184

School latent variable

The school scale investigated in this study is the level of school emphasis on academic success. This study adapted the context questionnaire from TIMSS 2015 constructed and based on the literature on academic optimism (Hoy, Tarter & Hoy, 2006; McGuigan & Hoy, 2006; Wu, Hoy, & Tarter, 2013). The indicators of school emphasis on academic success were measured by including three aspects: students' desire to achieve, parental support for students' physics achievement, and teachers' expectations for successful physics curriculum implementation (Hooper, Mullis, & Martin, 2013). This study investigated 13 items on principals' views regarding these three aspects including teachers' understanding of the school’s curricular goals (SEAS1), teachers’ degree of success in implementing the school’s curriculum (SEAS2), teachers’ expectations for students’ achievement (SEAS3), teachers working together to improve students’ achievement (SEAS4), teachers’ ability to inspire students (SEAS5), parental involvement in school activities (SEAS6), parental commitment to ensure that students are ready to learn (SEAS7), parental expectations for students’ achievement (SEAS8), parental support for students’ achievement (SEAS9), parental pressure for the school to maintain high academic standards (SEAS10), students’ desire to do well in school (SEAS11), students’ ability to reach academic goals (SEAS12), and students’ respect for classmates who excel in school (SEAS13).

At the initial step, this study examined factor loading values of four alternative models examined and compared to describe principals’ views regarding students’, teachers’, and parents’ roles in supporting academic success in schools. The first model is the one-factor model where only one factor, School Emphasis on Academic Success (SEAS), is reflected by the 13 items measured in the principal questionnaire. The second model, the three-orthogonal factor model, proposed three factors that are uncorrelated to describe principals’ views regarding students’ desire, parental support, and teacher expectations in emphasising academic success within schools. The third model proposed three factors as was proposed by the three-orthogonal model, but all three factors are correlated. The final model was the hierarchical model that proposed a second-level factor (ATTITUDES) reflected by the previous three factors (STUDENT, TEACHER, PARENTS).

The comparison of factor loading values can be seen in Table 4.8. All items in the one-factor model exhibit a value more than the cut-off value (0.3). Therefore, all items on the model can be considered to measure school emphasis in academic success (SEAS) as the potential factor influencing physics achievement. Furthermore, in the three-orthogonal factor model, one item exhibits a factor loading of more than 1 (1.020). Therefore, it can be concluded that the one-factor model is better than the three-orthogonal model. Furthermore, factor loadings of the three-correlated model were examined. All items exhibited more than the cut-off value (0.3) which indicates that items could be used to examine factors. However, when correlation values between factors were checked, the correlation between teacher and students was more than 1 (1.024). Therefore, in terms of the correlation value, the one-factor model is better than the three-correlated model. The last alternative model was examined for its factor loadings. All items had factor loadings more than cut-off values, meaning that all items could be considered to measure the factor well. However, factor loading STUDENTS with SEAS was more than 1, meaning that in terms of factor loading, the one-factor model is the best compared to alternative models.

Table 4.8 Comparison of factor loading values of items

			Loadings			
Item	One-factor	three-orthogonal factor	three-correlated factor		Hierarchical	
Teacher				Parent with		SEAS by
				0.819		0.93
Seas1	0.463	0.681	0.515		0.515	
Seas2	0.672	0.677	0.681		0.681	
Seas3	0.757	0.694	0.764		0.764	
Seas4	0.667	0.443	0.643		0.643	
Seas5	0.724	0.895	0.784		0.784	
Parent				Student with		0.88
				0.971		
Seas6	0.762	0.724	0.816		0.816	
Seas7	0.750	0.652	0.775		0.775	
Seas8	0.810	1.020	0.875		0.875	
Seas9	0.623	0.553	0.628		0.628	
Seas10	0.509	0.603	0.490		0.490	
Student				Teacher with		1.10
				1.024		
Seas11	0.718	0.705	0.715		0.715	
Seas12	0.843	0.860	0.822		0.822	
Seas13	0.929	0.882	0.910		0.910	

At the second step, fit indices of alternative models were examined and compared. The comparison can be seen in Table 4.9. It can be concluded that alternative models are quite similar in terms of their fit indices. The highest RMSEA is exhibited by the three-orthogonal model, while other models exhibit RMSEA 0.256. In terms of RMSEA value, the three alternative models can be seen better than the three-orthogonal model because the value is smaller. Furthermore, in terms of CFI and TLI, the three-correlated and hierarchical factor models are considered better than others, but the one-factor model has CFI and TLI values close to two model values. In addition, χ^2/df is the same on all models. Even though these indices did not exhibit a perfect fit model, this model was used in subsequent analysis because factor loadings were good enough to be used to measure teaching practice in physics. Furthermore, only 19 principals participated in this study; therefore, this model can be used in further analysis (Shi et al., 2019; Wolf et al., 2013).

Table 4.9 Comparison of fit index values of alternative models

Model	RMSEA	CFI	TLI	χ^2	df	χ^2/df
One-factor	0.256	0.615	0.538	288.55	78	3.69936
3-orthogonal factor	0.315	0.417	0.301	288.55	78	3.69936
3-correlated factor	0.255	0.635	0.541	288.55	78	3.69936
Hierarchical	0.255	0.635	0.541	288.55	78	3.69936

The alternative model comaprison can be seen in Table 4.9. Based on the factor loadings comparison and Fit indices. The fit indices are comparable for one-factor, three-factor correlated and hierarchical linear models. The last two models were slightly better. However, based on parsimony, it can be concluded that the one-factor model is the best model for describing principals’ views in School Emphasis on Academic Succees (SEAS). As factor loadings on the 13 measured variables are more than cut-off values, and fit indices are close to the three- correlated factor model and hierarchical linear model. Furtheremore, it can also be concluded that fit indices are not good enough because the sample size for principals is 19.

Construct reliability of the scales

After the items were evaluated by looking at alternative models to decide the best model, another step is examining construct reliability. Construct reliability can be used to measure reliability and internal consistency and to what extent a construct or latent variable underlies measured variables (observed indicators) (Hair et al., 2017). This should be calculated to provide a dependable estimate of scale reliability which cannot be provided by Cronbach's alpha coefficient as a traditional reliability test (Wang & Wang, 2012).

Construct reliability can be computed from the squared sum of standardised factor loading (λ_i) for each factor (constructs) and the sum of error variance for each factor (s.e_i) (Hair et al., 2017). The formula to compute reliability can be seen below:

$$CR = \frac{(\sum_{i=1}^{n} L_i)^2}{\sum_{i=1}^{n} {L_i}^2 + \sum_{i=1}^{n} e_i}$$

where,

CR : Construct Reliability

L_i : factor loadings

Table 4.10 Construct Validity (CR) of factors

Variables	CR
VALUE	0.85
SELFCON	0.83
LIKE	0.83
ATTITUDES	0.97
CHAL	0.90
TP	0.97
COLLABORATION	0.96
SEAS	0.98

The calculation for construct reliability of factors can be seen in Table 4.10 above. The rule of thumb for this construct reliability to be accepted is a value between 0.6 and 0.7, and reliability can be considered good when it is more than 0.7 (Hair et al., 2017). Construct reliability (CR) of all factors can be considered acceptable because all values are more than the cut-off value (0.7). Therefore, the final models for examining construct validity can be used in subsequent analysis.

Summary

In this chapter the instruments used to investigate factors influencing physics achievement of Year 12 students in Malang, Indonesia have been validated using Confirmatory Factor Analysis (CFA). The scales validated were students' attitudes toward physics (ATTITUDE) for the student questionnaire, teachers' attitudes toward physics (ATT), teaching challenges (CHAL), teachers' collaboration (COL), and teaching practice (TP) for the teacher questionnaire, and the school emphasis on academic success (SEAS) for the principal questionnaire.

Students' attitudes toward physics scales have been validated using four alternative models (i.e. one-factor, three-factor orthogonal, three-correlated factor, and hierarchical linear model). It was concluded that the best of those attitude scales was the three-correlated factor model that proposed students' attitudes (ATTITUDES) be divided into three correlated factors including valuing of physics (VALUE), Self-confidence in learning physics (SELFCON), and liking of physics (LIKE). This was chosen as the best model based on factor loadings and fit indices exhibited. Factor loadings were quite similar, although there were some differences. However, in terms of fit indices, it can be concluded that the three-correlated factor model was the best model for describing student data.

Teacher scales were evaluated for the best model by using factor loadings. Fit indices can be considered for evaluating the model; however, because the sample size participating in this study is only 20 teachers, this study focused on factor loadings. Items were considered for this study if they exhibited factor loadings more than the cut-off value (0.3).

For the school scale, four alternative models were examined to check the best model. It was concluded that the one-factor model was the best model for the school scale compared to alternative models. This one-factor model indicated that all items used in the teacher questionnaire can be used to measured school emphasis on academic success as a single factor, even though the items investigated the emphasis on academic success from three different perspectives (student, teacher, principal).

Construct Reliability (CR) values were calculated in this study to measure reliability of scales. The results showed that whole factors exhibited reliability of more than 0.7 as the cut-off value. It can be concluded that all constructs had good reliability for constructing measured variables for factors influencing physics achievement of Year 12 students in Malang, Indonesia.

The findings in this chapter are evaluated further in Chapter 5 which reports on Rasch analysis. While this chapter examined construct validity and reliability of different scales, Rasch analysis pays more attention to item level analysis.

CHAPTER 5

RASCH ANALYSIS

Introduction

Rasch analysis aimed to check whether results of Confirmatory Factor Analysis (CFA) in the previous chapter fit the Rasch model discussed in this chapter. If the data fit, the probability of students' physics achievement can be predicted based on respondents' views and other features provided by the Rasch Measurement Model (Masters & Keeves, 1999; Thorndike & Thorndike-Christ, 2013).

Rasch analysis was conducted to provide additional information on items that their construct validity was checked using CFA to confirm the structure and relationship between items measured in the questionnaires (observed variables) and their underlying latent variables (factors). In addition to CFA, Rasch analysis was carried out to examine each item's validity by comparing the spacing and order of item difficulty in actual models with theoretical models based on those confirmed in CFA (Boone, Staver, & Yale, 2014). Therefore, by using the results of both Rasch and CFA, the study could estimate factors and their relationship to physics achievement accurately. These estimates were used in subsequent analysis using Structural Equation Modelling (SEM) and Hierarchical Linear Modelling (HLM).

Rasch analysis in this study provided several estimates regarding model fit, item reliability, Point Biserial (P_{bt}), Different Item function (DIF), and the Wright map. This chapter discusses model fit by using weighted mean square (INFIT MNSQ) values to check how well the data fit the Rasch model. Item reliability was also provided to ensure consistency in measuring intended variables. In addition, the Wright map was provided to make interpreting results easier by comparing and connecting students' ability on the left-hand side with item difficulties on the right-hand side. Furthermore, DIF analysis was carried out and is reported in this chapter to check participant's response based on their gender, to ensure there was no gender bias on items. Moreover, Point Biserial (P_{bt}) was carried out to identify how well the item discriminated students' ability.

Rasch measurement model and fit indices

Before we can apply the benefits of Rasch analysis, it is important to check how well the data in this study fit the Rasch model (Gómez et al., 2012). Rasch measurement can estimate the probability of students succeeding in the physics test based on their ability and item difficulty and the probability of responses to the student questionnaire, teacher questionnaire, and principal questionnaire (Bond & Fox, 2015; Wu & Adams, 2007). To examine the extent to which items fit the Rasch model, Infit MNSQ values were used. (Further discussion regarding the Infit MNSQ decision regarding the Rasch model appears in Chapter 3.)

To examine Infit MNSQ values, this study referred to the acceptable range suggested by Bond and Fox (2015). Items fit the Rasch model when the Infit MNSQ value fall inside the acceptable range and can be retained and used in subsequent analysis. However, if the Infit MNSQ values of the item fall outside the acceptable range, the item will be deleted and Rasch analysis will be examined further. The acceptable range was decided based on the items/ scales examined (see Table 5.1).

Table 5.1 Infit MNSQ range based on items/ scales

Type of test	**Range**
Multiple choice test (high stake)	0.8-1.2
Rating scale (Likert/Survey)	0.6-1.4

Student performance on physics achievement

Items used to measure the level of students’ achievement were adapted from the 2014 national examination test conducted by the Ministry of Education and Culture. The items included several physics topics at senior high school level. Twenty items were used to check students’ achievement in physics.

The number of students who participated in this study was 473. From these participants, several items have missing values (see Table 5.4). Missing values here can be interpreted as ‘not attempted’ items when there was no indication of a students’ answer on particular items (Jacob et al., 2014).

Items checked students’ performance on several topics detailed in Table 5.2. As described before, these items were adapted from the 2014 national examination, therefore the number of the items were not changed by the researchers. Even though items were divided into seven topics delivered at senior high school level, they were assumed to measure a single dimension which is students’ performance in physics. Furthermore, the majority used within each topic are less than three items and thus cannot be consolidated into a multidimensional model. Therefore, the diagnostic test was examined as a unidimensional model in Rasch analysis.

Table 5.2 Items tested in physics test

No.	Topic	Item
1	Measurement	1, 2
2	Dynamics	5, 6, 7, 8, 9, 10, 11, 12, 13
3	Kinematics	3, 4
4	Fluid	14, 15
5	Temperature and Heat	16, 17
6	Thermodynamics	18, 19
7	Wave	20

Item fit analysis for physics diagnostic test

Items used in the physics diagnostic test were analysed using a dichotomous model. This model was chosen because the physics test only provided one correct answer and other choices are incorrect. Results of the dichotomous model can be seen in Table 5.3 The table shows the Logit scale indicating item difficulties and their respective standard error. Missing values are also shown in this table to indicate participants' responses. It can be seen from the table that all items fit the Rasch model where Infit MNSQ values are within the acceptable range (0.8 – 1.2) (Bond & Fox, 2015).

Table 5.3 Fit statistics, missing values, and discrimination

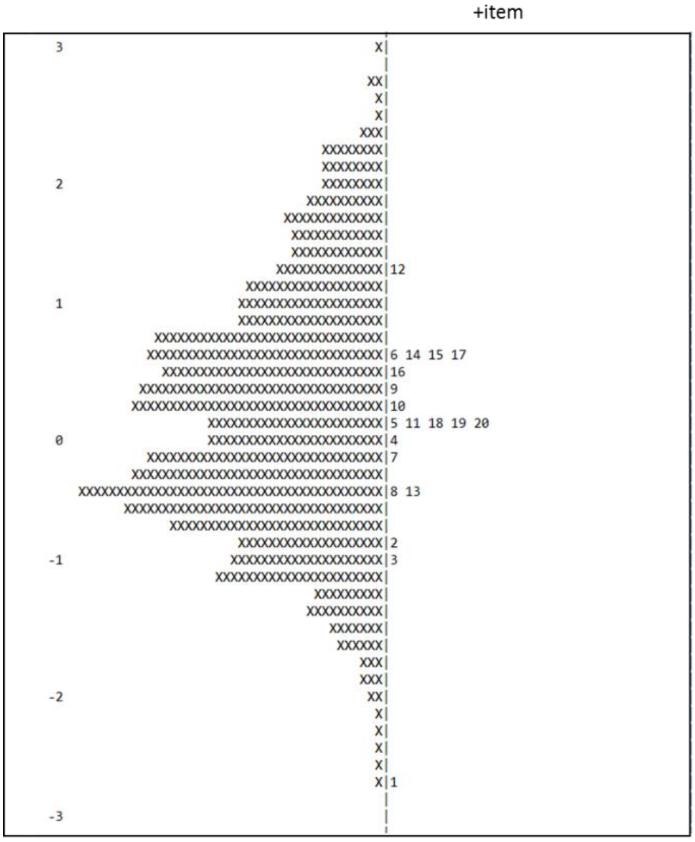
Variables item	**Estimate**	**Standard Error**	**INFIT**		**Missing Values**	**Pt Bis**
			MNSQ	T		
ITEM01	-2.703	0.088	1.02	0.2	0	0.31
ITEM02	-0.815	0.074	1.14	2.9	2	0.24
ITEM03	-0.952	0.075	0.92	-1.7	0	0.51
ITEM04	0.018	0.072	1	0	2	0.47
ITEM05	0.131	0.072	1.03	0.9	2	0.4
ITEM06	0.649	0.072	1.02	0.6	3	0.38
ITEM07	-0.146	0.072	1.01	0.2	2	0.48
ITEM08	-0.462	0.072	1	0.1	2	0.49
ITEM09	0.356	0.072	0.92	-2.1	3	0.53
ITEM10	0.223	0.072	1.03	0.7	2	0.45
ITEM11	0.162	0.072	0.89	-3.1	0	0.58
ITEM12	1.3	0.075	1.02	0.4	1	0.36
ITEM13	-0.366	0.072	1.04	1	0	0.42
ITEM14	0.585	0.072	0.97	-0.7	2	0.49
ITEM15	0.649	0.072	1.05	1.3	1	0.39
ITEM16	0.449	0.072	1.07	1.9	4	0.39
ITEM17	0.648	0.072	0.87	-3.3	5	0.55
ITEM18	0.15	0.072	1.01	0.2	2	0.48
ITEM19	0.068	0.072	0.97	-0.7	3	0.49
ITEM20	0.058*	0.319	0.91	-2.6	2	0.54

*Indicates that a parameter estimate is constrained

It can be seen in Table 5.3 that all diagnostic test items can be considered as good test items, with Infit MNSQ values within the acceptable range (0.8–1.2). This means that test items fit the Rasch model, and all items can be used to analyse Year 12 students' physics achievement if the items met further Rasch analysis.

Wright map on students' physics achievement

To provide a simpler description of item difficulties and student abilities, this study provides a Wright map. Figure 5.1 shows that the Wright map details item difficulties and person abilities of Year 12 students in Malang, Indonesia. The right-hand side is a hierarchical ordering of item difficulty in the physics diagnostic test. These are indicated with their relative position toward 0-logit unit, which is set at the average item difficulty. The difficult items are located above the base point, and the easy items are located lower than the base point. Furthermore, the number of students who succeeded on particular items appears on the left-hand side of the map. Students with higher abilities are positioned higher towards the 0-logit unit, and students with lower abilities are located under the base point.



Each 'X' represents 0.8 cases

Figure 5.1 Wright map describing item difficulty and students' abilities

Based on the Wright map in the above graph, it can be concluded that Dynamics, Kinematics, Fluid, Thermodynamics, Wave, and Temperature and Heat are difficult topics for students. The most difficult item is ITEM12 (Dynamics), with more than 1 on the logit scale (1.3). Several items including ITEM06 (Dynamics), ITEM14, ITEM15 (Fluid), and ITEM17 (Temperature and Heat) exhibited similar difficulty and are the second most difficult items. Furthermore, both Temperature and Heat (ITEM16) and Dynamics (ITEM09, ITEM10) are considered difficult for students. In addition, Dynamics (ITEM05), Thermodynamics (ITEM18, ITEM19), and Wave (ITEM20) can be considered relatively difficult, but relatively close to the base point. Another item that is very close to zero is ITEM04 (Kinematics). In addition, the study found that the majority of the students could not handle abstract topics such as Thermodynamics, Wave, Temperature and Heat, and Fluid. However, both Dynamics and Kinematics are considered as both difficult and easy items.

However, several items including Kinematics, Dynamics, and Measurement can be considered as easy items. This is an interesting finding where some items were considered easy for Dynamics and Kinematics, while others were considered more difficult. It can be seen in the Wright map that the easiest item is ITEM1 (-2.73) (Measurement). Furthermore, both ITEM3 (-0.952) and ITEM2 (-0.815) are relatively close to each other, and it can also be concluded that ITEM3 (Kinematics) and ITEM2 (Measurement) can be considered easy items for students. Other topics considered easy for students are Dynamics (ITEM8, ITEM13, ITEM7) and Kinematics (ITEM4).

Point biserial index (r_{pb})

Point biserial index (r_{pb}) was used for examining how well the items discriminate students' ability in physics. Items could be retained if they exhibited an index more than the cut-off value. The category used in the point biserial index is based on Ebel and Fresbie (1991). Items can be used to indicate student performance if the index is more than 0.2.

Table 5.4 Point biserial index

No.	**r_{pb}**	**Criteria**
1	Below 0.2	Poor discrimination, poor items (to be rejected/ improved by revision)
2	0.2 – 0.29	Mediocre discrimination, usually needing and being subject to improvement
3	0.3 – 0.39	Reasonably good but possibly subject to improvement
4	0.40 and up	Very good items

The point biserial index of the items indicated they can be used to discriminate students' ability in physics. Thus, in Table 5.4, it can be seen that all test items have at least mediocre discrimination based on their Point Biserial test (Pt Bis). ITEM02 has mediocre discrimination. Several items including ITEM01, ITEM06, ITEM012, ITEM15, and ITEM16 indicated a good discrimination index. Furthermore, other items indicated excellent discrimination. However, a positive point biserial index on a distractor is indicated by ITEMS 06 and ITEMS12, which are 0.13 and 0.02 respectively. This discrimination index for distractors can be considered as a lot smaller than the point biserial for the correct answer, and both ITEMS 06 and ITEMS12 can be considered as good items to discriminate students' ability. Therefore, all items can be examined for their Differential Item Functioning (DIF) before they could be used to indicate student performance in physics.

Differential Item Functioning (DIF) on Multiple Choice Question items

A DIF test was carried out to ensure that items tested in investigating physics achievement behaved equally for all respondents. The DIF test was conducted to not only avoid unfairness, but DIF also prevents comparison of two or more groups on a single trait (Boone, et al., 2014). In other words, DIF dealt with biased items (Boone, et al., 2006).

DIF was conducted before the study calculated student performance on the physics diagnostic test. Thus, this test played an important role in analysing the items used on the diagnostic test regarding gender difference. The DIF test here employed logit differences on each single item suggested by Scheuneman and Shubiyah (1998) (Bond & Fox, 2015). The item exhibited DIF if the items showed logit differences on a single item more than the cut-off value (0.5) (Bond & Fox, 2015; Wu et al., 2016).

After the items had been checked for their fit indices to the Rasch model and point biserial index, DIF was carried out to check how items tested behaved to check students' ability in physics using gender difference as the main indicator. At the first step, items used to diagnose the students' physics achievement were checked for their DIF. If they exhibited DIF, items were deleted. Further DIF analysis was conducted to ensure there was no item bias in test items analysing students' physics achievement.

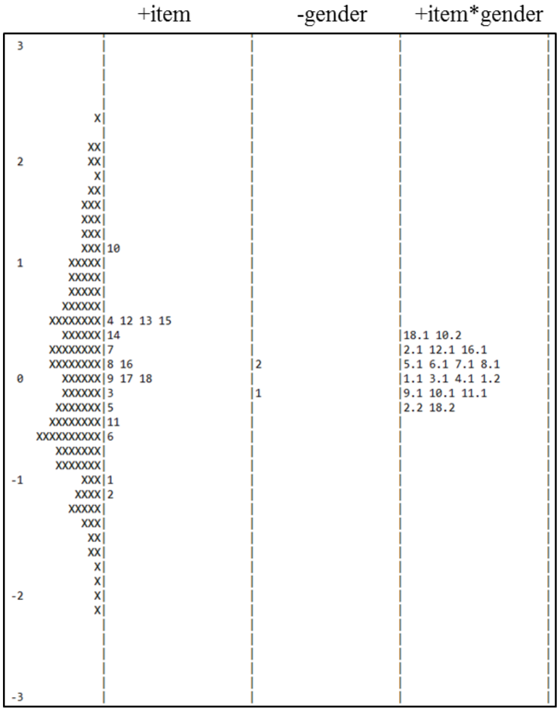
Furthermore, this study calculated DIF on the physics diagnostic test. However, the scales used in the student, teacher, and principal questionnaires were not checked for their DIF because DIF is not commonly used for detecting items performing differently for different groups (Johanson, 1997). Johnson (1997) also noted that DIF methods assume that the data are dichotomous while the questionnaires provide polytomous data, and item biases had been evaluated during CFA.

DIF analysis results can be seen in Table 5.5. The table shows two DIF analyses carried out in the study, with both Estimate diff 1 and Estimate diff2 showing results for DIF analysis step 1 and DIF analysis step 2, respectively. The second analysis was conducted because DIF had been found on ITEM01 and ITEM05. Table 5.5 indicates that the strong DIF exists at ITEM01 and ITEM05, which are 0.52 and -0.548 respectively. Both values are bigger than 0.5, meaning that DIF existed on both items, but they functioned differently in terms of gender difference. Therefore, these items were deleted from physics achievement analysis.

The second test was conducted to check the possibility of DIF in test items after ITEM01 and ITEM05 had been deleted. The results were that no item showed a logit difference more than the cut-off value (0.5). It can be seen in Table 5.5 that the highest estimate difference was shown by ITEM20 (0.458), and the lowest by ITEM06 (-0.05). ITEM20 (18) shows a big difference response by gender followed by ITEM13 (10). However, because the estimated difference is under 0.5, it can be concluded that the DIF is not strong enough. Therefore, the rest of the items can be retained to indicate students’ physics achievement in the subsequent analysis.

Table 5.5 Estimate difference on physics diagnostic test items based on gender difference

item	Estimate diff 1	Estimate diff 2
ITEM01	0.520	
ITEM02	-0.038	-0.048
ITEM03	0.410	0.376
ITEM04	-0.242	-0.236
ITEM05	-0.548	
ITEM06	-0.052	-0.05
ITEM07	0.144	0.132
ITEM08	0.184	0.194
ITEM09	0.202	0.208
ITEM10	0.128	0.088
ITEM11	-0.298	-0.274
ITEM12	-0.382	-0.348
ITEM13	-0.250	-0.258
ITEM14	0.190	0.174
ITEM15	-0.140	-0.176
ITEM16	-0.284	-0.252
ITEM17	-0.182	-0.160
ITEM18	0.096	0.090
ITEM19	0.076	0.082
ITEM20	0.470	0.458



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                    +item                 -gender            +item*gender
  3           |                      |                      |                      |
              |                      |                      |                      |
              |                      |                      |                      |
              |                      |                      |                      |
              |                      |                      |                      |
             X|                      |                      |                      |
              |                      |                      |                      |
            XX|                      |                      |                      |
  2         XX|                      |                      |                      |
             X|                      |                      |                      |
            XX|                      |                      |                      |
           XXX|                      |                      |                      |
           XXX|                      |                      |                      |
           XXX|                      |                      |                      |
           XXX|10                    |                      |                      |
  1      XXXXX|                      |                      |                      |
         XXXXX|                      |                      |                      |
         XXXXX|                      |                      |                      |
        XXXXXX|                      |                      |                      |
      XXXXXXXX|4 12 13 15            |                      |                      |
        XXXXXX|14                    |                      |18.1 10.2             |
      XXXXXXXX|7                     |                      |2.1 12.1 16.1         |
      XXXXXXXX|8 16                  |2                     |5.1 6.1 7.1 8.1       |
  0     XXXXXX|9 17 18               |                      |1.1 3.1 4.1 1.2       |
        XXXXXX|3                     |1                     |9.1 10.1 11.1         |
       XXXXXXX|5                     |                      |2.2 18.2              |
      XXXXXXXX|11                    |                      |                      |
    XXXXXXXXXX|6                     |                      |                      |
       XXXXXXX|                      |                      |                      |
       XXXXXXX|                      |                      |                      |
 -1        XXX|1                     |                      |                      |
          XXXX|2                     |                      |                      |
         XXXXX|                      |                      |                      |
           XXX|                      |                      |                      |
            XX|                      |                      |                      |
            XX|                      |                      |                      |
             X|                      |                      |                      |
             X|                      |                      |                      |
 -2          X|                      |                      |                      |
             X|                      |                      |                      |
              |                      |                      |                      |
              |                      |                      |                      |
              |                      |                      |                      |
              |                      |                      |                      |
              |                      |                      |                      |
 -3           |                      |                      |                      |
```

Figure 5.2 Wright map of latent distributions and response model parameter estimates after DIF

In addition, a Wright map was created to compare student responses on test items based on their gender. The DIF test showed that female students performed better in the physics diagnostics test. Dynamics (ITEM12) was the most difficult item for female students, and thermodynamics (ITEM20) and kinematics (ITEM03) were the easiest items. However, male students showed different strengths where the easiest items were dynamics (ITEM11, ITEM12, and ITEM13), and the difficult item was thermodynamics (ITEM20). These differences showed that male and female students have different interests and difficulty levels in their physics.

Another finding is that DIF exhibited that there were gender differences regarding Measurement (ITEM01) and Dynamics (ITEM05). Both items showed logit different estimates on these two items. Female students performed better on measurement, but male students performed better on dynamics. These differences show that gender differences may cause students' ways of thinking in learning physics or different area of interest.

Student latent variables

Rasch analysis for students' attitudes toward physics employed a polytomous model because items used in the student questionnaire presented more than two response possibilities. This differs from the dichotomous model for the physics diagnostic test where items provided incorrect or correct answers. In addition, multidimensional scale analysis was carried out to analyse students' attitudes toward the physics scale because their attitudes toward physics were constructed through three different factors (see Chapter 4). In conducting Rasch analysis, the Rating Scale Model (RSM) was employed to analyse students' responses. The RSM provides better results for analysing the student questionnaire using a Likert scale (Bond & Fox, 2015).

The results of students’ attitudes toward physics using RSM within a multidimensional model are shown in Table 5.6. This indicates no delta disorder, meaning that choices provided worked for discriminating respondents’ attitudes.

Table 5.6 Fit statistics of students’ attitudes toward physics

	Measure	**Standard**	**INFIT**			**Delta**		
Item	(logit)	Error	MNSQ	CI	T			
VAL1	-1.215	0.059	1.17	(0.87, 1.13)	2.5	-3.96	-1.25	1.57
VAL2	-0.292	0.057	1.37	(0.88, 1.12)	5.3	-3.04	-0.33	2.49
VAL3	-0.743	0.058	1.41	(0.88, 1.12)	5.8	-3.49	-0.78	2.04
VAL4	-0.349	0.057	1.15	(0.88, 1.12)	2.3	-3.09	-0.38	2.43
VAL5	1.449	0.056	1.19	(0.88, 1.12)	2.8	-1.3	1.41	4.23
VAL6	-0.026	0.057	1.23	(0.88, 1.12)	3.4	-2.77	-0.06	2.75
VAL7	-0.13	0.057	1.1	(0.88, 1.12)	1.6	-2.88	-0.17	2.65
VAL8	0.452	0.056	0.98	(0.88, 1.12)	-0.3	-2.29	0.42	3.23
VAL9	0.854*	0.161	1.34	(0.88, 1.12)	5	-1.89	0.82	3.63
SELFCON1	-1.717	0.055	0.81	(0.88, 1.12)	-3.2	-4.46	-1.75	1.06
SELFCON2	0.429	0.055	1.11	(0.88, 1.12)	1.8	2.32	0.39	3.21
SELFCON3	0.466	0.055	0.61	(0.88, 1.12)	-7.3	-2.28	0.43	3.25
SELFCON4	0.328	0.055	0.7	(0.88, 1.12)	-5.3	-2.42	0.29	3.11
SELFCON5	-0.366	0.055	0.71	(0.88, 1.12)	-5	-3.11	-0.4	2.41
SELFCON6	0.613	0.055	0.87	(0.88, 1.12)	-2.1	-2.13	0.58	3.39
SELFCON7	0.239	0.055	1.21	(0.88, 1.12)	3.2	-2.51	0.2	3.02
SELFCON8	0.008*	0.146	1.02	(0.88, 1.12)	0.4	-2.74	-0.03	2.79
LIKE1	-0.06	0.055	0.65	(0.88, 1.12)	-6.4	-2.81	-0.09	2.72
LIKE2	0.388	0.055	1.14	(0.88, 1.12)	2.1	-2.36	0.35	3.17
LIKE3	-0.219	0.055	0.76	(0.88, 1.12)	-4.1	-2.96	-0.25	2.56
LIKE4	-0.964	0.056	0.76	(0.88, 1.12)	-4.2	-3.71	-1	1.82
LIKE5	0.302	0.055	0.59	(0.88, 1.12)	-7.7	-2.44	0.27	3.08
LIKE6	0.027	0.055	0.78	(0.88, 1.12)	-3.7	-2.72	-0.01	2.81
LIKE8	-0.709	0.056	1.44	(0.88, 1.12)	6.2	-3.45	-0.74	2.07
LIKE9	1.236*	0.146	0.73	(0.88, 1.12)	-4.7	-1.51	1.2	4.02

*Indicates that a parameter estimate is constrained
Separation reliability = 0.994
Chi-square test of parameter equality = 3268.50, df = 22, Sig Level = 0.000

The multidimensional model also fits the Rasch model. It can be seen from the Infit MNSQ scores shown in Table 5.6 that most items were within the acceptable range of 0.6 and 1.4 (Bond & Fox, 2015). However, two items, VAL3 (MNSQ= 1.41) and LIKE8 (MNSQ=

1.41), showed that Infit MNSQ was outside the acceptable range. However, these two items showed a good delta order, and these two items were close to the acceptable range; therefore, both items were used to measure students' attitudes toward physics. Furthermore, in terms of separation reliability, Rasch analysis results showed a high degree of confidence for placement of items where the separation reliability value is close to 1 (0.994) (Bond & Fox, 2015). The Infit MNSQ value of both VAL3 and LIKE8 was acceptable based on the acceptable range proposed by Linacre (2002), which is between 0.5 and 1.5.

Valuing of physics (VAL)

It can be seen in Table 5.6 that the easiest item to agree with is 'I think learning physics will help me in my daily life' VAL1 (-1.215). this means that the majority of students participating in this study tend to agree that physics will help them in their daily life. The second easiest item to agree on was 'I need to do well in physics to get into the college or university of my choice' VAL3 (-0.743). Students tended to agree that physics could help them learn at university level. However, when physics was connected with their future job, students tended to disagree with this view. It was indicated that VAL5 (I would like a job that involves using physics) was the hardest item to agree on (1.499).

Self-confidence in learning physics (SELFCON)

What can be concluded from students' self-confidence in learning physics? It can be seen in Table 5.4 that the easiest item to agree on was SELFCON1 (I usually do well in physics). This indicates that the majority of students think they can do well in their physics subject. This was followed by SELFCON5 (I am good at working out difficult physics problems) which supports SELFCON1 indicating that students can solve physics problems even though they are difficult.

However, there was an interesting finding regarding students' self-confidence in learning physics. The most difficult item to agree on is SELFCON6 (My teacher tells me I am good at physics). This finding shows that teachers did not show any supporting statement to help students learn physics with confidence. It is supported by the two other most difficult items, ITEM3 (Physics is my strength, 0.466) and SELFCON2 (Physics is easier for me than for many of my classmates, 0429). These views indicate that physics is relatively difficult for students supported by SELFCON7 (Physics is easier for me than other subjects, 0.239), which was difficult to agree on.

Liking of physics

Another factor describing the extent to which students like physics can be seen in their response to the questionnaire. The easiest item to agree on is LIKE4 (I learn many interesting things in physics, -0.964), followed by LIKE8 (I like to conduct physics experiments, -0.709) and LIKE3 (physics is interesting, -0.219), respectively. This indicates that students tend to agree that physics is an interesting subject regarding physics topics and experiments.

However, the study found several items difficult to agree with. The most difficult was LIKE9 (Physics is one of my favourite subjects, 1.236), followed by LIKE2 (I wish I did not have to study physics, 0.388). This finding shows that although physics is an interesting subject, students had difficulty agreeing that physics is their favourite subject and only learn physics because it is a compulsory subject.

Teacher latent variables

The study employed a Rating Scale Model (RSM) when analysing teacher scales because all are polytomous data where items provided more than one alternative response for respondents. The RSM was chosen to indicate that items provided the same number of response options and applied one set of response threshold values to all items (Bond & Fox, 2015).

Teachers' attitudes toward physics teaching and learning

Ten items were examined in teachers' attitudes toward physics teaching and learning (ATT) scale. Most items were in the accepted range (between 0.6 and 1.4). However, ATT10 (Infit MNSQ = 1.68) exhibited Infit MNSQ outside the acceptable range. Even though ATT10 was outside the acceptable range, it could still be used in this study because it had item deltas in order which means it can be accepted to measure teachers' attitudes toward physics teaching and learning. Furthermore, if the item was deleted, another item would change its Infit MNSQ to outside the accepted range and there would be no significant improvement. Therefore, the item was retained, and it is supported by Linacre's acceptable range for fit indices between 1.5 and 2.0 which is unproductive for construction of measurement, but does not degrade the measurement (Linacre, 2002).

In addition, during Rasch analysis ATT4 was deleted (Infit MNSQ = 0.4) because it exhibited Infit MNSQ out of the acceptable range. Furthermore, when ATT4 was deleted, another item (ATT5) showing the closest Infit MNSQ to ATT4, exhibited better fit indices (0.68) and the separation reliability increased from 0.810 to 0.820.

Table 5.7 Fit statistics of teachers' attitudes toward physics teaching and learning

		Standard Error	**Infit**			**Item Delta**		
Item	Estimate		MNSQ	CI	T			
ATT1	-0.584	0.266	1	(0.34, 1.66)	0.1	-2.87	1.06	2.18
ATT2	0.313	0.259	1.23	(0.37, 1.63)	0.8	-1.97	-0.16	3.07
ATT3	0.859	0.255	1.24	(0.40, 1.60)	0.8	-1.43	0.39	3.62
ATT5	-1.079	0.27	0.68	(0.37, 1.63)	-1	-3.37	-1.58	1.68
ATT6	-0.428	0.265	0.62	(0.34, 1.66)	-1.2	-2.71	-0.9	2.33
ATT7	-0.585	0.266	0.71	(0.34, 1.66)	-0.8	-2.87	-1.06	2.17
ATT8	-0.428	0.265	1.29	(0.34, 1.66)	0.9	-2.17	-0.9	2.33
ATT9	0.17	0.26	0.65	(0.36, 1.64)	-1.1	-2.2	-0.3	2.93
ATT10	1.761*	0.744	1.68	(0.43, 1.57)	2.1	-0.53	1.29	4.52

*Indicates that a parameter estimate is constrained
Separation reliability = 0.820
Chi-square test of parameter equality = 44.10, df = 8, Sig Level = 0.000

After Rasch analysis was conducted, the results of teachers' attitudes can be seen in Table 5.7. The easiest item to agree on was ATT5 (Helping students appreciate the value of learning physics, -1.079) followed by several items including ATT7 (Improving the understanding of struggling students, -0.585), ATT1 (Inspiring students to learn physics, -0.584), and ATT8 (Making physics relevant to students, -0.428). These items show that teachers believed they encouraged students to know the benefits or value of physics in their lives and helped students to learn physics.

However, it may be difficult to teach physics using high order thinking or the inquiry method. It can be seen in Table 5.7 above that the most difficult item to agree on is teaching physics using the inquiry method (ATT10, 1.761). This item shows a more difficult 0.9 logit unit than the second difficult item. It shows that the inquiry method was very difficult to use when teaching students. The second difficult item was providing challenging tasks for the highest achieving students (ATT3, 0.859) followed by other items with around 0.546 logit unit difference, which explain physics concepts or principles by doing physics experiments (ATT2, 0.313) and developing students' high order thinking skills (ATT9, 0.17).

Teaching challenges

Seven items were examined in teaching challenges (CHAL). Most items exhibited infit in the accepted range (between 0.6 and 1.4), except CHAL2 showing Infit MNSQ falling outside the acceptable range. Therefore, Rasch analysis deleted CHAL2 (infit MNSQ = 1.7). Furthermore, when CHAL2 was deleted, all items exhibited better Infit MNSQ values and separation reliability increased from 0.976 to 0.979, meaning that the deletion improved scale quality for measuring teaching challenges. Furthermore, all items exhibited item delta in order which indicated that all items could measure teaching challenges during physics teaching and learning. Therefore, the retained items could be used to interpret teaching challenges.

Table 5.8 Fit statistics of teaching challenges

Item	Estimate	**Standard** Error	**INFIT**			**Delta**		
			MNSQ	CI	T			
CHAL1	0.461	0.214	1.05	(0.45, 1.55)	0.3	-1.72	0.19	1.91
CHAL3	0.549	0.214	1.25	(0.45, 1.55)	0.9	-0.63	0.28	2
CHAL5	-1.899	0.238	1.2	(0.31, 1.69)	0.7	-3.08	-2.17	-0.45
CHAL6	2.349	0.246	0.9	(0.23, 1.77)	-0.1	1.17	2.08	3.8
CHAL7	-0.683	0.217	0.63	(0.41, 1.59)	-1.3	-1.86	-0.95	0.76
CHAL8	-0.777*	0.506	0.99	(0.41, 1.59)	0.1	-1.95	-1.05	0.67

*Indicates that a parameter estimate is constrained
Separation reliability = 0.979
Chi-square test of parameter equality = 175.96, df = 5, Sig Level = 0.000

Rasch analysis found that the easiest item to agree on was ‘I need more time to assist individual students’ (CHAL5, -1.899). This is far behind the other two easy items to agree on, which showed a 1.122 logit unit difference. This means teachers needed more time to help individual students to learn physics. CHAL5 is followed by ‘I have difficulty keeping up with all of the changes to the curriculum’ (CHAL7, -0.683) and ‘I have too many administrative tasks’ (-0.777).

Teachers’ collaboration

After Rasch analysis was conducted, six items were retained in the teachers’ collaboration scale (COL). Most items were in the accepted range (between 0.6 and 1.4), except that COL7 did not fall within the acceptable range. Therefore, Rasch analysis deleted COL7 (Infit MNSQ = 1.63). When COL7 was deleted, all items exhibited better Infit MNSQ (within the acceptable range), and separation reliability increased from 0.948 to 0.964, meaning that the deletion improved the scale quality for measuring teachers’ collaboration in the physics classroom.

Furthermore, all items exhibited delta in order which indicated that all items could measure teacher's collaboration. Thus, retained items can be used to indicate teachers' collaboration.

Table 5.9 Fit statistics of teachers' collaboration

Item	Estimate	**Standard**	**Infit**			**Delta**		
		Error	MNSQ	CI	T			
COL1	-1.2	0.319	0.83	(0.39, 1.61)	-0.5	-5.38	-0.93	2.69
COL2	0.232	0.323	1.19	(0.39, 1.61)	0.7	-3.95	0.52	4.12
COL3	-1.58	0.319	0.84	(0.38, 1.62)	-0.4	-5.76	-1.29	2.31
COL4	2.702	0.332	0.62	(0.40, 1.60)	-1.3	-1.47	2.99	6.59
COL5	0.653	0.325	1.39	(0.36, 1.64)	1.2	-3.52	0.94	4.54
COL6	-0.807*	0.724	0.8	(0.41, 1.59)	-0.6	-4.98	-0.52	3.84

*Indicates that a parameter estimate is constrained
Separation reliability = 0.935
Chi-square test of parameter equality = 125.25, df =9, Sig Level = 0.000

Items indicating teachers' collaboration that were retained can be seen in Table 5.9. The easiest item to agree on was 'Share what I have learned about my teaching experiences' (COL3, -1.58). It was followed by 'Discuss how to teach a particular topic' (COL1, -1.2) and 'Work as a group on implementing the curriculum' (COL6, -0.807). This finding shows that teachers' collaboration was about sharing their experiences in teaching particular topics on implementing the curriculum.

However, it is different from other types of collaboration such as visiting other classes or trying out new ideas. This can be seen by the most difficult item to agree on: 'Visit another classroom to learn more about teaching' (COL4, 2.702). This item is quite different from the second difficult item to agree 'Work together to try out new ideas' (COL5, 0.653) indicated by the its logit unit difference (2.149 logit unit). The following difficult item is 'Collaborate in planning and preparing instructional material' (COL2, 0.233).

Teaching practice

Eleven items were examined on the teaching practice scale (TP). All items were in the accepted range (between 0.6 and 1.4) except TP5 (Infit MNSQ = 0.47) and TP2 (infit MNSQ = 1.95). After both TP5 and TP2 were deleted, all items exhibited better Infit MNSQ and separation reliability increased from 0.935 to 0.944. Thus, this deletion improved scale quality for measuring teaching challenges.

Furthermore, all items also exhibited delta in order which indicated that all items could measure teaching practice. Thus, retained items could be used to indicate teaching practice.

Table 5.10 shows the teaching practice scale. It can be concluded that the majority of teachers tend to agree with ‘Take a written test or quiz’ (TP13, -2.325) followed by ‘Read their textbooks or other resource materials’ (TP09) and ‘Have students memorise facts and routine problems’ (TP10) with a -1.403 logit unit. Another easy item to agree on is ‘Present data from experiments or investigations’ (TP06). In other words, teachers tended to encourage students to explore physics actively using experiments, reading books, and memorising facts.

Table 5.10 Fit statistics of teaching practice

Item		**Standard**	**Infit**			**Delta**		
	Estimate	Error	MNSQ	CI	T			
TP03	0.041	0.307	1	(0.40, 1.60)	0.1	-2.48	0.49	2.11
TP04	1.256	0.301	1.22	(0.38, 1.62)	0.7	-1.26	1.7	3.33
TP06	-0.101	0.309	0.58	(0.40, 1.60)	-1.5	-2.62	0.35	1.97
TP07	0.455	0.303	0.78	(0.40, 1.60)	-0.7	-2.06	0.9	2.52
TP08	0.857	0.301	0.93	(0.39, 1.61)	-0.1	-1.66	0.96	0.67
TP09	-1.403	0.339	0.87	(0.31, 1.69)	-0.3	-3.92	-0.96	0.67
TP10	-1.403	0.339	0.98	(0.31, 1.69)	0.1	-3.92	-0.96	0.67
TP12	2.624	0.309	1.38	(0.37, 1.63)	1.2	0.11	3.07	4.69
TP13	-2.325*	0.888	1.03	(0.14, 1.86)	0.2	-4.84	-1.88	-0.26

*Indicates that a parameter estimate is constrained

Separation reliability = 0.946
Chi-square test of parameter equality = 134.21, df = 8, Sig Level = 0.000

However, the most difficult item is ‘Do fieldwork outside of class’ (TP12, 2.624) followed by ‘Design or plan experiment or investigation’ (TP04, 1.256). The third difficult item to agree on is ‘Use evidence from experiments or investigations to support conclusions’ (TP08, 0.857) followed by interpreting data from experiments or investigations (TP07, 0.455) and watch me demonstrate an experiment or investigation (TP03, 0.041), respectively. It can be concluded that teachers tended to teach physics in the class or laboratory. Higher-order thinking was rarely conducted by the teacher for experiments or investigations indicated by a preference to disagree with planning/ designing experiments/ investigations (TP04) and concluding the experiment using experiment evidence (TP08). This is supported by teachers’ views which tend to agree with ‘Watch the teacher’s demonstration’ (TP03).

School latent variable

A rating scale model was carried out to examine items used in the principals’ questionnaire. Infit MNSQ was used to check how well the data fit the Rasch model. In addition, the delta orders were also examined to check principals’ responses to items.

It can be seen in Table 5.11 that all items exhibited Infit MNSQ within the accepted range, between 0.6 and 1.4 for the rating scale model. Items that exhibited the lowest Infit MNSQ were SEAS8 and SEAS13 (0.6). Furthermore, the item that exhibited the highest Infit MNSQ was SEAS10 (1.3). Therefore, all items could be used in subsequent analysis because they fit the Rasch model.

In addition, Rasch analysis also found that deltas were in order. Items could measure participant principals describing their views regarding the roles of students, teachers, and parents in achieving academic success in their schools. This means that the scale could be used properly to measure principals' views on school emphasis on academic success.

Table 5.11 Fit statistics of School Emphasis on Academic Success (SEAS)

Item	**Measure**	**Standard Error**	**Infit**			**Delta**		
			MNSQ	CI	T			
SEAS1	-1.009	0.369	1.2	(0.25, 1.75)	0.5	-5.2	-1.83	2.99
SEAS2	-0.168	0.356	1.2	(0.30, 1.70)	0.5	-3.52	-0.98	3.83
SEAS3	-2.332	0.383	0.9	(0.34, 1.66)	-0.1	-7.85	-3.15	1.67
SEAS4	-1.002	0.369	1.1	(0.25, 1.75)	0.5	-5.19	-1.82	3
SEAS5	-0.425	0.361	0.7	(0.28, 1.72)	-0.9	-4.04	-1.24	3.58
SEAS6	2.407	0.329	1.0	(0.36, 1.64)	-0.1	1.63	1.59	6.41
SEAS7	1.22	0.336	1.2	(0.36, 1.64)	0.7	-0.75	0.4	5.22
SEAS8	-0.702	0.365	0.6	(0.26, 1.74)	-1	-4.59	-1.52	3.3
SEAS9	-0.423	0.361	1.2	(0.28, 1.72)	0.7	-4.03	-1.24	3.58
SEAS10	1.22	0.336	1.3	(0.36, 1.64)	1	-0.75	0.4	5.22
SEAS11	0.335	0.348	1.2	(0.34, 1.66)	0.6	-2.52	-0.48	4.34
SEAS12	0.789	0.342	1.0	(0.36, 1.64)	0.2	-1.61	-0.03	4.79
SEAS13	0.090*	1.23	0.6	(0.32, 1.68)	-1.3	-3	-0.73	4.09

*Indicates that a parameter estimate is constrained
Separation reliability = 0.922
Chi-square test of parameter equality = 144.62, df = 12, Sig Level = 0.000

It can be seen in Table 5.11 that the easiest item to agree on was 'Teachers' expectations for students' achievement' (SEAS3, -2.332) followed by 'Teachers' understanding of the school's curricular goals' (SEAS1, -1.009) and 'Teachers working together to improve students' achievement' (SEAS4, -1.002), respectively. Based on these items, it can be concluded that principals tended to agree that all physics teachers were working hard to help students succeed in their learning, particularly meeting curricular goals.

In addition, principals also tended to agree with other variables showing support for parents and teachers to help students in physics. Other variables that were easy to agree on were 'Parental expectations for students' achievement' SEAS8 (-0.702), 'Parental support for students' achievement' SEAS9 (-0.423), 'Teachers' ability to inspire students' SEAS5 (-0.425), and 'Teachers' degree of success in implementing the school's curriculum' SEAS2 (-

0.168). These items showed that principals believed that parents showed a high level of expectation and support on students' achievement, and this was supported with teachers' ability to inspire students to learn physics and teachers' ability to implement the curriculum in classrooms.

However, the most difficult item to agree on was 'Parental involvement in school activities' SEAS6 (2.407) followed by 'Parental commitment to ensure that students are ready to learn' SEAS7 and 'Parental pressure for the school to maintain high academic standards' SEAS10 which exhibited the same logit unit (1.22). These findings show that parental involvement in school activities was low. Principals were also of the view that there is limited concern from parents about the academic standard in the school. However, parents were viewed as careless regarding the readiness of students to learn.

In addition, in terms of student aspects, principals were of the view that students' ability, desire and respect for academic success is a bit difficult to agree on. It can be seen from Table 5.11 that 'Students' ability to reach school's academic goals' SEAS12 shows 0.789 logit unit followed by 'Students' desire to do well in school' SEAS11 (0.335), and 'Students' respect for classmates who excel in school' SEAS13 (0.90). It can be concluded that student motivation to succeed academically should receive more attention.

Summary

Rasch analysis was carried out to check item validity of physics diagnostic test items, and student, teacher, and school scales. Items were identified that could be used in subsequent analysis, and which needed to be discarded.

Item validity of the physics diagnostic test was checked. Even though seven topics were examined in the test, items were consolidated into a single factor to simplify the discussion, as each topic consisted of less than three items. The study found that the easiest items for students were measurement, kinematics, and dynamics. However, interestingly, some of the difficult items were Dynamics and Kinematics, besides items from topics such as Fluid, Thermodynamics, Wave, and Temperature and Heat. In terms of item discrimination, the study found that all items can be used to discriminate students' abilities in physics. Only two items, ITEM01 (Kinematics) and ITEM05 (Dynamics), exhibited Differential Item Functioning (DIF) regarding gender difference. DIF suggested that students' perceptions about these two items were different, although they showed the same abilities.

Item validity of student scales was examined. The Rating scale model used in this study showed that both VAL3 and LIKE8 exhibited Infit MNSQ close to the acceptable range (between 0.6 and 1.4) and showed acceptable delta order; therefore, these items were retained. In addition, it can be concluded that students tended to value physics in helping them in their daily life and pursuing study at university level. However, they tended to disagree about work in physics-related jobs. Furthermore, students tended to agree with being able to perform well when they learnt physics. But they viewed physics as a difficult subject and teachers rarely appreciated their performance. Moreover, although physics is an interesting subject, students found it difficult to agree on physics as their favourite subject and learning physics as a compulsory subject.

A rating model was carried out to examine teacher scale. Teacher attitude scale indicated that teachers tend to encourage students to know the benefits or value physics in their lives and help them to learn physics. However, using inquiry is difficult for teaching Year 12 physics students. Delivering physics using high order thinking was also difficult. In terms of teachers' collaboration, teachers tended to agree that they share their experiences in teaching particular topics and implementing the curriculum when they collaborated with other colleagues. However, teachers indicated how difficult it was to try out new ideas or visit other classes. Furthermore, teachers tended to agree with encouraging students to present data from experiments, read books, memorise facts, and take a written test or quiz. However, higher-order thinking was rarely conducted by the teacher for experiments or investigations, even though teachers tended to teach physics in the class or laboratory.

A rating scale model was used to analyse the principal questionnaire. It was found that Infit MNSQ items were within the acceptable range and delta order was acceptable. It can thus be concluded that all items could be used in subsequent analysis. In addition, based on easy items to agree on, principals were of the view that both teachers and parents supported students' success in learning in school. All physics teachers were viewed as working hard to help students succeed at learning, particularly meeting school curricular goals. Parents also expected their children to succeed in their studies by supporting their learning. However, both parental involvement in school activities and attention to student readiness to learn at school were seen to be limited. In addition, the majority of principals participating in this study were of the view that it was very difficult to agree that students showed high motivation in their ability, desire to succeed and respect on classmate achievement in their schools.

Validity of items was examined using Rasch analysis, and items fitting the Rasch model were retained and used in further analysis. Descriptive statistics of items are presented in Chapter 6, presenting demographic background of respondents.

CHAPTER 6

DEMOGRAPHIC AND DESCRIPTIVE INFORMATION

Introduction

In this chapter, demographic information of participants is presented. In addition, validated latent variables (see Chapter 4 for construct validity and Chapter 5 for item validity), are described. Data are presented at student-, teacher-, and principal-level.

Data were processed using the IBM SPSS 25 software program. This program provides a bar chart and pie chart to assist with data description on student demographic information. Error bars are also provided to show the distribution of participant responses to questionnaires. In addition, several statistics described demographic information including Mean, Median, Variance, Standard Deviation, Skewness, Kurtosis, Range, as well as minimum and maximum values.

Student-level data includes several demographic variables such as gender, highest parent education, age, and future education aspirations. In addition, these data also contain several latent variables assessed in Chapters 4 and Chapter 5 (i.e., students' attitudes toward physics, physics homework frequency assigned by the teachers, additional physics tuition, and the physics diagnostic test result).

With regards to teacher-level data, demographic information includes the teacher's characteristics described through the teaching certificate, education level, major education, and class size. Several latent variables such as teachers' collaboration, teaching challenges in the physics class, teaching practice, and teachers' attitudes toward physics teaching are also described.

In addition to student- and teacher-level data, school-level data are described in terms of demographic information and principals' views. Demographic information includes school types, school location, laboratory availability, laboratory staff, library availability, principals' experiences, and principals' education qualification. Furthermore, principals' views regarding teachers', parents', and students' aspects in supporting academic success in the physics class are presented.

Student-level data

Student-level data are presented as demographic information and factors describing students' attitudes. Demographic variables are the characteristics of students, frequency of homework, additional physics tuition, and the physics diagnostic test used to indicate students' achievement. Students' attitudes toward physics are described as liking physics (LIKE), valuing physics (VAL) and self-confidence in learning physics (SELFCON). These variables and factors were then examined for their causal relationship in the student-level model and in the Structural Equation Model (SEM), and data were analysed at the student level in Hierarchical Linear Modelling (HLM).

Demographic information of Year 12 students in Malang, Indonesia

Demographic information is described by gender, age, parents' highest education level, and future education aspirations as follows.

Gender

The number of students participating in this study was 473. This study had almost equal numbers of participants in terms of gender. Of 473 students, 260 participants (55%) were female, and 213 participants (45%) were male. Gender proportion is shown in the pie chart (see Figure 6.1).

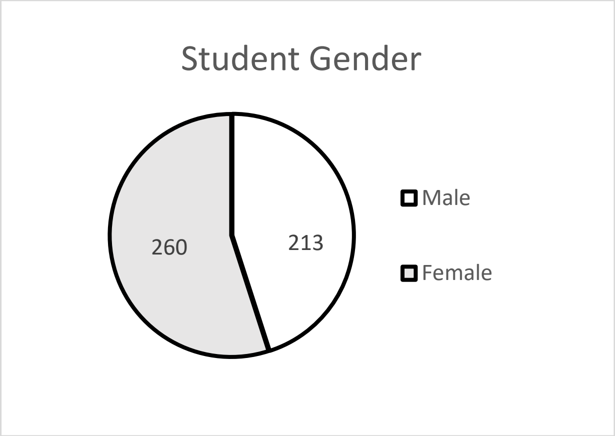


Figure 6.1 Gender proportion of students in the study

Age

The proportion of Year 12 student participants in terms of age can be seen in Figure 6.2. The majority of participants, nearly 300 students, were born in 2000 and were 18 years old during data collection. The second group of participants were born in 1999 (19 years old) and there were slightly more than 100 students. Around 50 students were born in 2001 (17 years old), and the minority of students were born in 1997 (21 years old) or 2002 (16 years old), respectively.

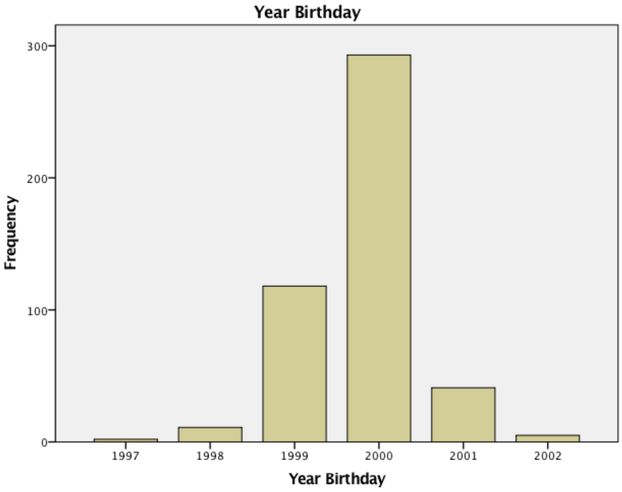


Figure 6.2 Proportion of students based on their year of birth

It can be concluded that in terms of their age, students were diverse. This could be caused by educational policy in Indonesia where students can join accelerated classes in several schools when they meet particular requirements or stay at the current level when they do not meet the minimum requirement to move to the upper level. To simplify analyses, student age data were categorised based on their year of birth. However, in the actual data participants provided their date of birth using date, month, and year. Therefore, there is a possibility that the real age of students did not differ as much as one year.

Parents' highest education level

Data for parents' highest education level are shown in Figure 6.3. Parent's education level for both mother and father had a fairly similar pattern. This can also be seen in the order of the number of fathers or mothers graduating from their highest education level.

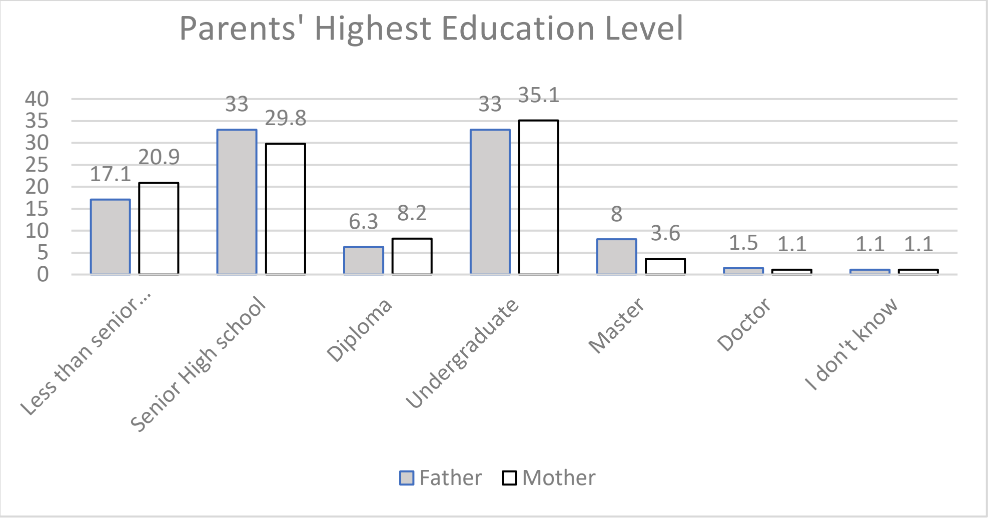


Figure 6.3 Parents' highest education level

The majority of students have parents who graduated at undergraduate level and senior high school. 35.1% of students whose mothers completed undergraduate level, which is very similar to the number of students whose fathers who were also undergraduates (33%).

However, the majority of students' fathers graduated at both undergraduate and senior high school levels.

Future education aspirations

Students' future education aspirations can be seen in the bar chart in Figure 6.4. Students' views regarding their highest future education level indicate different patterns compared to their parent's highest education level. If the minority of respondents are students whose parents graduated at doctoral level, on the other hand, it is different with future education aspirations where the minority of the students would like to finish their study at senior high school. It can be concluded that students will achieve a higher-level education than their parents.

The majority of respondents (more than 95%) would like to continue their education at least to undergraduate level. Of more than 150 students who chose undergraduate level as their highest education level, followed by a Masters (150 students) and PhD (140 students) respectively. Neither senior high school nor diploma degrees are popular for students' future education.

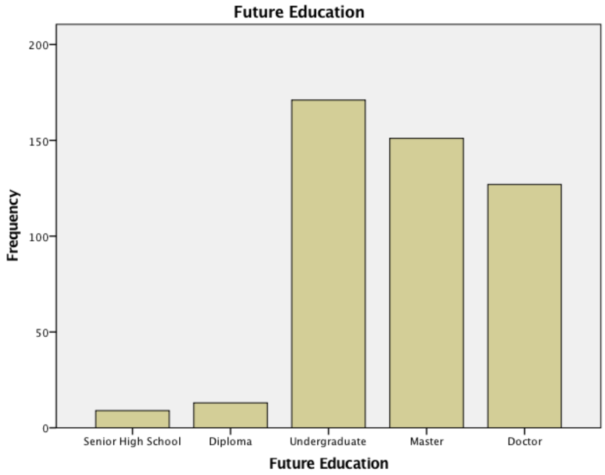


Figure 6.4 Students' future education aspirations

Students' attitudes toward physics

Students' attitudes toward physics were constructed by three different correlated factors based on CFA findings (see Chapter 4). The three factors were valuing of physics (VALUE), students' self-confidence in learning physics (SELFCONF), and liking of physics (LIKE). Furthermore, after Rasch analysis was conducted, the majority of scales of students' attitudes toward physics were retained except LIKE7 (see Chapter 5).

Table 6.1 Descriptive statistics for valuing of physics, liking of physics, self-confidence in learning physics

	Mean	**SE**	**SD**	**Skewness**	**Kurtosis**
Val1	1.75	0.03	0.64	0.47	0.28
Val2	2.03	0.03	0.74	0.27	-0.39
Val3	1.89	0.04	0.93	0.62	-0.75
Val4	2.01	0.04	0.89	0.50	-0.59
Val5	2.61	0.04	0.96	-0.16	-0.93
Val6	2.11	0.04	0.78	0.29	-0.36
Val7	2.08	0.04	0.82	0.33	-0.50
Val8	2.27	0.04	0.84	0.14	-0.63
Val9	2.41	0.04	0.87	0.10	-0.65
Like1	2.24	0.03	0.67	-0.01	-0.30
Like2	2.39	0.04	0.75	0.28	-0.20
Like3	2.18	0.03	0.62	0.33	0.46
Like4	1.93	0.03	0.59	0.33	1.08
Like5	2.36	0.03	0.69	-0.07	-0.30
Like6	2.27	0.03	0.65	-0.07	-0.32
Like8	2.02	0.04	0.76	0.23	-0.59
Like9	2.70	0.03	0.73	-0.42	0.10
SelfConf1	2.07	0.03	0.61	0.14	0.19
SelfConf2	2.81	0.04	0.78	-0.03	-0.69
SelfConf3	2.83	0.03	0.66	-0.40	0.49
SelfConf4	2.78	0.03	0.62	-0.42	0.56
SelfConf5	2.54	0.03	0.65	-0.03	-0.20
SelfConf6	2.88	0.03	0.65	-0.30	0.36
SelfConf7	2.75	0.04	0.81	-0.07	-0.64
SelfConf8	2.67	0.04	0.80	-0.04	-0.52

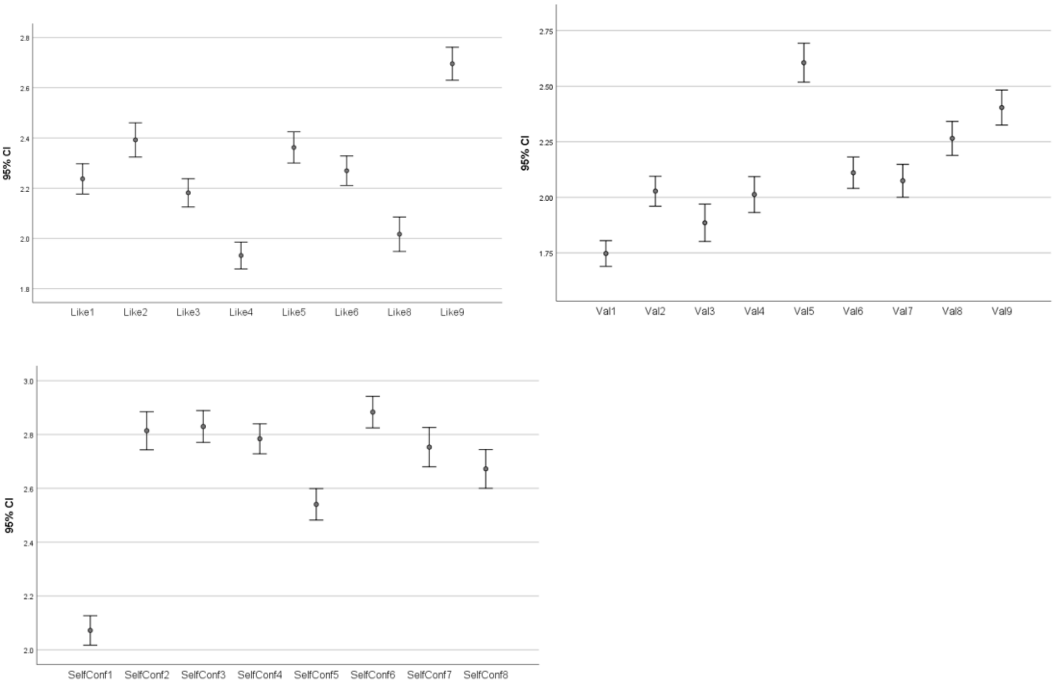


Figure 6.5 Error bars for liking of physics, valuing of physics, self-confidence in learning physics

Students were asked to rate their views regarding measuring their attitudes toward physics on four scales as: “1 = Disagree a lot”, “2 = Disagree a little”, “3 = Agree a little”, and “4 = Agree a lot”. Descriptive statistics of students’ responses can be seen in Table 6.1 and Figure 6.5 above. It can be seen in the error bar chart that students relatively tended to rate higher on their self-confidence in learning physics than both valuing of physics and liking of physics. Student believed that their teachers told them they were good at physics (SELFCON6, M=2.88, SE=0.03); however, students tended to disagree a little that they did not do well in physics (SELFCON1, M=2.07, SE=0.03). The charts with a 95% confidence interval indicate that students showed positive confidence during physics learning. In addition, the chart shows that the students indicated consistently disagree a little about their liking of physics. Mean values indicated that students agree a little that their favourite subject is physics (LIKE9, M=2.70, SE=0.03), but they disagree a little that they learnt many interesting topics in physics (LIKE4, M=1.93, SE=0.03). Furthermore, the error bar chart with 95 confidence intervals also shows that students indicated less value in physics. It can be indicated that the majority of items showed a mean value around disagreeing a little (M=2), that physics will help them in their daily life (VAL1, M=1.75, SE=0.03). However, they agree a little that their future job will be related to physics (VAL5, M=2.61, SE=0.04).

Table 6.1 above shows that variables are normally distributed. The distribution is indicated by skewness and kurtosis values being within acceptable range, which are < ±3 and Kurtosis < ± 8, respectively (Kline, 2015). Therefore, this data can be analysed further in SEM and HLM.

Homework and additional physics tuition

Other variables investigated for their causal relationship in influencing physics achievement were frequency of physics homework assigned by teachers and students' motivation and duration to do additional tuition. Table 6.2 shows that 451 students gave their responses on the item asking about physics homework. However, fewer participants (447 students) responded on items asking about additional physics tuition. Participants who did not respond were treated as missing values.

Table 6.2 shows that all variables were normally distributed, indicated by skewness and kurtosis values of variables within the acceptable range. Skewness values are 0.87, 0.48, and 0.28 for HOMEWORK, ADDLMOT, ADLLDUR respectively, and within the acceptable range, < ±3 (Kline, 2015). In addition, kurtosis values are -0.38, -1.53, and -1.08 for HOMEWORK, ADDLMOT, ADLLDUR respectively, and within the acceptable range, Kurtosis < ± 8(Kline, 2015). Therefore, the data could be examined for their causal relationship in influencing physics achievement using both SEM and HLM.

It can also be seen in Table 6.2 that, on average, students were assigned homework (M = 2.10, SD 1.04) where frequency codes for homework are between 1 for never assigned and 3 for always assigned. The value of 2.1 means students were assigned physics homework once a week on average.

Table 6.2 Descriptive statistics of homework and motivation and duration on additional tuition

Statistics	HOMEWORK	ADDLMOT	ADDLDUR
Mean	2.10	2.09	2.34
Standard Deviation	1.04	0.83	1.06
Range	3	2	4
Skewness	0.87	-0.16	0.28
Kurtosis	-0.38	-1.53	-1.08

Codes used to describe the duration of students' additional tuition were 1 = Never, 2 = Less than 4 months, 3 = 4-8 months, 4 = more than 8 months. The data shows that an average student (mean value 2.3) attended private tuition for less than 4 months (M=2.33 SD=1.06).

In addition, students tended to follow their friends or follow their parents' orders (M=2.09 SD=0.83). Codes used to describe students' motivation for learning physics were 1 = No, 2 = Yes, not left behind, and 3 = Yes, be the best. The student mean value (2.09) indicates that students are motivated to avoid being left behind in physics.

Teacher-level data

Teacher-level data describe the data about demographic information and other teacher factors obtained from the teacher questionnaire. This demographic information includes class size, teaching certificate, highest education level, and major education. Furthermore, teacher factors involve teaching challenges, teachers' attitudes, teachers' collaboration, and teaching practice. In addition, these data were examined using SEM in the teacher-level model and were measured for their influence at school level within HLM.

Class size

Class numbers for teaching physics was divided into five groups in terms of size. The majority of teachers (seven participants) taught a class where between 20 and 25 students learnt physics. A second group (six teachers) taught between 26 and 30 students in their classes. The other three teachers taught 36-40 students in their classes. The minority (two teachers) taught 10 to 15 students and 31 to 35 students in their classes. Class size can be seen in Figure 6.6.

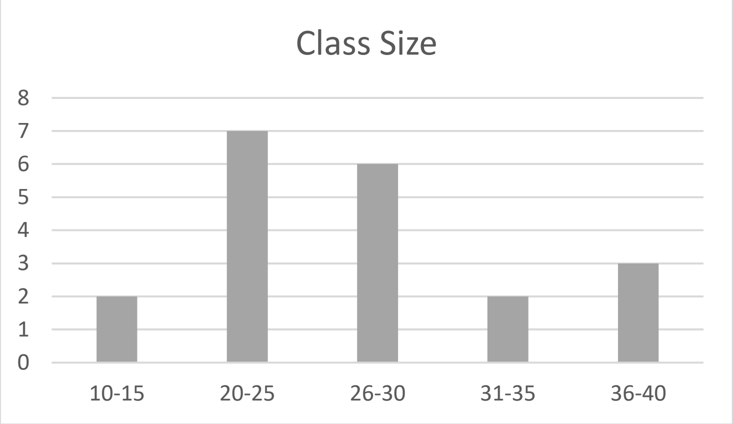


Figure 6.6 Class size of participant schools

Teaching certification

Teaching certification is a program initiated by the Indonesian government to enhance quality of education. This certification program started in 2007 based on law number 14 2005 pertaining to national education. This certification program is conducted to ensure classrooms are managed by high quality and well-trained teachers, and also provides additional financial benefits for certified teachers who meet the requirements (Abubakar, 2016; Masruroh, 2010).

The majority of physics teachers participating in this study was certified in 2018 when the data collection was conducted. It can be seen in Figure 6.7 that 15 teachers (75 %) were certified by the Ministry of Education or Ministry of Religious Affairs. The effects of teacher certification might be expected to improve teachers' quality in teaching and learning in the physics classroom. Meanwhile, five physics teachers (25%) did not have a teacher's certificate (see pie chart below).

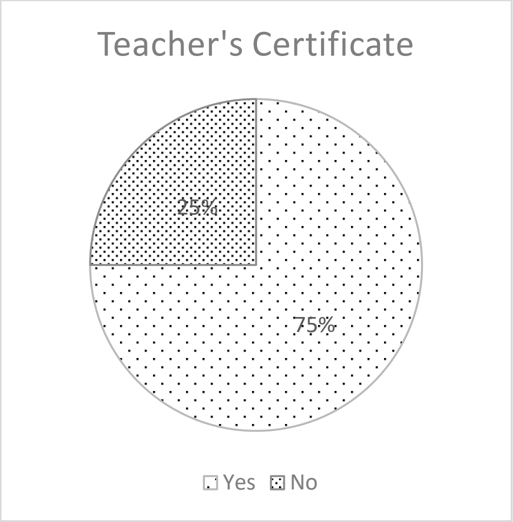


Figure 6.7 Proportion of teacher' certificate

Highest education level and Education major

It can be seen in Figure 6.8 that the majority of teachers (80% of 20) finished their studies at undergraduate level. The rest of the respondents graduated with a Master degree. Teachers' highest-level education indicated they had met the minimum requirement to teach physics in senior high school. The requirement to teach at senior high school level based on the national education law is completion at undergraduate level.

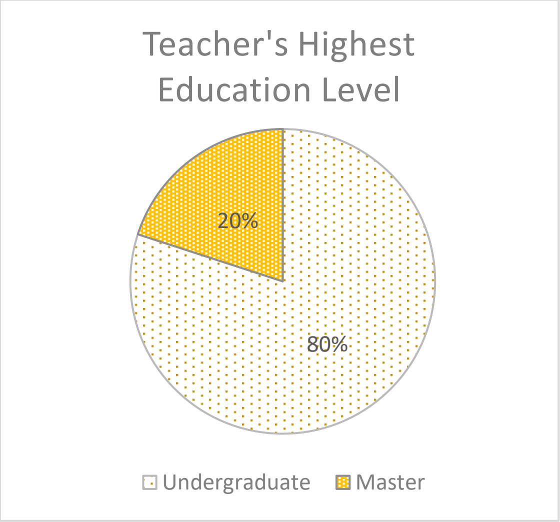


Figure 6.8 Teacher's highest education level

In addition, the majority of teachers (85%) had completed their study in physics education. Two teachers (10%) graduated from physics. However, an interesting finding was that one teacher (5%) had graduated from chemistry education (see Figure 6.9).

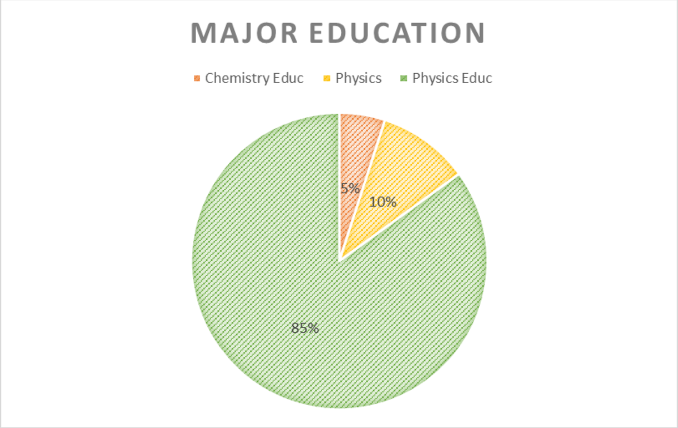


Figure 6.9 Teacher's major education

Teacher latent variables

Four teacher latent variables are discussed here including teaching challenges in their physics class (CHAL), teachers' attitudes toward physics teaching and learning (ATT), teachers' collaboration with other physics teachers (COLL), and teaching practice in the physics classroom (TP). Based on findings of CFA and Rasch analysis, TP1, TP2, TP5 and TP11 were deleted in teaching practice (TP). For teachers' collaboration, COL7 was deleted. In addition, CHAL2 was deleted to measure teaching challenges in teaching physics, and ATT4 was deleted for measuring teachers' attitudes toward teaching and learning physics. For measuring these latent variables, this study used four scales: "0 = Disagree a lot", "1 = Disagree a little", "2 = Agree a little", and "3= Agree a lot".

Statistical description of these four factors can be seen in Table 6.4. Generally, all variables were normally distributed, indicated by skewness and kurtosis values within the acceptable range, which are < ±3 and Kurtosis < ± 8 respectively (Kline, 2015). Therefore, the data can be examined further using SEM and HLM to check their influence on physics achievement.

Table 6.3 Descriptive statistics of teachers' latent variables

	Mean	SE	SD	Skewness	Kurtosis
Att1	2.05	0.15	0.69	-0.06	-0.63
Att2	1.75	0.19	0.85	-0.61	0.24
Att3	1.55	0.17	0.76	0.22	-0.11
Att5	2.20	0.14	0.62	-0.12	-0.21
Att6	2.00	0.15	0.65	0.00	-0.28
Att7	2.05	0.14	0.61	-0.01	0.19
Att8	2.00	0.18	0.80	-0.70	0.81
Att9	1.80	0.16	0.70	0.29	-0.73
Att10	1.20	0.21	0.95	-0.03	-1.23
Chal1	1.25	0.24	1.07	0.30	-1.09
Chal3	1.20	0.23	1.01	0.25	-1.00
Chal5	2.45	0.15	0.69	-0.89	-0.24
Chal6	0.40	0.17	0.75	1.61	1.00
Chal7	1.90	0.18	0.79	0.19	-1.31
Chal8	1.95	0.20	0.89	-0.40	-0.53
Col1	1.65	0.15	0.67	0.55	-0.55
Col2	1.30	0.19	0.87	0.42	-0.11
Col3	1.75	0.18	0.79	-0.23	-0.02
Col4	0.75	0.10	0.44	-1.25	-0.50
Col5	1.20	0.19	0.83	0.19	-0.36
Col6	1.55	0.15	0.69	-0.20	0.15
TP3	2.10	0.20	0.91	-0.21	-1.85
TP4	1.65	0.21	0.93	-0.06	-0.73
TP6	2.15	0.17	0.75	-0.26	-1.04
TP7	1.95	0.21	0.95	-0.31	-1.01
TP8	1.80	0.21	0.95	-0.38	-0.59
TP9	2.55	0.15	0.69	-1.28	0.54
TP10	2.55	0.14	0.61	-1.00	0.19
TP12	1.15	0.20	0.88	0.73	0.40
TP13	2.75	0.12	0.55	-2.24	4.66

Teachers' responses in teacher questionnaires regarding attitudes toward physics teaching and learning can be seen in Figure 6.10. The error bar chart with a 95% confidence interval showed that teachers' responses on their attitudes toward physics teaching and learning are positive which on average is the mean value close to agree a little (M=2). It can be seen in the error bar chart that teachers indicated disagree a little with developing higher-order thinking skills of students undertaken by teachers (ATT10, M=1.2 SE=0.21), and the majority of items showed a positive attitude indicated by the highest mean score for teachers who always encouraged students to appreciate the value of physics (ATT5, M=2.20 SE=0.14).

Furthermore, for teachers' collaboration, it can be seen in the error bar chart with a 95% confidence interval that teachers showed positive responses regarding collaboration. The three items indicated that teachers showed a positive response on teachers' collaboration and tended to share their experiences during such collaboration (COL3 M=1.75 SE=0.18); however, the minimum mean score was visiting another classroom to learn more about teaching when they undertook collaboration (COL4, M=0.75 SE=0.10).

In addition, in terms of teaching practice, the error bar chart with a 95% confidence interval showed that teachers tended to study inside the classroom indicated that they agree a lot is to take a written test or quiz (TP13, M=2.75 SE=0.12). However, learning activities outside the classroom was responded to with teachers disagreeing a little (TP12, M=1.15 SE=0.20).

Moreover, the error bar chart with a 95% confidence interval showed that teachers faced several challenges, indicated by the mean value, which received majority responses from teachers of disagree a little to disagree (M=1) with regard to delivering physics. The error bar chart also shows that teachers believed the biggest challenge was to allocate more time helping students learn physics (CHAL5, M=2.40 SE=0.15). However, teachers had less pressure from the parents (CHAL6, M=0.40 SE=0.17).

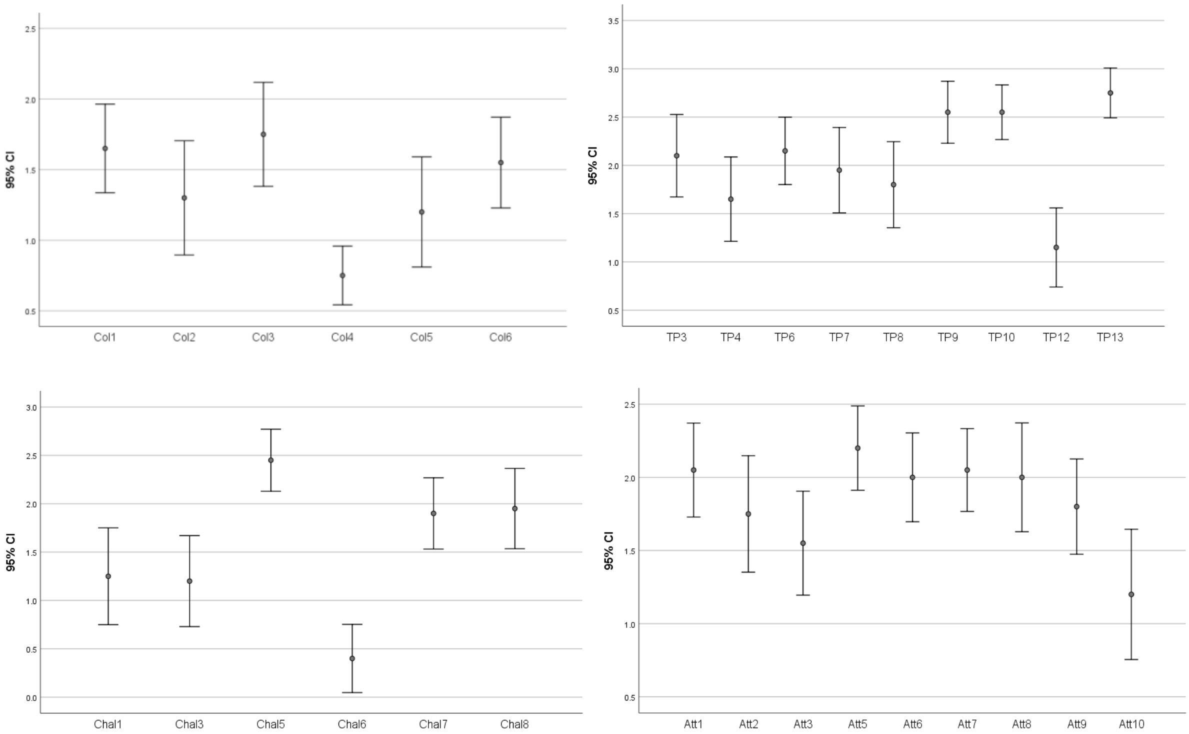


Figure 6.10 Error bars of teachers’ latent variables

School-level data

School-level data consist of a school scale measuring school emphasis on academic success and school demographic information including school types, school location, physics laboratory, and principal’s highest education level and experience.

School types

Based on types, the schools which participated in this study can be grouped into four including public, private, religion-based public, and religion-based private schools.

The majority of schools in this study are private schools (37%), with public schools (32%). There were four religion-based private schools and two religion-based public schools. These school types can be seen in Figure 6.11 below.

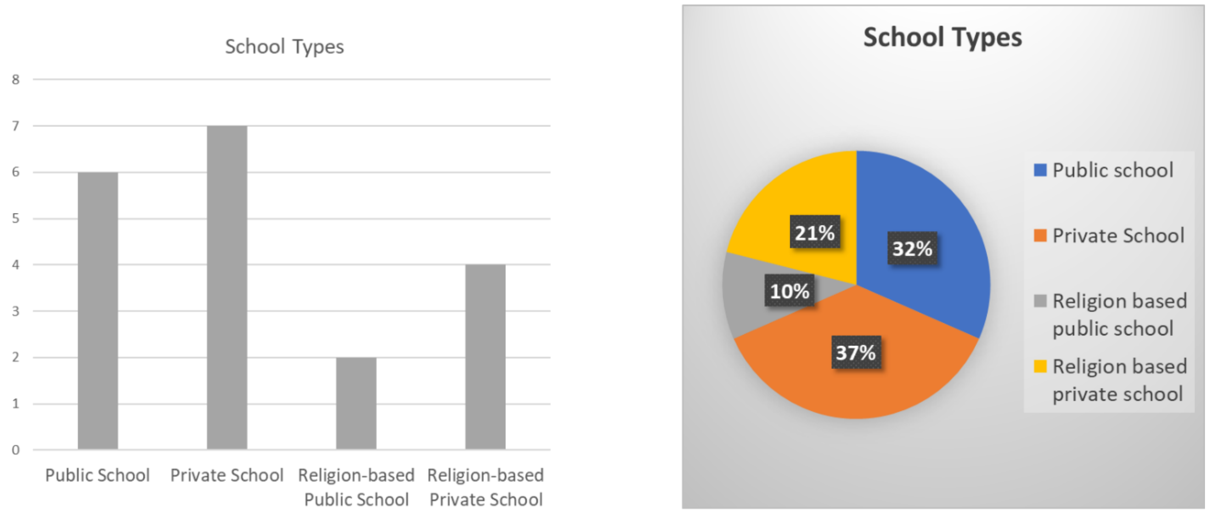


Figure 6.11 Distribution of school types participating in this study

School location

In terms of school location, schools were located in two different areas, namely urban and sub-urban areas. Because this study was located in Malang city, the majority of schools were located in both areas in, or close to, the city. The proportion of each school location was relatively well balanced, although urban schools outnumbered suburban schools by three (see Figure 6.12).

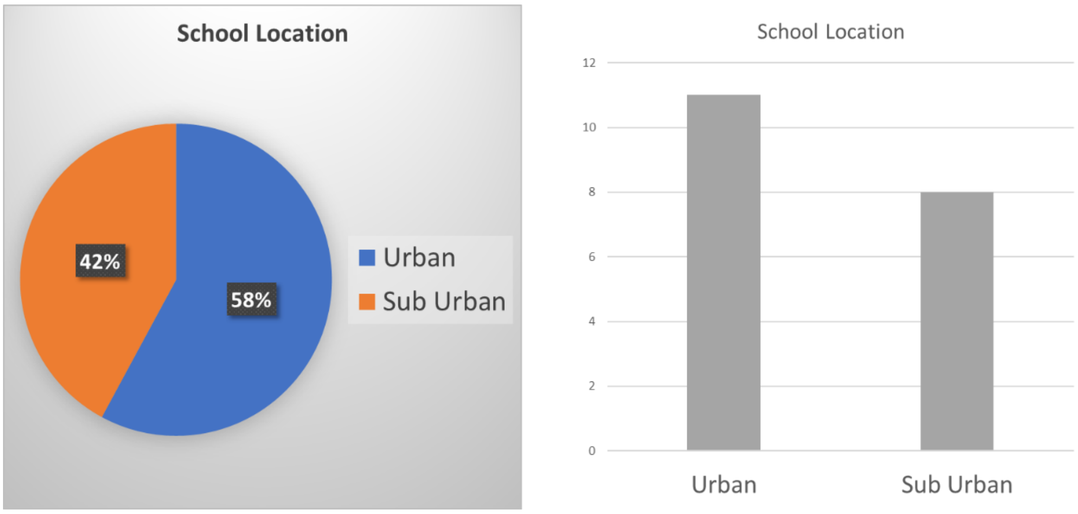


Figure 6.12 Distribution of schools based on location

Physics laboratory

Based on Figure 6.13, it can be seen that only two schools (11%) did not have a physics laboratory. However, a physics laboratory does not ensure the availability of laboratory staff to help physics teachers during the physics learning process. It can be seen that only 14 schools (74%) had laboratory staff within the physics laboratory.

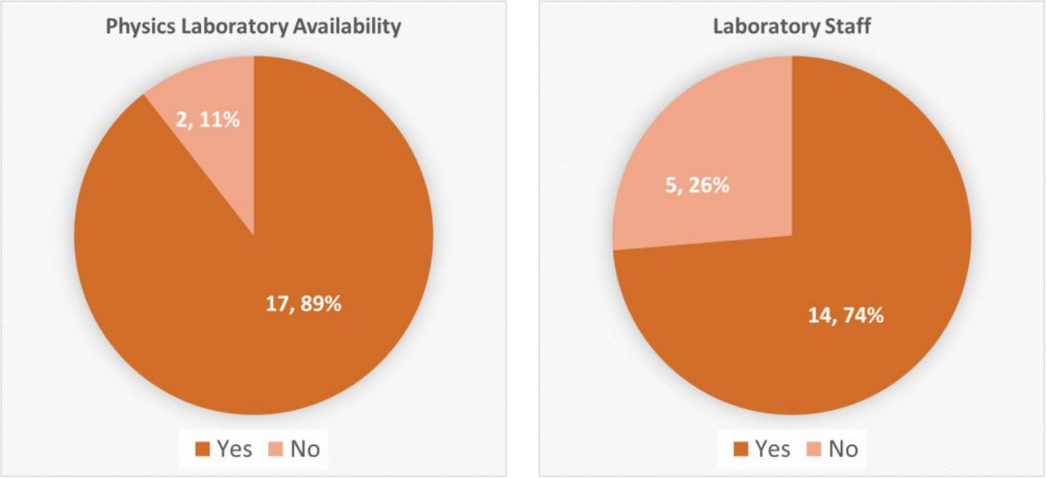


Figure 6.13 Physics laboratory and staff availability

Principal's highest education level and experience

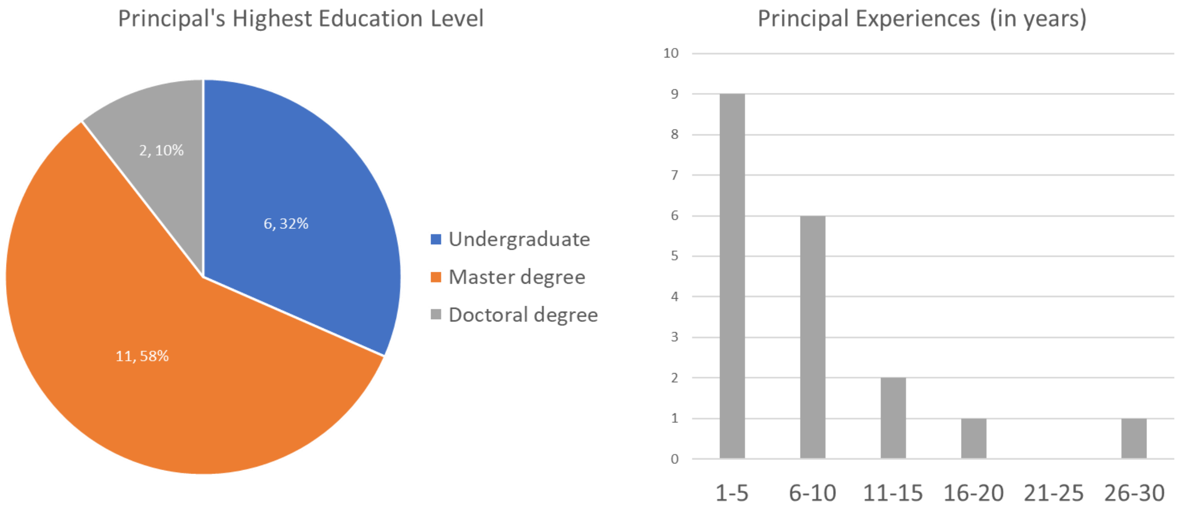


Figure 6. 14 Principal's highest education levels and experience (in years)

In terms of school principals' characteristics, it can be seen in Figure 6.14 that the majority of principals (11), graduated from their studies with a Masters degree. Only two principals graduated with an undergraduate degree.

In addition, the majority of principals had led their schools for under 11 years, with nine and six principals being in this position from 1 to 5 years and from 6 to 10 years respectively. Surprisingly, only one principal had been managing the school for about 30 years, much longer than other principals.

School latent variable

The school latent variable described here was examined for its construct validity and item validity. The school scale was considered as one factor after construct validity was checked using CFA (see Chapter 4). After both CFA and Rasch analyses were conducted, it can be concluded that all variables were retained to measure school emphasis on academic success. In addition, principals' views were measured in five scales: "1 = very low", "2 = low", "3 = medium", "4 = high", and "5 = very high".

Table 6.4 Descriptive statistics of principal scales

	Mean	**Std. Error**	**Std. Deviation**	**Skewness**	**Kurtosis**
SEAS1	4.37	0.11	0.50	0.59	-1.86
SEAS2	4.21	0.15	0.63	-0.17	-0.31
SEAS3	4.58	0.12	0.51	-0.35	-2.12
SEAS4	4.37	0.14	0.60	-0.31	-0.55
SEAS5	4.26	0.13	0.56	0.06	-0.17
SEAS6	3.58	0.19	0.84	-0.28	-0.18
SEAS7	3.89	0.19	0.81	-0.50	0.30
SEAS8	4.32	0.13	0.58	-0.12	-0.44
SEAS9	4.26	0.17	0.73	-0.47	-0.88
SEAS10	3.89	0.17	0.74	-0.76	1.49
SEAS11	4.11	0.17	0.74	-0.17	-1.00
SEAS12	4.00	0.17	0.75	0.00	-1.06
SEAS13	4.16	0.16	0.69	-0.21	-0.66

It can be seen in Table 6.5 that all variables were normally distributed. Distribution can be indicated by the skewness and kurtosis values within the acceptable range, which are < ±3 and Kurtosis < ± 8, respectively (Kline, 2016). Therefore, the data can be examined for causal relationships to check its influence on physics achievement using SEM and HLM.

Principals' responses to the principal questionnaire can be seen in Figure 6.15 using an error bar chart. The 95% confidence interval of the mean indicates that principals were of the view that the majority of parents, teachers, and students showed a positive emphasis on students' academic success. It can be seen that principals' response is more than 3.5 (high) on the items measuring principals' views regarding school emphasis on academic success.

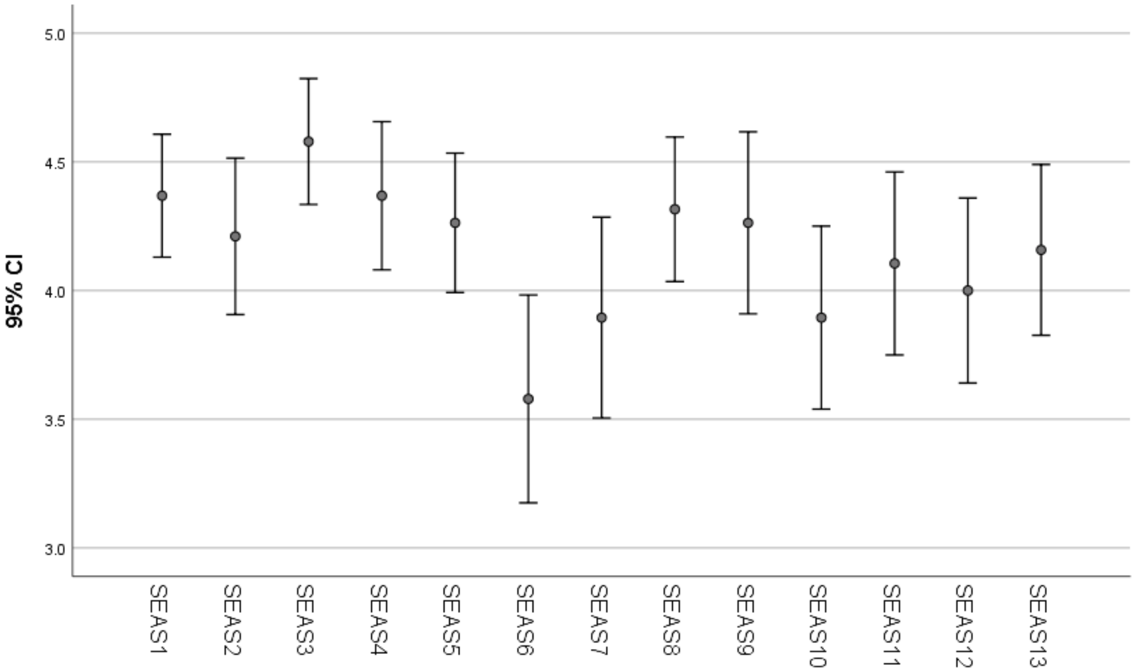


Figure 6.15 Error bars of principal latent variable

Summary

Descriptive statistics of demographic and latent variables were described in this chapter. The data were divided into three different groups: student-, teacher-, and school-level data.

Demographic information and general characteristics of students, teachers, and schools were described. Both pie and bar charts presented demographic information to simplify the information provided by tables which describe the nature of the data. In addition, error bar charts were provided to present the mean distribution of the latent variables.

In addition, all of the data are normally distributed, which is indicated by the values of skewness and kurtosis within the acceptable range < ±3 and Kurtosis < ± 8, respectively (Kline, 2016). Therefore, the data can be examined further in both SEM and HLM.

Data described in this chapter were analysed at a single level using SEM as will be reported in Chapter 7. The data were also analysed applying multilevel analysis combining all data into a single analysis using a multilevel model using HLM, proposed earlier in the hypothesised model described in Chapter 2.

CHAPTER 7

STRUCTURAL EQUATION MODELLING

Introduction

After scales were validated using CFA (Chapter 4) and Rasch analysis (Chapter 5), they were described using descriptive statistics in Chapter 6. Subsequently, causal relationships among variables/ scales and other demographic variables were explored using Structural Equation Modelling (SEM). These relationships are reported in this chapter at three different levels: student, teacher and principal analyses and examined using Mplus version 7. This statistical program offers easy-to-use software with a powerful ability to analyse a wide variety of statistical data from unorder categorical to continuous data with various statistical analysis (Muthén & Muthén, 1998-2017). The models analysed were hypothesised based on the theoretical framework described in Chapter 2 and modified based on modification indices and significance tests provided in Mplus 7 outputs.

In reporting SEM analysis, all variables are introduced first within each level. The codes and scale are described in this introduction followed by hypothesised models describing proposed relationships between variables. At the final stage, the final model is described in detail including significance of causal relationships among variables and their impact on physics achievement, where, in examining the significance of causal relationships, the cut-off value for *p-value* in this study is 0.05. Final models were decided based on fit indices and results of significance testing as described in Chapter 3.

Student-level model

The first model examined in this study is student level. This model examines the effect of several student-level variables in influencing physics achievement. The effects focus on physics achievement directly and indirectly. Before the hypothesis and final model are described, variables are introduced.

Variables included at student-level

Variables included at student level are listed in Tables 7.1 and 7.2 and divided into latent and observed variables. They can also be grouped into Presage, Process, and Product as indicated in Chapter 3 based on the 3Ps learning model.

Latent variables

The model proposes one latent variable, parent education (PARED). The parent education (PARED) variable is indicated by two indicators, mother's highest education level (MOTHED) and father's highest education level (FATHED). PARED is also part of Presage. The level of parents' highest education level is coded in Table 7.1.

Table 7.1 Latent variables at student-level model

Latent Variable		**Observed Variable**		**Code**
Variable	**Description**	**Variable**	**Description**	
PARED	Parent Education	MOTHED	Mother education highest level	1 = Less than senior high school, 2 = Senior high school, 3 = Diploma, 4 = Undergraduate, 5 = Master, 6 = Doctor, 7 = I don't know/ Missing values
		FATHED	Father education highest level	

Observed variable

The student-level model includes 10 observed variables (see Table 7.2). Students' future education aspirations (FUTED), students' gender (GENDER), students' age (YEAR), frequency of physics homework assigned to students (HOMEWORK), motivation to learn in additional physics tuition (ADDLMOT), duration of students' learning in additional physics tuition (ADDLDUR), and students' attitudes toward physics (LIKE, VALUE, SELFCONF) were examined in respect to their causal relationships with physics achievement (PHYACH). The level was estimated using different scales (see Table 7.2).

Six observed variables were coded using raw scores or scales as they were used in the student questionnaire. Variables are FUTED, GENDER, YEAR, HOMEWORK, ADDLMOT, and ADDLDUR. However, four observed variables for students' attitudes (LIKE, VALUE, SELFCONF) and ability (PHYACH) were estimated using W-score (see Table 7.2).

Table 7.2 Variables at student-level model

Variable	**Description**	**Code**
FUTED	Future Education	1 = Senior high school, 2 = Diploma, 3 = Undergraduate, 4 = Master, 5 = Doctor, 6= Missing values
GENDER	Gender	0 = male, 1 = female
AGE	Age	21, 20, 19 ,18, 17, 16, 99 = Missing values
SELFCONF	Self-confidence	W-score
LIKE	Like physics	W-score
VALUE	Value physics	W-score
HOMEWORK	Physics homework	1= Never, 2 = Less than once a week, 3 = Always
ADDLMOT	Motivation to learn at private tuition	1 = No, 2 = Yes, follow friends, 3 = Yes, parents order 4 = Yes, not left behind, 5 = Yes, be the best
ADDLDUR	Duration for private tuition	1 = Never, 2 = Less than 4 months, 3 = 4-8 moths, 4 = more than 8 months
PHYACH	Physics achievement	W-score

In addition, SELFCONF, LIKE, and VALUE are latent variables investigated via the student questionnaire, and their construct validity was validated using Confirmatory Factor Analysis (CFA). SELFCONF, LIKE, and VALUE are three correlated factors describing students' attitudes and analysed using CFA. However, in SEM analysis, these were treated as uncorrelated variables. Subsequently, item validity was also checked using Rasch analysis. During the Rasch analysis, students' attitudes (LIKE, VALUE, and SELFCONF) and physics achievement (PHYACH) were estimated using WLE-scores. WLE-scores were then converted into W-score using Microsoft Excel and using the equation provided in Chapter 3. The three factors were treated as observed variables in SEM analysis. W-scores were then used in subsequent SEM analysis in this chapter and HLM in Chapter 8 for these three factors and students' physics achievement.

Presage, Process, and Product variables

Variables can also be divided into three groups using 3Ps learning theory. The first group is Presage including PARED, GENDER, FUTED, and AGE. The second group is Process, including SELFCONF, LIKE, VALUE, ADDLMOT, ADDLDUR, and HOMEWORK. The third group is Product and includes PHYACH.

Hypothesised student-level model

This study proposed a hypothesised student-level model that can be seen in Figure 7.1. The model evaluates the causal relationship of one latent variable, which is parents' highest education level (PARED), and other 10 observed variables.

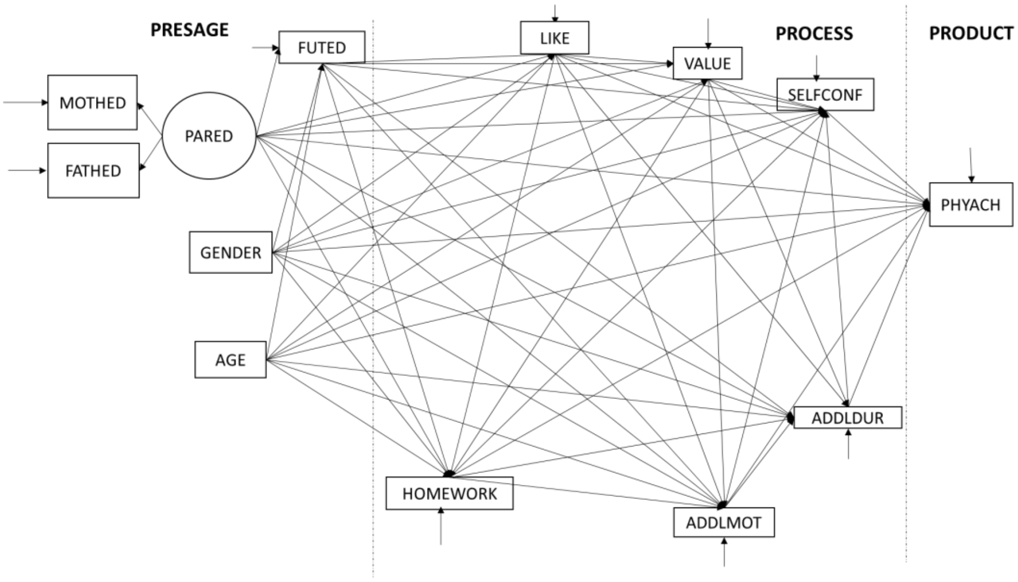


Figure 7.1 Hypothesised student-level model

Parents' highest education level (PARED)

PARED is the only latent variable in the student-level model, reflected by two indicators: mother's highest education level (MOTHED) and father's highest education level (FATHED). Furthermore, PARED is hypothesised to influence the other eight variables including students' physics achievement (PHYACH). PARED was predicted to influence students' vision to continue their future education (FUTED), frequency of physics homework assigned by teachers (HOMEWORK), students' like to learn physics (LIKE), students' self-confidence in learning physics (SELFCONF), how students value physics (VALUE), students' motivation to enrich physics through attending additional private tuition (ADDLMOT), attending additional private tuition in physics within a particular period (ADDLDUR), and students' achievement in physics indicated by students' score in the diagnostic test (PHYACH).

Gender difference (GENDER)

Students' gender (GENDER) (as a part of presage) was predicted to influence FUTED, HOMEWORK, LIKE, VALUE, SELFCONF, ADDLMOT, ADDLDUR, and PHYACH.

Age difference (AGE)

Students' age (AGE) was predicted to influence physics achievement (PHYACH) and other variables including FUTED, HOMEWORK, LIKE, VALUE, SELFCONF, ADDLMOT, ADDLDUR.

Future education aspirations (FUTED)

Students' aspirations to learn more at a higher level (FUTED) is also investigated in this model. FUTED is hypothesised to be affected by PARED, GENDER, and YEAR. FUTED is also hypothesised to influence several variables including LIKE, VALUE, SELFCONF, HOMEWORK, ADDLMOT, ADDLDUR, and PHYACH.

Students' attitudes toward physics (ATTITUDE)

Another variable is students' attitudes toward physics (ATTITUDE). Based on the results of CFA in Chapter 4, the three-factor correlated model was selected for attitudes toward physics. The three factors are students' interest in studying with respect to physics (LIKE), students' values in physics as a subject (VALUE), and students' self-confidence during physics learning (SELFCONF).

Students' like physics as a subject (LIKE) was predicted to influence VALUE, ADDLMOT, ADDLDUR, SELFCONF, HOMEWORK, and PHYACH. In addition, LIKE was hypothesised to be affected by all presage variables (GENDER, AGE, PARED, FUTED).

Furthermore, students' values in physics as a subject (VALUE) were predicted to be influenced by LIKE, GENDER, AGE, PARED, and FUTED. In terms of its influence, VALUE was predicted to affect ADDLMOT, ADDLDUR, SELFCONF, HOMEWORK, and PHYACH.

Moreover, students' self-confidence in learning physics (SELFCONF) as a part of ATTITUDE were hypothesised to be influenced by all variables in presage (GENDER, AGE, PARED, FUTED). SELFCONF was also predicted to be affected by other ATTITUDE variables (LIKE and VALUE), HOMEWORK, ADDLMOT, and ADDLDUR. In addition, SELFCONF was predicted to influence students' physics achievement (PHYACH).

Frequency of physics homework assigned by physics teachers (HOMEWORK)

Another aspect investigated in this hypothesised model is the frequency of physics homework assigned by teachers (HOMEWORK). Homework as a tool for enriching student's skills and concepts in physics was hypothesised to influence ADDLMOT, ADDLDUR, SELFCONF, and PHYACH. HOMEWORK was also predicted to be influenced by FUTED, GENDER, YEAR, PARED, LIKE, SELFCONF, and VALUE.

Motivation and duration in attending physics private tuition (ADDLMOT, ADDLDUR)

Private tuition in physics is investigated using motivation underlying students attending additional physics tuition (ADDLMOT) and duration of tuition (ADDLDUR). In the hypothesised model, ADDLDUR is affected by ADDLMOT. Both variables are affected by PARED, GENDER, AGE, FUTED, LIKE, VALUE, and HOMEWORK. In addition, both variables are predicted to influence SELFCONF and PHYACH.

Final student-level model

Structural Equation Modelling (SEM) analysis was performed to test the hypothesised model at student level. During analysis, both the unstandardised estimate (b) and standardised estimate (β) indicating the relation estimate between variables were examined. Fit indices were also reported to check how well the data fit the model.

Measurement model

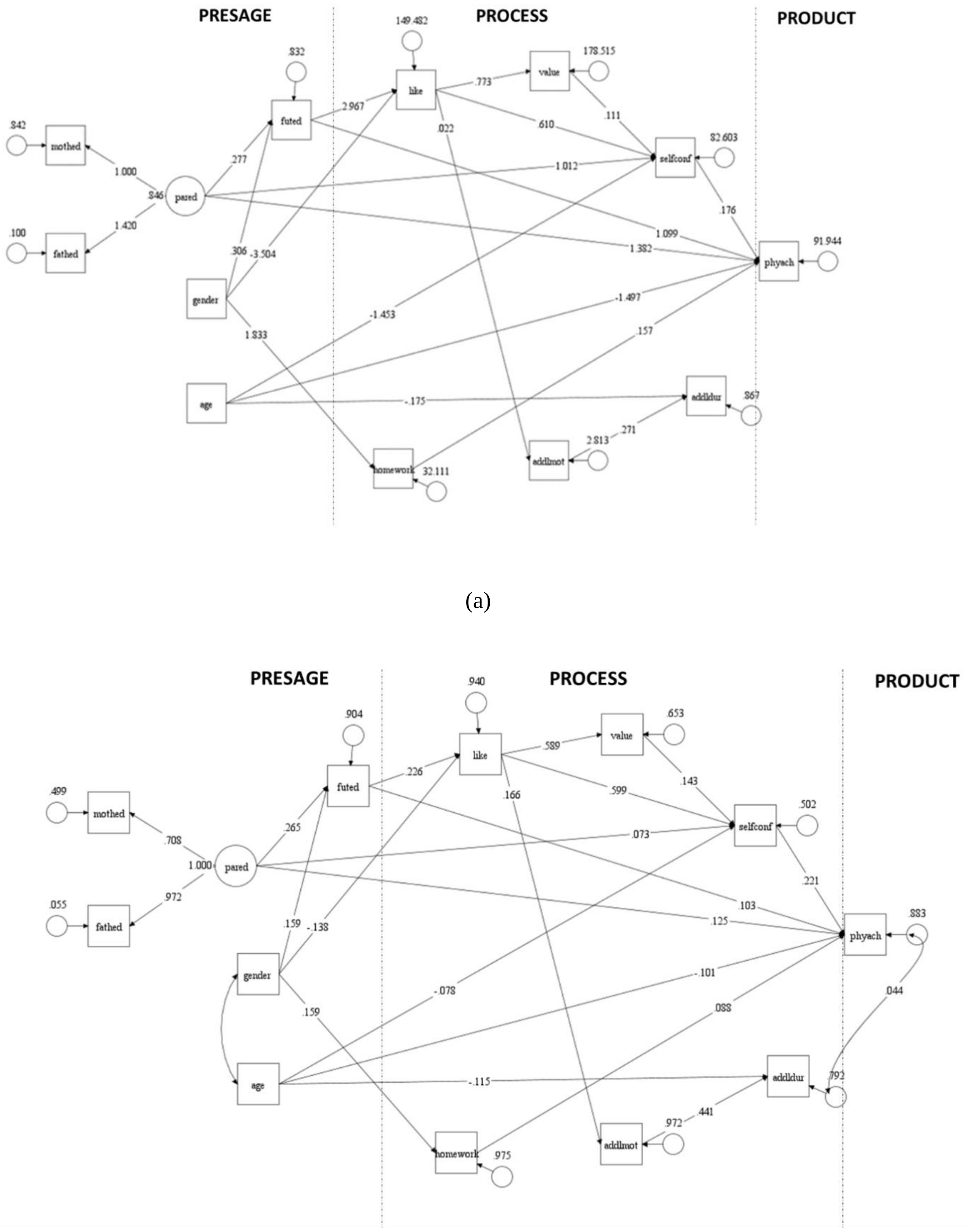
Measurement of the final student-level model shows that both mother's highest education level (MOTHED) and father's highest education level (FATHED) exhibited significant relationship with parents' highest education level (PARED). Both MOTHED (β = 0.708, b = 1.000) and FATHED (β = 0.972, b = 1.420) indicate a strong relationship with PARED, and was more than the cut-off value (0.3) (see Table 7.3).

Table 7.3 Measurement model at student-level

	Standardised				**Unstandardised**			
	β	S.E.	Est./S.E.	*p*	b	S.E.	Est./S.E.	*p*
PARED BY								
MOTHED	0.708	0.025	28.818	0.000	1.000	0.000	999.000	999.000
FATHED	0.972	0.002	519.089	0.000	1.420	0.070	20.284	0.000

Structural model

It can be seen in Table 7.4 that variables included in the final student-level model are future education aspirations (FUTED), students' age (AGE), self-confidence (SELFCONF), parents' highest education (PARED), frequency of physics homework assigned by teachers (HOMEWORK), liking of physics (LIKE), motivation and duration in doing private tuition on physics (ADDLMOT and ADDLDUR), and gender difference (GENDER). In addition, the results of SEM analysis can be seen in Figures 7.2(a) and Figure 7.2(b) for unstandardised and standardised estimates, respectively.



(a)

(b)

Figure 7.2(a) Unstandardised final student-level model, and 7.2(b) Standardised final student-level model

Students’ future education aspirations (FUTED)

Students’ future education aspirations (FUTED) is affected by two variables: students’ gender (GENDER, β = 0.159, b = 0.306) and parents’ highest education level (PARED, β = 0.265, b = 0.277). The positive effect of students’ gender (GENDER) on students’ future education aspirations (FUTED) indicates that female students tend to have higher levels of future education aspirations. Similarly, the effect of parents’ higher education level (PARED) on students’ level of future education aspirations (FUTED) can be interpreted as students whose parents graduated from higher education levels tend to have higher levels of aspiration to continue their education.

Table 7.4 Direct effect of several variables on students’ physics achievement

	Standardised				**Unstandardised**			
	β	S.E.	Est./S.E.	*p*	b	S.E.	Est./S.E.	*p*
FUTED ON								
GENDER	0.159	0.043	3.646	0.000	0.306	0.085	3.588	0.000
PARED	0.265	0.044	6.013	0.000	0.277	0.049	5.604	0.000
LIKE ON								
GENDER	-0.138	0.045	-3.088	0.002	-3.504	1.144	-3.063	0.002
FUTED	2.967	0.044	5.102	0.000	2.967	0.596	4.981	0.000
VALUE ON								
LIKE	0.589	0.030	19.592	0.000	0.773	0.049	15.827	0.000
SELFCONF ON								
PARED	0.073	0.035	2.080	0.038	1.012	0.489	2.070	0.038
AGE	-0.078	0.034	-2.308	0.021	-1.453	0.628	-2.312	0.021
LIKE	0.599	0.036	16.561	0.000	0.610	0.041	14.691	0.000
VALUE	0.143	0.041	3.519	0.000	0.111	0.032	3.502	0.000
HOMEWORK ON								
GENDER	0.159	0.046	3.349	0.001	1.833	0.540	3.394	0.001
ADDLMOT ON								
LIKE	0.166	0.045	3.704	0.000	0.022	0.006	3.652	0.000
ADDLDUR ON								
AGE	-0.115	0.041	-2.793	0.005	-0.175	0.063	-2.789	0.005
ADDLMOT	0.441	0.037	11.869	0.000	0.271	0.025	10.712	0.000
PHYACH ON								
PARED	0.125	0.048	2.615	0.009	1.382	0.535	2.582	0.010
AGE	-0.101	0.045	-2.254	0.024	-1.497	0.664	-2.252	0.024
SELFCONF	0.221	0.044	5.059	0.000	0.176	0.036	4.935	0.000
FUTED	0.103	0.046	2.269	0.023	1.099	0.486	2.260	0.024
HOMEWORK	0.088	0.045	1.986	0.047	0.157	0.080	1.972	0.049

Liking of physics as a subject (LIKE)

How students tend to like physics as a subject (LIKE) is affected by both students' gender (GENDER, β = -0.138, b = -3.504) and students' future education aspirations (FUTED, β = 0.226, b = 2.967). The causal relationship of students' gender (GENDER) shows a negative relationship, which means that male students like physics as a subject more than female students. However, students' future education aspirations exhibit positive relationships. This means that the higher the level of students' future education aspirations, the more students like physics as a school subject. Furthermore, based on standardised value, it can be concluded that students' future education aspirations have a greater effect on how students like physics compared to students' gender on how students tend to like physics as a subject.

Students' value on physics (VALUE)

It can be seen in Table 7.4 that how students like physics (LIKE, β = 0.589, b = 0.773) influences how students give value on physics (VALUE). The positive effect of LIKE on VALUE indicates that students who like physics tend to give more value on physics as a subject.

Students' self-confidence in learning physics (SELFCONF)

Four variables influence students' self-confidence in learning physics (see Table 7.4). These variables are parents' highest education level (PARED, β = 0.073, b = 1.012), students' age (AGE, β = -0.078, b = -1.453), students' liking of physics (LIKE, β = 0.599, b = 0.610), and students' value on physics (VALUE, β = 0.143, b = 0.111). Three variables exhibit a positive causal relationship with students' self-confidence in learning physics. The first variable is parents' highest education level, where students whose parents graduated from higher levels of education tend to show more self-confidence in learning physics. The second variable is student liking of physics (LIKE), which shows that students who like physics tend to have higher levels of self-confidence in learning physics. The third variable is valuing of physics (VALUE), which addresses a higher level of values to learning physics that also relates to a higher level of self-confidence in learning physics. However, students' age difference (AGE) indicates a negative causal relationship with students' self-confidence (SELFCON). The relationship indicates that those students, younger than their counterparts, tend to have higher levels of self-confidence in learning physics. In addition, if we compare the influence of variables on students' self confidence in learning physics, it can be concluded that students liking of physics (LIKE) shows the highest influence on physics self-confidence when learning physics.

Frequency of physics homework assigned by the teacher (HOMEWORK)

It can be seen in Table 7.4 that frequency of physics homework assigned by the teacher is influenced by students' gender (GENDER, $\beta = 0.159$, $b = 1.833$). The positive causal relationship between GENDER and HOMEWORK indicates that the teacher assigned more physics homework in a physics class dominated by female students.

Motivation to study additional physics tuition (ADDLMOT)

There is only one variable, students liking physics (LIKE, $\beta = 0.166$, $b = 0.022$), that influences students' motivation to study through additional physics tuition (ADDLMOT). LIKE shows a positive causal relationship on ADDLMOT. This means that students who like physics (LIKE) will likely indicate a higher level of motivation to attend additional physics tuition.

Duration of study in additional physics tuition (ADDLDUR)

The duration of study in additional physics tuition (ADDLDUR) is affected by two variables: students' age (AGE) and students' motivation to learn in additional physics tuition (ADDLMOT). Age difference shows a negative relationship (AGE, $\beta = -0.115$, $b = -0.175$)

with students' duration to study through additional physics tuition (ADDLDUR). This negative relationship indicates that younger students are more likely to attend additional tuition. However, students' motivation to attend additional tuition has a positive impact (ADDLMOT, $\beta = 0.441$, $b = 0.271$) on additional physics tuition (ADDLDUR), which means students have higher motivation to attend additional tuition. Furthermore, students' motivation to attend additional tuition (ADDLMOT) has a bigger impact than AGE, indicated by the standardised coefficient for ADDLMOT being bigger than AGE.

Physics achievement (PHYACH)

There are five variables that show a direct effect on students' physics achievement (PHYACH) including parents' highest education level (PARED, $\beta = 0.125$, $b = 1.382$), students' age (AGE, $\beta = -0.101$, $b = -1.497$), self-confidence in learning physics (SELFCONF, $\beta = 0.221$, $b = 0.176$), students' future education aspirations (FUTED, $\beta = 0.103$, $b =1.099$), and physics homework (HOMEWORK, $\beta = 0.088$, $b = 0.157$). The positive relationship of students' self-confidence (SELFCONF) indicates that students who show more self-confidence in learning physics tend to perform better in physics. Another variable which exhibits a positive direct effect on physics achievement is students' future education aspirations (FUTED). This means students who have higher future education aspirations tend to achieve better in physics. Similar, with future education aspirations, the frequency of physics homework assigned to students (HOMEWORK) positively influences achievement in physics, as students who were assigned more frequent homework tend to achieve better in physics. Moreover, parents' highest education level indicates that students whose parents have higher education levels tend to show better physics achievement. However, it is different with the effect of students' age (AGE) on students' achievement. Students' age exhibits a negative effect, showing that younger students tend to achieve better in physics.

Indirect effect of variables on students' physics achievement

This study focused exclusively on indirect effects of variables on physics achievement. Other indirect effects are still available, because every variable has a possibility of interacting with others, but they are not described in this chapter. This is because this study focused on reporting the effect of factors or variables on physics achievement.

Table 7.5 Indirect and total effect of several variables on students' physics achievement

	Standardised				**Unstandardised**			
	β	S.E.	Est./S.E.	*p*	b	S.E.	Est./S.E.	*p*
Effects from PARED to PHYACH								
PARED-FUTED-PHYACH	0.027	0.013	2.122	0.034	0.304	0.145	2.103	0.035
PARED-SELFCONF-PHYACH	0.016	0.008	1.931	0.053	0.178	0.093	1.913	0.056
PARED-FUTED-LIKE-SELFCONF-PHYACH	0.008	0.003	2.977	0.003	0.088	0.030	2.914	0.004
PARED-FUTED-LIKE-VALUE-SELFCONF-PHYACH	0.001	0.000	2.272	0.023	0.012	0.006	2.244	0.025
Direct	0.125	0.048	2.615	0.009	1.382	0.535	2.582	0.010
Total indirect	0.052	0.016	3.343	0.001	0.582	0.178	3.262	0.001
Total	0.177	0.047	3.771	0.000	1.964	0.535	3.670	0.000
Effects from GENDER to PHYACH								
GENDER-FUTED-PHYACH	0.016	0.009	1.918	0.055	0.336	0.176	1.912	0.56
GENDER- HOMEWORK-PHYACH	0.014	0.008	1.719	0.086	0.288	0.169	1.712	0.087
GENDER-LIKE- SELFCONF-PHYACH	-0.018	0.007	-2.579	0.010	-0.375	0.146	-2.562	0.010
GENDER-LIKE-VALUE-SELFCONF-PHYACH	-0.003	0.001	-2.081	0.037	-0.053	0.025	-2.071	0.038
GENDER-FUTED-LIKE-SELFCONF-PHYACH	0.005	0.002	2.491	0.013	0.097	0.039	2.471	0.013
GENDER- FUTED-LIKE-VALUE- SELFCONF- PHYACH	0.001	0.000	2.033	0.042	0.014	0.007	2.022	0.043
Total Indirect	0.015	0.015	1.026	0.305	0.308	0.300	1.025	0.306
Total	0.015	0.015	1.026	0.305	0.308	0.300	1.025	0.306
Effects from AGE to PHYACH								
AGE-SELFCONF-PHYACH	-0.017	0.008	-2.104	0.035	-0.255	0.122	-2.093	0.036
Direct	-0.101	0.045	-2.254	0.024	-1.497	0.664	-2.252	0.024
Total indirect	-0.017	0.008	-2.104	0.035	-0.255	0.122	-2.093	0.036
Total	-0.118	0.045	-2.613	0.009	-1.752	0.672	-2.608	0.009

In addition, this sub-section only shows indirect effects of several variables with paths that started from presage variables. The final student-level model shows that all four variables in the presage stage, including gender difference (GENDER), parents' highest education level (PARED), students’ age (AGE), and future education aspirations (FUTED), exhibit indirect effects on students’ achievement on several paths. The indirect effect of these four variables can be seen in Table 7.5 and Figure 7.2. Table 7.5 shows the magnitude of the effects of variables on physics achievement, and Figure 7.2 shows the effects of variables on physics achievement.

Indirect effects of PARED on PHYACH

Physics achievement (PHYACH) is influenced indirectly by parents’ highest education (PARED) on four different paths via PARED, FUTED, LIKE, VALUE, and SELFCONF variables. The first path PARED indirectly influences PHYACH through FUTED ($\beta = 0.027$, $b = 0.304$). The indirect effect of parent highest education level (PARED) on physics achievement (PHYACH) is a positive relationship. This means that the higher the level of parents’ education, the higher the level of students’ aspirations to continue their study in future, and accordingly, higher students’ physics achievement. The second path PARED indirectly influences PHYACH through SELFCONF ($\beta = 0.016$, $b = 0.178$) that shows that the effect of parent’s highest education level positively influences students’ self-confidence, and in turn positively influences students’ physics achievement. The third path, PARED indirectly influences PHYACH through FUTED, LIKE, and SELFCONF ($\beta = 0.008$, $b = 0.088$). The positive relationship of the indirect effect of PARED through this path indicates that the higher parents’ highest education level (PARED), the higher students’ aspirations to continue their study (FUTED), the more students like learning physics (LIKE), the more self-confidence students have in learning physics (SELFCONF), and the better students perform in physics (PHYACH). The fourth path, parents’ highest education level (PARED) showed an indirect positive influence on physics achievement (PHYACH) through future education aspirations (FUTED), liking of physics (LIKE), valuing of physics (VALUE) and self-confidence during physics learning (SELFCONF) (β = 0.001, b = 0.012). This means that the higher parents' highest education level (PARED), the higher students' future education aspirations (FUTED), the more students like physics (LIKE), the more students value physics (VALUE), the more students have self-confidence in learning physics (SELFCONF), and the better students perform in physics (PHYACH).

Indirect effect of GENDER on PHYACH

Physics achievement is also influenced indirectly by students' gender (GENDER) through four different paths. The variables that indirectly influence physics achievement include FUTED, LIKE, VALUE, and SELFCONF.

In the first path, GENDER influences PHYACH through FUTED (β = 0.016, b = 0.336). This indicates that students' physics achievement is influenced by gender through future education aspirations. The relationship shows that female students tend to have higher future education aspirations, which positively influence their achievement. In the second path, PHYACH is influenced by GENDER through HOMEWORK (β = 0.014, b = 1.712) indicating that physics achievement is affected by gender through the frequency of physics homework assigned by teachers. The third path, GENDER indirectly influences PHYACH through LIKE and SELFCONF (β = -0.018, b = -0.375). Through this path, male students tend to like physics better compared to female students, where students who highly like physics as a subject will show self-confidence more in learning physics, and also had better physics achievement. However, different from the first and second path, PHYACH is also influenced negatively by GENDER through LIKE-VALUE-SELFCONF (β = -0.003, b = -0.053). This negative relationship means that male students perform better than female students in physics. The path of indirect influence is similar to the third path, but this fourth path shows that instead of influencing students' self-confidence directly, students' liking physics influences students' value of physics first, before influencing students' self-confidence and finally, physics achievement. Similar to the third path, the fourth path shows that male students tend to like physics more than female students, where students who like physics more express more values to physics and had more self-confidence in learning physics, and finally showed better performance. Different from the third and fourth path, both fifth and sixth paths exhibit a positive relationship with physics achievement. The fifth path shows that GENDER indirectly influenced PHYACH through FUTED, LIKE, and SELFCONF ($\beta = 0.005$, $b = 0.097$). Female students showed aspiration to continue their studies at a higher level compared to male counterparts. Those students who aspired to continue with future study (FUTED) meant that more students liked learning physics, and more students had more self-confidence in learning physics. Furthermore, the sixth path, GENDER, indirectly influences PHYACH through FUTED, LIKE, VALUE, and SELFCONF ($\beta = 0.001$, $b = 0.014$). This path is similar to the fourth path, but liking physics (LIKE) does not directly influence self-confidence in physics learning (SELFCONF); instead liking physics influences self-confidence during learning physics through valuing physics, where female students who like physics show both valuing physics and self-confidence during learning physics more and positively influence physics achievement.

Indirect effect of AGE on PHYACH

Physics achievement was indirectly affected by students' age (AGE) through students' self-confidence in learning physics (SELFCONF) ($\beta = -0.017$, $b = -0.255$). This negative relationship shows that younger students show self-confidence more during physics learning and tended to perform better in physics.

Total effect of PARED, GENDER, and AGE on PHYACH

The total effect of PARED, GENDER, and AGE on students' physics achievement can be calculated by adding direct and indirect effects of these variables. It can be seen in Table 7.5, that parents' highest education level exhibits the biggest effect on physics achievement ($\beta = 0.177$, p=0.000), followed by AGE ($\beta = -0.118$, p=0.009) and GENDER ($\beta = 0.015$, p=0.306).

Fit indices

This study used the traditional cut-off value (0.90) for CFI and TLI to indicate the best model fit (Wang & Wang, 2012). It can be seen through CFI and TLI that both values are greater than the cut-off value, where CFI = 0.948 and TLI = 0.925. Furthermore, RMSEA = 0.053 (less than 0.06). This means that the final model has a good fit with the data and can be used to interpret factors influencing physics achievement of Year 12 students in Malang, Indonesia.

Table 7.6 The fit indices at Student-level Model

Fit Indices	χ^2	df	χ^2/df	CFI	TLI	RMSEA
Values	103.728	45	2.305	0.948	0.925	0.053

Teacher-level model

Nine variables at teacher-level model listed in Table 7.7 were examined for their causal interaction. These variables were divided into three groups based on 3Ps learning theory (see Chapters 2 and 3): Presage, Process and Product.

Four variables were examined for their causal relationship at the Presage stage including teacher's highest education level (EDUC), major education background of physics teacher (MAJOR), physics classroom size (CLASIZE), and teaching certificate in physics

(CERT). Furthermore, teachers' major background education (MAJOR) was included into three dummy variables: physics education (PHYE), physics (PHY), and chemistry education (CHEME), indicating teachers graduated from physics education, physics, and chemistry education, respectively. Moreover, physics class size (CLASIZE) was also compared in this study to check its effects on physics achievement. Class size was coded by using the number of students learning in class. In addition, teachers' highest education level (EDUC) was also investigated to determine any impact on students' physics achievement. Education levels were coded by using numbers to examine the effect of education of teachers from undergraduate to doctoral level. Another variable examined in this model is teaching certificate in the physics classroom (CERT).

Table 7.7 Variables investigated in the teacher-level model

Variable	**Description**	**Code**
MAJOR	Teachers' Major of education	Dummy variables
PHYED	Physics Education	0 = No
PHY	Physics	1 = Yes
CHEMED	Chemistry education	
CLASIZE	Class size	Number of students
TEDUC	Teacher education qualification	1 = Undergraduate Level, 2 = Master, 3 = Doctor
CERT	Teacher certificate	0 = No, 1 = Yes
ATT	Teacher's attitudes toward physics learning	W score
COLL	Teachers' collaboration	W score
CHALL	Teaching challenges	W Score
TP	Teaching practice	W score
PHYACH	Aggregated data physics achievement	W Score

The second group is Process where four variables were included: teachers' attitudes toward physics teaching (ATT), teachers' collaboration (COLL), challenges faced by the physics teachers (CHALL), and teaching practice in physics (TP). These are latent variables and treated as a measured variable using the W-score resulting from Rasch analysis (see Chapter 5). The step to get the W-score was described at student-level model.

The third group is Product, that is, physics achievement (PHYACH). It is different from the physics achievement used at student level where scores were calculated by the score obtained by students when they finished the diagnostic test, the physics achievement at teacher level is the mean value of the students' scores within a class. These scores represent physics achievement of the students learning in the physics class taught by the particular physics teachers in average. Physics achievement at teacher level are mean values of student scores on the diagnostic test based on physics teachers. These mean values were calculated using SPSS version 26.

Teacher-level hypothesised model

The hypothesised model uses the 3Ps learning model to examine the effects of variables on physics achievement. The variables examined causal interaction in the hypothesised model that can be seen in Figure 7.3.

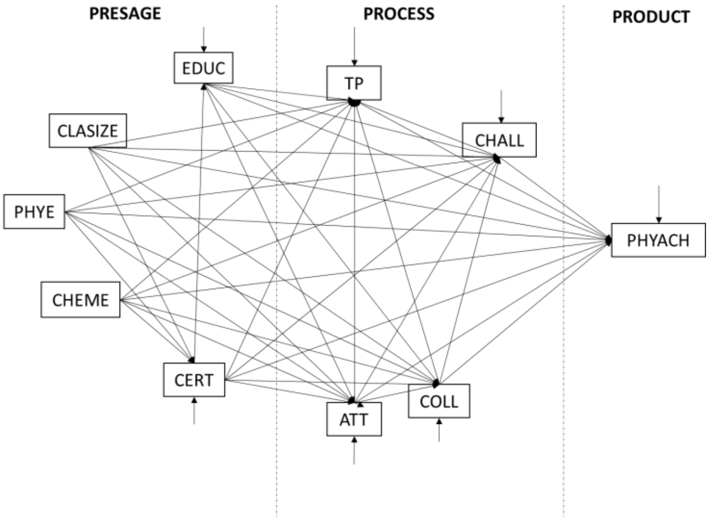


Figure 7.3 Hypothesised teacher-level model

Teachers' major education (PHYE, PHY, and CHEME)

Teachers' major education was examined for its effect on physics achievement by using three dummy variables including physics education (PHYE), physics non-education (PHY) and chemistry education (CHEME). This study used physics as the education major (PHY) as a basic comparison for other dummy variables. In other words, the effect of both physics education study (PHYE) and chemistry education study (CHEME) as teachers' major compared to teachers who graduated from a physics non-education study (PHY) on physics achievement. These dummy variables were predicted to influence teacher certification (CERT), teachers' attitudes (ATT), teaching practice (TP), teachers' collaboration (COL), teachers' challenges (CHALL), and students' physics achievement (PHYACH).

Class size (CLASIZE)

Class size is predicted to have a relationship with teacher certification (CERT), teachers' attitudes toward physics teaching and learning (ATT), teachers' collaboration (COL), challenges faced by teachers (CHALL), teaching practice (TP) and students' physics achievement (PHYACH).

Teaching certificate (CERT)

Teaching certificate (CERT), which is the Indonesian government's attempt to increase education quality and help teachers focus on teaching quality by fulfilling their basic needs, is checked for its effect on highest education level (TEDUC), teachers' attitudes toward physics teaching and learning (ATT), teachers' collaboration (COL), challenges faced by teachers (CHALL), teaching practice (TP), and students' physics achievement (PHYACH).

Teacher education qualification (TEDUC)

Teachers' highest education level (TEDUC) is also investigated for its effect on teachers' attitudes toward physics teaching and learning (ATT), teachers' collaboration (COL), challenges faced by teachers (CHALL), teaching practice (TP), and students' physics achievement (PHYACH).

Teachers’ attitudes toward physics teaching and learning (ATT)

Teachers’ attitudes toward physics teaching and learning (ATT) is predicted to influence physics achievement (PHYACH), teachers’ collaboration (COL), challenges faced by teachers (CHALL), and teaching practice (TP) at the process stage.

Teachers’ collaboration (COLL)

To investigate the impact of teachers’ collaboration, promoted by the Indonesia government through the subject based teacher association, the model investigates the effect of teachers’ collaboration (COLL) on other variables including challenges faced by teachers (CHALL), teaching practice (TP), and students’ physics achievement (PHYACH).

Teaching practice (TP)

Teaching practice (TP) is predicted to influence challenges faced by teachers (CHALL) and physics achievement (PHYACH).

Teachers’ Challenges (CHALL)

Challenges faced by teachers (CHALL) can be predicted to influence physics achievement (PHYACH).

Final teacher-level model

Unstandardised and standardised final teacher-level models can be seen in Figure 7.4 (a & b). Surprisingly, there is no variable which exhibits a significant effect on students’ achievement in physics in the final teacher-level model, which only shows the interaction of several variables within the presage and process stages.

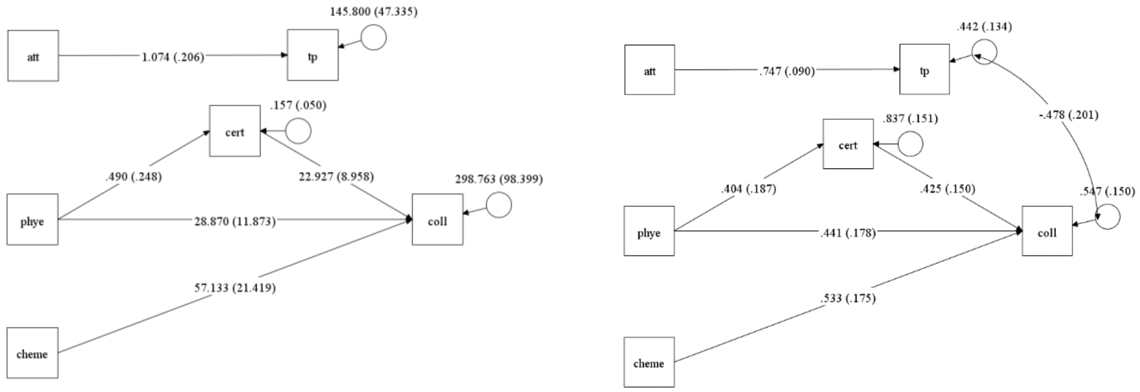


Figure 7.4 Final teacher-level model (a) unstandardised model (b) standardised model

The final model shows that at Presage stage, both teachers' educational background (PHYE and CHEME) and teachers' certification (CERT) indicated interaction with how teachers collaborate with other physics teachers (COLL). Furthermore, at the Process stage there are three variables showing interactions including teachers' collaboration (COLL), teachers' attitudes toward physics teaching and learning (ATT), and teaching practice (TP).

Table 7.8 Final teacher-level model

	Standardised				**Unstandardised**			
	b	S.E.	Est./S.E.	*p*	β	S.E.	Est./S.E.	*p*
Direct Effect								
CERT ON								
PHYE	0.404	0.187	2.161	0.031	0.490	0.248	1.976	0.048
COLL ON								
PHYE	0.441	0.178	2.482	0.013	28.870	11.873	2.432	0.015
CHEME	0.553	0.175	3.045	0.002	57.133	21.419	2.667	0.008
CERT	0.425	0.150	2.822	0.005	22.927	8.959	2.559	0.010
TP ON								
ATT	0.747	0.090	8.301	0.000	1.074	0.206	5.205	0.048
Indirect effect								
PHYE -CERT- COLL	0.172	0.103	1.667	0.096	11.239	7.185	1.564	0.118
Total effect	0.613	0.181	3.378	0.001	40.108	13.067	3.070	0.002

Teaching physics certificate (CERT)

It can be seen in the final model that teachers who graduated from a physics education major (PHYE, β = 0.404, b = 0.490) are more likely to be certified, compared to those who graduated from a physics non-education major (PHY and CHEME).

Teachers’ collaboration (COLL)

Teachers who graduated from a physics education (PHYE, β = 0.441, b = 28.870) and chemistry education (CHEME, β = 0.553, b = 57.133) tend to collaborate more with other physics teachers compared to those who graduated from a physics education major (PHY). In addition, based on the total effect, the teacher learning physics education (PHYE, β = 0.613, b = 4.018) shows more collaboration than the teacher who graduated from non-physics education (chemistry education or physics). This indicates that if the effect of certification is combined with major education, teachers who graduated from physics education and received a teaching certificate show more collaboration than other teachers.

Attitudes toward physics teaching and learning

Teachers’ attitudes toward teaching and learning (ATT, β = 0.747, b = 1.074) exhibit a significant effect on teaching practice (TP). It can be concluded that teachers who have a more positive attitude have better teaching practice compared to others.

Model fit

The traditional cut-off score (0.90) was used for CFI and TLI to indicate the best model fit (Wang & Wang, 2012). This can be seen through CFI= 0.910 (CFI > 0.9) but also TLI=0.823 (TLI < 0.9). Although the TLI value is less than the cut-off value, this model can be seen as a best fit for the teacher-level model due to the small-size sample participating in this study and TLI value is sensitive to sample size. Furthermore, RMSEA is more than the cut-off value (0.05) (RMSEA= 0.135).

Table 7. 9 The fit indices at teacher-level model

Fit Indices	χ^2	df	χ^2/df	CFI	TLI	RMSEA
Values	36.734	12	2.367	0.911	0.823	0.135

School-level model

Variables used in the school-level model are listed in Table 7.8. This model examines a causal relationship between several variables at principal level in influencing physics achievement. In line with the 3Ps learning model, causal interaction examined in this model, was divided into three groups: Presage, Process, and Product.

At the Presage stage, students' enrolled in participant schools (ENROLL), the availability of a physics laboratory (LAB), the availability of laboratory staff (LABSTAFF), the availability of a library (LIB), the principal's experience in managing the school (EXP), a public school (PUBLIC), a private school (PRIVATE), a religion-based public school (RELPUB), religion-based private school (RELPRI), school location (LOCATION) and the principal's highest education level (EDUC) were examined for their causal interaction in influencing physics achievement of Year 12 students.

Table 7.10 Variables used in school-level model

Observed variable		Code
Variable	Description	
ENROLL	Student enrolment	
LAB	Physics laboratory	0 = No, 1 = Yes
LABSTAFF	Physics laboratory staff	0 = No, 1 = Yes
LIB	Library availability	0 = No, 1 = Yes
EXP	Principal experience	
EDUC	Education qualification	
School types		
PUBLIC	Public schools	0 = No, 1 = Yes
PRIVATE	Private schools	
RELPUB	Religion-based public school	
RELPRI	Religion-based private school	
LOCATION	School location	0 = Sub Urban, 1 = Urban
SEAS	School Emphasis Academics Success	W-score
PHYACH	Aggregated data physics achievement	W-score

At the Process stage, principals' views regarding school emphasis on academic success (SEAS) were examined to check its effects on students' physics achievement. This variable is a factor which was constructed by responses in the principal questionnaire. During

SEM analysis, this factor was treated as a variable. The SEAS scale was converted into W-score during Rasch analysis.

At the Product stage, physics achievement (PHYACH) at school level is the aggregated value of the physics achievement score at teacher level. Aggregated values were calculated by using SPSS version 26, representing physics achievement of students learning in schools managed by principals.

Hypothesised school-level model

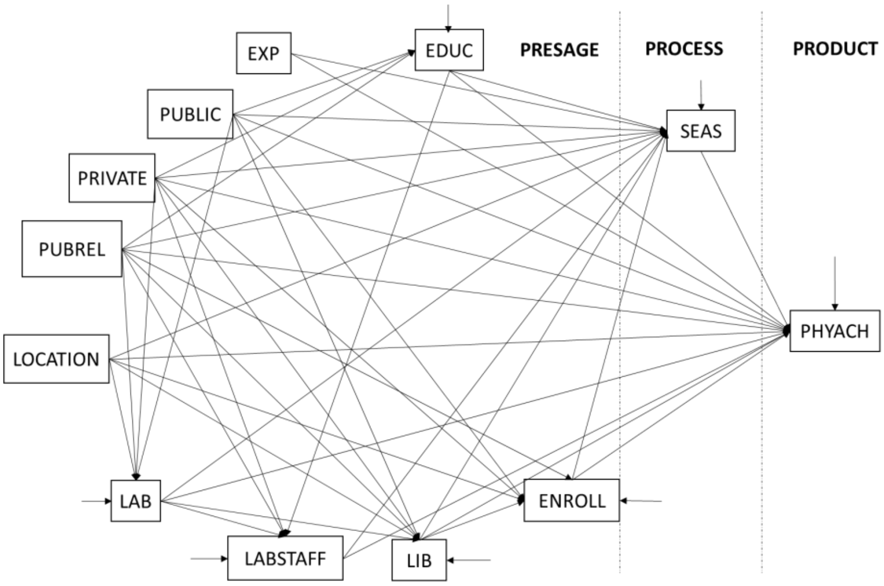


Figure 7.5 Hypothesised school-level model

The hypothesised model for school-level model can be seen in Figure 7.5, indicating causal relationships in the model. Physics achievement (PHYACH) was predicted by 11 variables including school emphasis on academic success (SEAS), availability of a library (LIB), student enrolment (ENROLL), principals' highest education level (EDUC), principals' experience (EXP), physics laboratory (LAB), physics laboratory staff (LABSTAFF), public schools (PUBLIC), private schools (PRIVATE), religion-based public schools (PUBREL), and school location (LOCATION).

School type (TYPE)

The model examines the effect of school type (TYPE) on other variables using four dummy variables including public school (PUBLIC), private school (PRIVATE), religion-based public school (PUBREL), and religion-based private school (RELPRI). This model uses RELPRI as the basic comparison where the influence of all school types is compared with religion-based private school (RELPRI). All dummy variables are predicted to influence physics laboratory (LAB), physics laboratory staff (LABSTAFF), student enrolment (ENROLL), availability of a library (LIB), principals' highest education level (EDUC), school emphasis on academic success (SEAS) and physics achievement (PHYACH).

School location (LOCATION)

School location (LOC) is predicted to influence physics laboratory (LAB), physics laboratory staff (LABSTAFF), student enrolment (ENROLL), availability of a library (LIB), principals' highest education level (EDUC), school emphasis on academic success (SEAS) and physics achievement (PHYACH).

Availability of a physics laboratory (LAB)

Availability of a physics laboratory in the school (LAB) is predicted to impact on physics laboratory staff (LABSTAFF), student enrolment (ENROLL), availability of a library (LIB), school emphasis on academic success (SEAS) and physics achievement (PHYACH).

Physics laboratory staff (LABSTAFF)

Physics laboratory staff (LABSTAFF) is predicted to influence three variables including student enrolment (ENROLL), school emphasis on academic success (SEAS) and physics achievement (PHYACH).

Availability of a library (LIB)

Availability of a library (LIB) is predicted to impact on three variables including student enrolment (ENROLL), school emphasis on academic success (SEAS) and physics achievement (PHYACH).

School enrolment (ENROLL)

School enrolment is predicted to influence both SEAS and PHYACH with school emphasis on academic success (SEAS) and physics achievement (PHYACH).

School emphasis on academic success (SEAS)

School emphasis on academic success (SEAS) is predicted to influence only physics achievement (PHYACH).

Final school-level model

It can be seen in Figure 7.6 and Table 7.11 that availability of a physics laboratory showed a significant influence on physics achievement. Availability of a physic laboratory shows a positive relationship (LAB, β = 0.526, b = 13.443) indicating that students tend to perform better in schools facilitated by a physics laboratory than schools that do not have a physics laboratory.

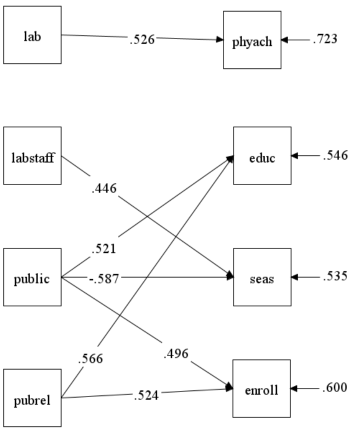


Figure 7.6 Final school-level model

Table 7.11 Final school-level Model

	Standardised				Unstandardised			
	B	S.E.	Est./S.E.	*P*	β	S.E.	Est./S.E.	*p*
SEAS ON								
PUBLIC	-0.587	0.147	-4.005	0.000	-23.671	8.488	-2.789	0.005
LABSTAFF	0.446	0.171	2.611	0.009	21.331	8.700	2.452	0.014
ENROL on								
PUBLIC	0.496	0.166	2.984	0.003	149.729	52.771	2.837	0.005
PUBREL	0.524	0.169	3.094	0.002	239.529	88.224	2.715	0.007
EDUC ON								
PUBLIC	0.521	0.160	3.248	0.001	0.703	0.225	3.133	0.002
PUBREL	0.566	0.160	3.527	0.000	1.156	0.376	3.074	0.002
PHYACH ON								
LAB	0.526	0.149	3.529	0.000	13.443	4.385	3.066	0.002

School emphasis on academic success (SEAS)

The final model shows that school emphasis on academic success (SEAS) is significantly influenced by public school (PUBLIC) and availability of laboratory staff (LABSTAFF). It can be seen in Table 7.11 that school type has a different influence on SEAS whereas public schools have a negative relationship on SEAS (PUBLIC, β = -0.587, b = -23.671). This negative relationship indicates that compared to other school types, public schools (PUBLIC) exhibit a worse effect on how the school emphasises academic success (SEAS). Furthermore, availability of staff in the physics laboratory shows a positive relationship with SEAS (LABSTAFF, β = 0.446, b = 21.331). This positive relationship indicates that schools with staff that help the physics teacher in the laboratory had better emphasis in supporting students' academic success (SEAS).

School enrolment (ENROL)

The final model shows a significant influence of school type on student enrolment (ENROL). It can be seen in Table 7.11 that there is a positive influence between both public schools (PUBLIC, β = 0.496, b = 149.729) and religion-based public schools (PUBREL, β = 0.524, b

= 239.529) on school enrolment (ENROL). This influence indicates that more students were enrolled in both public schools (PUBLIC) and religion based-public schools (PUBREL) compared to students enrolled in both religion-based private schools (RELPRI) and private schools (PRIVATE).

This positive relationship can also show that more students choose to enrol in public schools compared to private schools. It can also be concluded that public schools were the favourite schools in Malang, Indonesia. Thus, public schools are managed and subsidised by the Indonesian government in providing both teacher salary and facilities to ensure the school quality where the private schools were struggle to undertake (Togatorop, 2017).

Principals' highest education level (EDUC)

In terms of highest education level (EDUC), it can be concluded that school types have a positive correlation with principals' education level. This positive relationship shows that principals working in religion-based public schools (PUBREL, $\beta = 0.556$, $b = 1.156$) and public schools (PUBLIC, $\beta = 0.703$, $b = 13.443$) graduated at a higher level of education than both religion-based private schools (RELPRI) and private schools (PRIVATE). Such a positive relationship indicates that principals in public schools tend to graduate at a higher level of education compared to their counterparts in private schools.

Model fit

In terms of fit indices, the final model was examined using the traditional cut-off score (0.90) for CFI and TLI to indicate the best model fit (Wang & Wang, 2012). It can be seen in Table 7.12 that the model exhibited CFI= 0.9612 (CFI > 0.9) and TLI=0.981 (TLI > 0.9). Furthermore, RMSEA is 0.06 and χ^2/df is 1.068. It can be concluded that the best model fit is this final model.

Table 7. 12 The fit indices at school-level model

Fit Indices	χ^2	Df	χ^2/df	CFI	TLI	RMSEA
Values	9.612	9	1.068	0.981	0.953	0.060

Summary

Chapter 7 highlights Structural Equation Modelling (SEM) analysis conducted in this study. The SEM analysis was conducted in student-, teacher-, and school-level models separately, using MPlus version 7 to examine causal relationships between variables within each level. Variables in this SEM analysis were also divided into three P groups, which are Presage, Process, and Product, as proposed in the 3Ps learning model in Chapter 3.

At student level, after the causal relationship of variables was examined, the final model showed that five variables influenced physics achievement directly. For example, physics achievement (PHYACH) of Year 12 students was influenced directly by parents' highest education level (PARED, $\beta = 0.125$, $b = 1.382$), students' age (AGE, $\beta = -0.101$, $b = -1.497$), students' self-confidence in learning physics (SELFCONF, $\beta = 0.221$, $b = 0.176$), students' future education aspirations (FUTED, $\beta = 0.103$, $b =1.099$), and the frequency of physics homework assigned by the teacher (HOMEWORK, $\beta = 0.088$, $b = 0.157$). Compared to other variables, students' self-confidence in learning physics (SELFCONF) had the biggest effect on physics achievement (PHYACH).

It can also be concluded that parents' highest education level (PARED), students' self-confidence in learning physics (SELFCONF), students' future education aspirations (FUTED), and frequency of physics homework assigned by the teacher (HOMEWORK) showed a positive relationship with physics achievement (PHYACH). This meant that the more positive students show these three latent variables, the higher students achieved in their physics study. However, age difference (AGE) showed a negative relationship where younger students tended to perform better in their physics class.

Moreover, at student level, physics achievement was also influenced indirectly by three presage variables including parents' highest education level (PARED), gender difference (GENDER), and age difference (AGE) through different paths where the highest education level of parents had the biggest influence on physics achievement. Firstly, parents' highest education level (PARED) influenced indirectly physics achievement (PHYACH) by using four different paths through future education aspirations (FUTED), liking of physics (LIKE), valuing of physics (VALUE), and self-confidence during learning physics (SELFCONF). Secondly, physics achievement was also affected indirectly by gender difference (GENDER) within six different paths through five other variables including future education aspirations (FUTED), frequency of physics homework assigned by the teachers (HOMEWORK), liking of physics (LIKE), valuing of physics (VALUE), and self-confidence during learning physics (SELFCONF). Thirdly, physics achievement was influenced indirectly by age difference (AGE) and self-confidence in learning physics (SELFCONF).

In addition, at teacher level, there were no variables which exhibited significant effects on students' achievement in physics, and the final teacher-level model only showed the interaction between several variables at the Presage stage and several variables at the Process stage. Thus, it can be seen in the final model that teachers who graduated from a physics education major (PHYE, $\beta = 0.404$, $b = 0.490$) had more teaching certification compared to those who graduated from a physics non-education major (PHY). In addition, teachers who graduated from physics education (PHYE, $\beta = 0.441$, $b = 28.870$) and chemistry education (CHEME, $\beta = 0.553$, $b = 57.133$) showed more collaboration when compared to teachers who graduated from a physics major (PHY). Furthermore, teachers who graduated from a physics education study (PHYE) also showed an indirect effect through teaching certification (CERT) on teachers' collaboration (COLL), where teachers with a teaching certificate tended to collaborate more with other physics teachers than their counterparts. In terms of teachers' collaboration, teachers who graduated from both a physics education study and a chemistry education study collaborated more than teachers who graduated from a physics non-education study. Furthermore, teachers who graduated from a physics education course (PHYE) undertook more collaboration than those who graduated from a chemistry education course (CHEME) as indicated by the standardised score.

Moreover, at school level, only the availability of a physics laboratory (LAB) positively influenced physics achievement (PHYACH), whereas students who learnt at schools with a physics laboratory tended to perform better in physics. Furthermore, public schools (PUBLIC) showed less emphasis on academic success (SEAS) as compared with other school types. In addition, schools with laboratory staff (LABSTAF) showed better SEAS than their counterparts. Furthermore, more students enrolled in public schools (PUBLIC) and religion-based public schools (PUBREL) than in both religion-based private schools (RELPRI) and private schools (PRIVATE). Moreover, principals working at public schools (PUBLIC) and religion-based public schools (PUBREL) showed a higher education level than principals working at religion-based private schools (RELPRI) and private schools (PRIVATE).

The results found in this chapter can be compared with the results from data analysis at multilevel. In multilevel analysis, the data were examined in a multilevel environment. Multilevel analysis is reported in the next chapter using Hierarchical Linear Modelling (HLM).

CHAPTER 8

HIERARCHICAL LINEAR MODELLING

Introduction

In Chapter 7, the student-, teacher-, and school-level data were analysed using Structural Equation Modelling (SEM) to examine causal interaction among variables within three single-level analyses. The data were treated separately, with no relationship between different levels. However, it is important to consider the nature of the data where students are nested into different schools or classes. This may influence causal interaction among variables or the significance of factors influencing physics achievement. Therefore, it is essential to conduct analysis that accommodates the nature of the data that allows for interaction of variables within different levels.

In line with this consideration, this study employed the Hierarchical Linear Model (HLM) because students were nested within schools that share particular characteristics which may differ (Goldstein, 2011; Ker, 2014; Snijders & Bosker, 2011). Students learning within the same class share several characteristics, such as school characteristics, within groups as contextual explanatory variables that may cause difference in students' achievement besides individual explanatory variables such as gender and age (Field, 2018; Hox et al., 2017). Therefore, students who share similar characteristics within the same class will be treated dependently at the school level. Thus, it is important to conduct a Hierarchical Linear Model (HLM) analysis to deal with nested data for Year 12 students in Malang, Indonesia.

HLM analysis is reported in this chapter to analyse factors influencing the physics achievement of Year 12 students in Malang, Indonesia. Before conducting HLM analysis, variables investigated in the two-level model are described first. The null model as a fully unconditional model is also reported to check the Intraclass Correlation Coefficient (ICC) in advance before assessing the final model (Hox et al., 2017; Mertens, Pugliese, & Recker, 2017; Woltman et al., 2012). The ICC is assessed to check that HLM is appropriately applied in investigating factors influencing physics achievement of Year 12 students in Malang, Indonesia. This step is essential because ICC is a useful parameter associated with random effects ANOVA and provides information about the proportion of between-group variability compared with variance in the outcome (Bryk & Raudenbush, 1992). The final model was assessed to check variance explained by factors influencing physics achievement after the null model indicated enough reason to carry out HLM analysis. Interaction effects were also examined to check interaction between variables at different levels in affecting physics achievement.

Variables in the two-level model

Before carrying out HLM analysis, variables examined their effects on physics achievement were specified in advance. These variables are grouped into two levels, namely student- and teacher-level data (see Table 8.1). HLM analysis grouped teacher- and school-level data into single-level data, namely teacher-level.

In addition, HLM does not allow for the formation of latent variables. Therefore, this study used Confirmatory Factor Analysis (CFA) in Chapter 4 and Rasch analysis in Chapter 5 to deal with latent variables. Construct validity of all scales used was examined using CFA in Chapter 4. Furthermore, Rasch analysis was carried out to deal with observed variables, except for demographic variables.

Table 8.1 Variables investigated in HLM analysis

Variable Code	Variable Description
School-level variables	
TEDUC	Teacher highest education level (1 = Undergraduate, 2 = Master, 3 = Doctoral)
LOCATION	School location (0 = Urban, 1 = Sub Urban)
MAJOR	Teacher major study
PHYED	Physics education (0=No, 1=Yes)
PHY	Physics non-education (0=No, 1=Yes)
CHEMED	Chemistry education (0=No, 1=Yes)
CERT	Teacher certification (1 = Yes, 2 = No)
CLASIZE	Total number of students in the class
COL	Teachers' collaboration (W-score)
CHALL	Teaching challenging (W-score)
ATT	Teachers' attitudes toward teaching and learning in physics (W-score)
TP	Teaching practice (W-score)
ENROL	Students enrolment in the academic year
LAB	Disaggregated value of physics laboratory facility (0 = No, 1 = Yes)
LABSTAFF	Disaggregated value of physics laboratory staff availability (0 = No, 1 = Yes)
EDUC	Disaggregated value of principal education level (1 = less than under-graduate, …, 4 = Doctoral)
SEAS	Disaggregated value of school academic emphasis (W-score)
TYPE	School Type
PUBLIC	Public schools (0 = No, 1 = Yes)
PRIVATE	Private schools (0 = No, 1 = Yes)
RELPUB	Religion based Public school (0 = No, 1 = Yes)
RELPRI	Religion based private schools (0 = No, 1 = Yes)
TFUTED	Aggregated value of student future education at student-level
THOMEWORK	Aggregated value of physics homework assigned at student-level
TADDLMOT	Aggregated value of students' motivation to attend additional tuition in physics at student-level
TADDLDUR	Aggregated value of students' duration in attending additional tuition in physics at student-level
TGENDER	Aggregated value of students' gender at student-level
TAGE	Aggregated value of students' age at student-level
TVALUE	Aggregated value of students' values of physics at student-level
TSELFCONF	Aggregated value of students' self-confidence in learning physics at student-level
TLIKE	Aggregated value of students' liking of physics at student-level
TPARED	Aggregated value of parents' highest education level at student-level
Student-level variables	
GENDER	Students' gender (0 = male, 1 = female)
AGE	Students' age
PHYACH	Physics achievement (W-score)
HOMEWORK	The frequency of physics homework (1 = Never, …, 4 = Always)
ADDLMOT	Students' motivation to attend additional tuition on physics (1 = No, …4=Yes, be the best)
ADDLDUR	Learning duration on additional physics tuition (1 = Never, …, 4 = more than 8 months)
PARED	Students' parents' highest education level (1 = less than senior high school, …,6 = Doctor)
SELFCONF	Self-confidence in learning physics (W-score)
LIKE	Liking of physics (W-score)
VALUE	Valuing of physics (W-score)

Student-level variables

At student level, nine variables were examined for their effects on students’ physics achievement (PHYACH) including gender difference (GENDER), age difference (AGE), physics homework assigned by teachers (HOMEWORK), motivation to attend additional physics tuition (ADDLMOT), duration to attend additional physics tuition (ADDLDUR), self-confidence in learning physics (SELFCONF), liking of physics (LIKE), and valuing of physics (VALUE). Six variables used original scales in collecting data in the student questionnaire; however, three variables including SELFCONF, LIKE and VALUE used W-score (see Table 8.1).

School-level variables

At school level, variables included in the examination are combined with data collected in the teacher questionnaire, aggregated data of student-level data, and disaggregated value of school-level data. The data collected in the teacher questionnaire includes the highest education level of teachers (TEDUC), major education of students (MAJOR), teaching certification in teaching physics (CERT), number of students learning in class (CLASIZE), teachers’ collaboration (COL), teaching challenges (CHAL), teachers’ attitudes toward teaching and learning in physics class (ATT), and teaching practice (TP).

Furthermore, student-level data were also included in teacher-level analysis. At the school level, student data were aggregated by calculating the mean values of student-level variables based on teachers. The new variables are aggregated values of all student-level variables including students’ future education aspirations (TFUTED), frequency of physics homework (TPHYSICS), students’ motivation to attend additional physics tuition (TADDLMOT), duration to attend additional physics tuition (TADDLDUR), gender

(TGENDER), age (TAGE), students' values on physics (TVALUE), students' liking on physics (TLIKE), students' self-confidence (TSELFCONF), and parents' highest level of education (TPARED). However, this is different from student-level data, if student-level data were aggregated, and school-level data collected in principal questionnaires were disaggregated. After the disaggregated process, five new variables were used at teacher-level including disaggregated values of school type (TYPE), students' enrolment in the academic year (ENROL), availability of physics laboratory (LAB), availability of staff at the physics laboratory (LABSTAFF), and principal's highest educational level (EDUC).

In addition, both school type (TYPE) and teacher major study (MAJOR) employed dummy variables in examining their influences on physics achievement. On teacher educational background, a physics non-education major (PHY) was used as the basic comparison. Physics teachers graduating from both a physics education major (PHYED) and chemistry education (CHEMED) were compared with the basic comparison (PHY). Furthermore, for school type (TYPE), the basic comparison is religion-based private schools (RELPRI). Other variables including public schools (PUBLIC), private schools (PRIVATE), and religion-based public schools (RELPUB) were compared with religion-based private schools (RELPRI) as the basic comparison.

Two-level model of physics achievement

A two-level model was proposed to describe the causal relationship among variables between and within levels (see Figure 8.1). The model indicates that variables are grouped into two levels, namely student- and school-level data. This two-level model is chosen because the majority of sample schools participating in this study only had one teacher for Year 12 physics classes in Malang, Indonesia, except for a religion-based public school that had two physics teachers who participated in this study. Therefore, this model proposes a two-level model using data collected from student- and teacher-level data. As described in chapter 3, student-level data were collected using the student questionnaire and physics diagnostic test, and teacher-level data were collected using both the teacher questionnaire and school questionnaire.

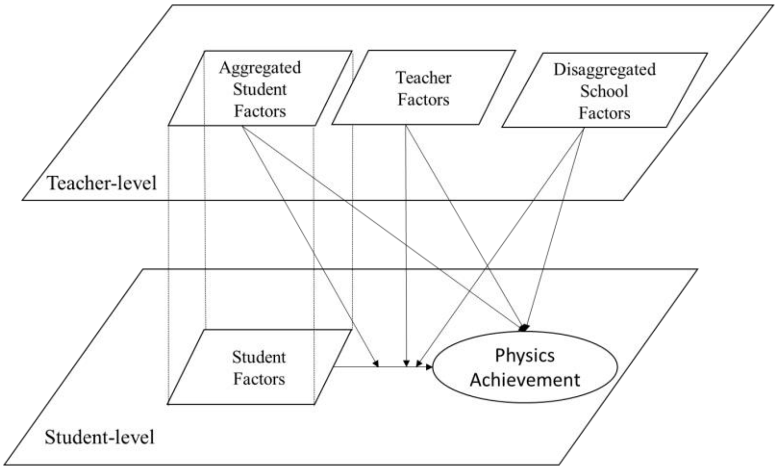


Figure 8.1 Two-level model of physics achievement

It should be noted that even though this model does not show the 3Ps learning model directly, this multilevel model employs the 3Ps framework in describing factors influencing physics achievement of Year 12 students in Malang, Indonesia. Variables included in each stage and hypothesised in this HLM are described in this chapter.

Hypothesised Model

Figure 8.2 shows the two-level hypothesised model proposed in this study based on previous studies in the theoretical framework presented in Chapter 2. Figure 8.2 shows the causal relationship that may occur among factors influencing physics achievement (PHYACH). The figure was drawn based on Figure 8.1 by adding more detail on factors or variables within both student- and teacher-levels. Figure 8.2 also shows additional information about interaction effects among variables between teacher-level variables and student-level variables that may exist in the model. In addition, aggregated student factors (shown in Figure 8.2) are the aggregated values of student-level variables. Furthermore, at teacher level, nine variables were disaggregated from school-level variables. Disaggregated school variables can also be seen in Figure 8.2.

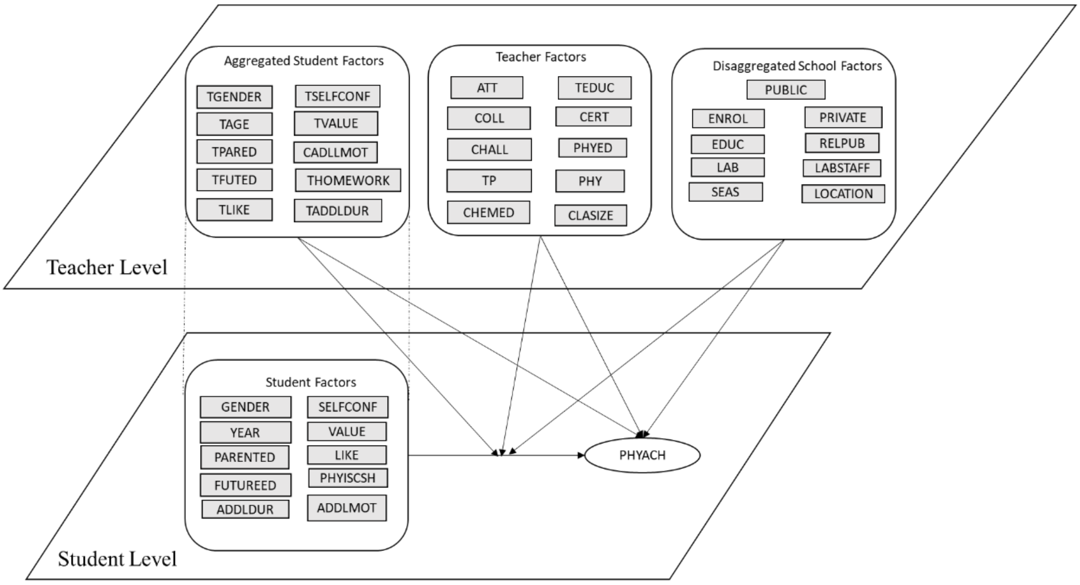


Figure 8.2 Hypothesised model at two levels of physics achievement

At student level, the causal relationship among variables examined included students' gender (GENDER), students' age (AGE), parent's highest education level (PARED), students' self-confidence in learning physics (SELFCONF), students' like in learning physics (LIKE), students' values in physics (VALUE), students' motivation to learn additional physics tuition outside school time (ADDLMOT), time spent by students to do additional physics tuition (ADDLDUR), and students' test scores (PHYACH). Based on their stages in the theoretical framework, these student-level variables could be grouped into three stages. The presage stage at the student level includes GENDER, YEAR, and PARED. Furthermore, the process stage includes SELFCONF, LIKE, VALUE, ADDLMOT, and ADDLDUR. In addition, the Product stage includes only students' scores in the physics diagnostic test adapted from the 2014 Physics national examination test (PHYACH).

Furthermore, at teacher level, the variables examined include teacher's related variables, principal related variables, students' aggregated data. Teacher's variables are indicated by teachers' major education (MAJOR), teacher certification (CERT), teacher highest education level (TEDUC), class size (CLASIZE), teaching challenges during the physics learning process (CHAL), teachers' collaboration (COL), teacher's attitudes (ATT), and teaching practice (TP). In addition, teachers' major education was examined using three dummy variables including teachers who graduated from physics education (PHYED), physics non-education (PHY), and chemistry education (CHEED). Furthermore, several variables using the principal questionnaire disaggregated their values and were grouped into the teacher-level. The disaggregated variables were physics laboratory availability (LAB), availability of laboratory staff (LABSTAFF), school location (LOCATION), principals' education level (EDUC), school type (TYPE) and school emphasis on academic success (SEAS). At this level, school types (TYPE) were examined using four dummy variables including public schools (PUBLIC), private schools (PRIVATE), religion-based public schools (RELPUB), and religion-based private schools (RELPRI). In addition, students' aggregated values were indicated by TGENDER, TYEAR, TPARENTED, TFUTURED, TADDLDUR, TSELFCONF, TVALUE, TLIKE, THOMEWORK, and TADLLMOT. In terms of the 3Ps proposed in the theoretical framework, variables at school level were grouped into two stages, namely Presage and Process. The Presage stage included MAJOR, CERT, TEDUC, CLASIZE, LAB, LAB, LOCATION, EDUCPRIN, PUBLIC, PRIVATE, RELPUB, and RELPRIV. Other variables, CHAL, COL, ATT, TP, TGENDER, CYEAR, TPARED, TFUTED, TADDLDUR, TSELFCONF, TVALUE, TLIKE, TPHYSICS, TADLLMOT and SEAS were included in the process stage.

The Null model

The null model was analysed at the initial step in HLM analysis to check the urgency of multilevel analysis of factors influencing physics achievement. This model has two main purposes, which are calculating the Intraclass Correlation coefficient (ICC) to identify the urgency of HLM, and providing statistics information as a baseline for further information when comparing more complex models (Garson, 2013). The null model is an initial step in HLM analysis before further analysis is conducted. The urgency of HLM can be seen by the variability of outcomes at both student- and teacher-level. This can be estimated through ICC indicating the variance proportion associated with teacher level.

The null model is the simplest hierarchical linear model because there is no predictor specified at both student- and teacher-level. Due to the predictor's absence, this model can also be seen as the fully unconditional model. This model can be considered as a one-way ANOVA with random errors (Raudenbush & Bryk, 2002), comparing the mean of the groups with additional information regarding measurement errors during collecting data.

Generally, the null model describes the students' achievement ($PhyAch_{ij}$) as partitioning of the variance across student- and teacher-levels within the mean student score and student/ teacher random error. The null model predicts students' achievement in physics of student *i* in a class taught by teacher *j* ($PhyAch_{ij}$) through the equations below.

The student-level model describing the physics achievement of student *i* who studied in a class taught by teacher *j* can be formulated in equation 8.1:

$$PhyAch_{ij} = \beta_{0j} + r_{ij} \tag{8.1}$$

where $PhyAch_{ij}$ represents physics achievement (students' score on the physics diagnostic test) of students *i* within a class taught by teacher *j*; β_{0j} represents the intercept or mean physics achievement for all students in school j; and r_{ij} is a random 'student effect' error or the deviation of the student i's score within school j from the school mean score. This equation generally includes students' physics achievement ($PhyAch_{ij}$), students mean physics achievement (β) and random error (e).

The level-2 (school-level) model employs school mean, β_{0j}, as an outcome varying randomly. This model can be seen in equation 8.2:

$$\beta_{0j} = \gamma_{00} + u_{0j} \tag{8.2}$$

where β_{0j} represents the mean physics achievement of students within school j; γ_{00} is the intercept or the grand mean of physics achievement for the students across classes; and u_{oj} indicates a random 'school effect' error or deviation from grand mean (γ_{00}) for the class taught by teacher j. Equation 8.2 then can be substituted in equation 8.1 to formulate a general model for physics achievement in this study.

If we combine both equation 8.1 and equation 8.2, the null model can be defined as follows:

$$PhyAch_{ij} = \gamma_{00} + u_{0j} + r_{ij} \tag{8.3}$$

Based on equation 8.3, it can be concluded that the physics achievement of Year 12 students in Malang, Indonesia is modelled by the mean value of students' physics achievement, combined with an individual student effect and a school effect described with their deviation toward the means. These effects are then identified as random effects and can be formulated in equation 8.4:

$$Var\left(PhyAch_{ij}\right) = Var\left(u_{oj} + r_{ij}\right) = \tau_{00} + \sigma^2 \tag{8.4}$$

The equation above indicates the variability of physics achievement, Var ($PhyAch_{ij}$) as the total variance in students' physics achievement (total outcome). The total variance is composed of student-level variance (σ^2) and teacher-level variance (τ_{00}). Both variances describe the variability of students' physics achievement within the school and the variability of students' achievement between schools respectively.

The proportion of variance associated with student-level in physics achievement can be seen below. Based on Table 8.2, the proportion of explained variance can be calculated based on variance components at the student level divided by total variance. The student-level variance proportion can be formulated in equation 8.5:

$$\rho_1 = \frac{\sigma^2}{\tau_{00}+\sigma^2} \tag{8.5}$$

In addition, the variance proportion attributed to teacher level is calculated using equation 8.6, which can also be seen as the Intra-class Correlation Coefficient (ICC) to measure variability between schools. This ICC can be also be used as an essential parameter for indicating HLM analysis in a particular study in equation 8.6:

$$\rho_2 = \frac{\tau_{00}}{\tau_{00}+\sigma^2} \tag{8.6}$$

Table 8.2 The null model: two-level model of physics achievement

Final estimation of fixed effects						
Fixed effect		Coefficient	Standard Error	t-ratio	Approx. d.f.	*p*-value
For INTRCPT1, β_{00}						
INTRCPT2, γ_{00}		500.207726	1.722757	290.353	19	0.000
Final estimation of level-1 and level-2 variance components						
Random Effect	Reliability	Standard Deviation	Variance Component	df	Chi-square	*p*-value
INTRCPT1, U0	0.954	7.72228	59.63368	19	435.04750	0.000
Level-1, R		7.73469	56.40943			
Statistics for current covariance components model						
Deviance			3309.543861			
Number of estimated parameters			2			

Using equation 8.6 above, the preliminary step can be done to examine the variance partition indicated by the ICC at teacher level. The calculation of variance component at student level is σ^2, and variance component in intercept1 is τ_{00}:

$$ICC = \frac{\tau_{00}}{\sigma^2 + \tau_{00}} = \frac{59.63368}{59.82549 + 56.40943} = 0.51$$

Based on the above calculation, it can be seen that the proportion of variance at school level is 0.51, which is not zero or negative. Therefore, HLM analysis in this study is needed to explain factors influencing physics achievement, since dependency among variables exists in this study (Garson, 2013). Furthermore, as shown in Table 8.1, the reliability estimate is 0.944. Because the reliability estimate value is more than 0.9, it can be concluded that there is a random effect for physics achievement (Bryk & Raudenbush, 1992). In conclusion, HLM is appropriately applied in this study.

Final model of students' physics achievement

After the examination of the null model, all variables at student level were tested one by one using a bottom-up approach. They were inputted from Presage to Product variables. Significant variables were retained, and insignificant variables were removed. At the next stage, the teacher-level model was examined using exploratory analysis to check the probability of variables at teacher level, to be included in the next analysis, and combined with significant variables at student level. These two stages are described in detail in the following sections.

Student-level model

The student-level model was calculated using all student-level variables listed in Table 8.1. These variables were entered into the HLM 6.08 software program freely within the student-level equation (see equation 8.1). To check significance variables influencing physics achievement, this study used 0.05 as the cut-off for *p-value*. The model selected significance variables when it had a *p-value* less than the cut-off value (0.05) and omitted non-significant variables from the equation when their *p-value* was more than the cut-off value (0.05).

After the variables were examined for their significance, the student-level model in describing the physics achievement of student *i* within the physics class taught by teacher *j*, $PhyAch_{ij}$ could be calculated. The result showed that only SELFCONF indicated a significant influence on physics achievement where its *p-value* is 0.005 (*p-value* < 0.05). Therefore, the study found the final equation at student level as 8.7.

$$\boldsymbol{PhyAch_{ij} = \beta_{0j} + \beta_{1j}*(SELFCONF)} + r_{ij} \tag{8.7}$$

where $PhyAch_{ij}$ shows physics achievement of student *i* associated with the physics class taught by teacher *j*; β_{0j} is mean of physics diagnostic test within the physics class taught by teacher *j*; β_{1j} is the slope of mean physics achievement-self-confidence within the physics class taught by teacher *j*; and r_{ij} is the random error as student *i's* effect in the physics class taught by teacher *j* on physics achievement.

It can be seen in equation 8.7 that the variable that significantly influences physics achievement is students' self-confidence in learning physics (SELFCONF). This equation shows a positive influence of self-confidence in learning physics on physics achievement. This equation also explains that students who showed more self-confidence in their physics learning tended to perform better in physics.

School-level model

This model is different from the student-level model, where variables examined directly, one by one, at teacher-level were investigated using two steps. The first step is exploring the probability of variables to predict students' outcomes using exploratory analysis. During the exploratory step, the variables which revealed t-values of more than two (cut-off value) were retained, and those where the t-value was lower than the cut-off value were omitted. After the first step was conducted, the second step examined variables retained in the exploratory step by entering variables into the equation using HLM 6.08 software. During the second step, variables which indicated *p-values* less than 0.05 were included in final equations, and non-significance variables where the *p-value* was more than the cut-off value were omitted from the final equation. The final equation shows the factors that significantly influence physics achievement.

After HLM analysis was conducted, analysis at teacher-level found the following equations:

$$\boldsymbol{\beta_{0j}} = \gamma_{00} + \gamma_{01} * (\boldsymbol{THOMEWORK}) + \gamma_{02}(\boldsymbol{TFUTED}) + u_{0j} \tag{8.8}$$

$$\boldsymbol{\beta_{1j}} = \gamma_{10} + \gamma_{11} * (\boldsymbol{PHYED}) + u_{1j} \tag{8.9}$$

where β_{0j} *is* mean of physics diagnostic test within the physics class taught by teacher *j*; γ_{00} is grand mean of physics diagnostic test; γ_{01} is the regression coefficient/ slope at teacher-level by the aggregated value of the frequency of physics homework assigned (THOMEWORK) predictor within physics class taught by teacher *j*; γ_{02} is the regression coefficient/ slope at teacher-level by the aggregated value of students' future education aspirations (TFUTED) predictor within physics class taught by teacher *j*; β_{1j} is the slope of mean physics achievement-physics within school *j*; γ_{10} is the regression coefficient/ slope at teacher-level by SELFCONF predictor within physics class taught by teacher *j*; γ_{11} is the slope of teacher' physics major education and students' self-confidence in physics achievement; u_{oj} is a random 'teacher effect' error or deviation from the grand mean for teacher *j*, u_{ij} is a random 'teacher effect' error or deviation from mean of physics achievement influenced by SELFCONF for teacher *j*.

It can be seen in equation 8.8 that two factors significantly influence physics achievement at school level: aggregated values of including physics homework assigned by physics teachers (THOMEWORK) and aggregated values of students' future education aspirations (TFUTED). Furthermore, HLM analysis also found an interaction effect between two variables at student- and school-level. Equation 8.9 indicates an interaction effect between students' self-confidence when they learnt physics (SELFCONF) with teachers' who graduated from their study in physics education (PHYED) in influencing physics achievement.

Final model: a combination of student- and school-level

The final model can be written by combining student- and school-level models. If equations 8.8 and 8.9 in the school-level model are substituted in the student-level model equation, new equations can be obtained as follows:

$$\boldsymbol{PhyAch_{ij}} = \beta_{0j} + \beta_{1j}*(\boldsymbol{SELFCONF}) + r_{ij} \qquad (8.10)$$

$$\boldsymbol{PhyAch_{ij}} = \gamma_{00} + \gamma_{01} * (\boldsymbol{THOMEWORK}) + \gamma_{02}(\boldsymbol{TFUTED}) + u_{0j} + \gamma_{10} * (\boldsymbol{SELFCONF}) + \gamma_{11} * (\boldsymbol{PHYED}) * (\boldsymbol{SELFCONF}) + u_{1j} * (\boldsymbol{SELFCONF}) + rij \qquad (8.11)$$

$$\boldsymbol{PhyAch_{ij}} = \gamma_{00} + \gamma_{01} * (\boldsymbol{THOMEWORK}) + \gamma_{02}(\boldsymbol{TFUTED}) + \gamma_{10} * (\boldsymbol{SELFCONF}) + \gamma_{11} * (\boldsymbol{PHYED}) * (\boldsymbol{SELFCONF}) + u_{0j} + u_{1j} * (\boldsymbol{SELFCONF}) + rij \qquad (8.12)$$

Equation 8.12 can be considered as the final model of the factors influencing physics achievement. The model explains the interaction between variables in the student- and teacher-level models. Equation 8.12 shows that students' physics achievement ($PhyAch_{ij}$) is modelled by an overall intercept (γ_{00}), three main effects $\left(\gamma_{01} * (THOMEWORK) + \gamma_{02} * (TFUTED) + \gamma_{10} * (SELFCONF)\right)$, one cross-level interaction $(\gamma_{11} * (PHYED) *$

$(SELFCONF)$), and a random error ($u_0 + u_{1j} * (SELFCONF) + r_{ij}$). It can be concluded that physics achievement is affected by students' self-confidence in learning physics (SELFCONF) at student level. The influence students' self-confidence is combined with three variables at school level including aggregated values of the frequency of physics homework assigned by teachers (THOMEWORK), aggregated values of the frequency of students' future education aspirations within the class (TFUTED), and teachers' major education in physics education (PHYED).

Effects of student- and teacher-level predictors on physics achievement

This subsection describes the direct effect of several variables at student- and teacher-level. Another effect, the interaction effect, is described in the next subsection. It can be seen in both Table 8.1 and Figure 8.2 that three variables have a direct effect on physics achievement including aggregated value of the frequency of physics homework (THOMEWORK), aggregated value of students' future education aspirations (TFUTED), and self-confidence during physics learning (SELFCONF). These variables have a positive influence on physics achievement. This means that the more the students had positive values, the better their performance in physics.

At the student level, students who had more self-confidence (SELFCONF) tended to achieve better in physics. Furthermore, at the teacher level, students learning in physics classes where students were assigned more physics homework (THOMEWORK) performed better compared to students learning in other physics classes with a lower frequency of physics homework. In addition, the teachers who taught in a physics class with higher students' future education aspirations (TFUTED) would have better students' physics performance compared to other classes.

No table of figures entries found. Table 8.3 Final result: two-level model of physics achievement

Fixed Effects	Coefficient	Standard Error	t-ratio	Approx. d.f.	*p*-value
For INTRCPT1, β_{00}					
INTRCPT2, γ_{00}	500.15	1.28	388.93	17	0.000
THOMEWORK, γ_{01}	6.11	2.37	2.58	17	0.020
TFUTED, γ_{02}	6.59	2.34	2.82	17	0.012
For SELFCONF Slope, $\beta 2$					
INTRCPT2, γ_{10}	0.10	0.03	3.51	18	0.003
PHYED, γ_{11}	-0.15	0.06	-2.47	18	0.024

Random Effect	Standard Deviation	Variance Component	df	Chi-square	*p*-value
INTRCPT1, U_0	5.50	30.28	17	256.57	0.000
SELFCONF slope, U_1	0.01	0.01	18	21.61	0.249
Level-1, R	7.27	53.26			

Statistics for current covariance component model

Deviance = 3273.39

Number of estimated parameters = 4

SEM analysis findings are different, where five variables had a positive influence on physics achievement including parents' highest education level (PARED), age difference (AGE), future education aspirations (FUTED), frequency of physics homework assigned by teachers (HOMEWORK), and self-confidence in learning physics (SELFCONF). At the student level, HLM analysis found only SELFCONF had a positive direct effect. In addition, HLM analysis also concluded that two other variables influenced physics achievement including aggregated values of HOMEWORK and FUTED showing a positive effect on students' physics achievement at school level instead of influencing physics achievement at student level. Factors significantly influencing physics achievement can be seen in Figure 8.3.

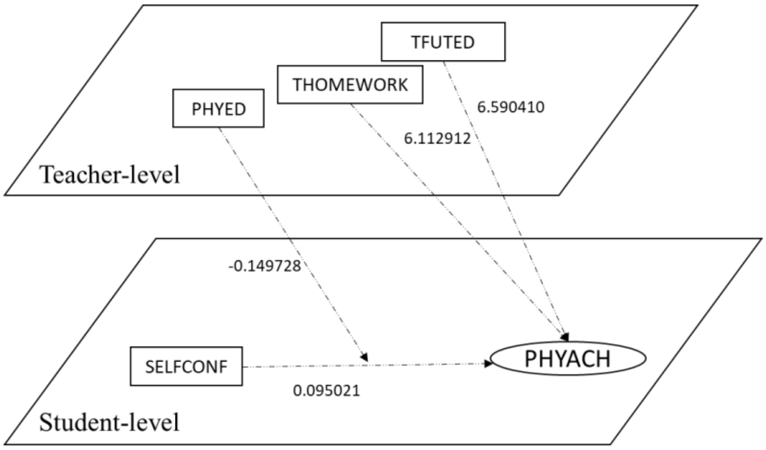


Figure 8.3 Final two-level model of physics achievement

Interaction effects

The final model also shows one interaction effect exhibited by teachers' major education. The interaction effect showed the interaction between teacher graduated from physics education (PHYED) and students' self-confidence on learning physics (SELFCONF). The interaction of these two variables in influencing physics achievement can be seen in Figure 8.3. This interaction means that students' self-confidence in learning physics interacted with teachers who graduated from a physics education study in influencing physics achievement.

The first cross-level interaction involves SELFCONF and PHYED as predictor variables to predict PHYACH. By keeping other variables at zero or constant, physics achievement can be modelled which involves both SELFCONF and PHYED as seen in equation 8.13 below:

$$PhyAch_{ij} = \gamma_{00} + \gamma_{10} * (\text{SELFCONF}) + \gamma_{11} * (\text{SELFCONF}) * (\text{PHYED}) + e_{ij} \quad (8.13)$$

where γ_{00} represents the average students' physics achievement, where in this equation is 500.15. $\gamma_{10} = 0.09$ and $\gamma_{11} = -0.15$.

And these values have resulted in the following equation:

$$PhyAch_{ij} = 500.15 + 0.1(\text{SELFCONF}) + (-0.15)(\text{SELFCONF})(\text{PHYED}) + e_{ij} \quad (8.14)$$

This equation can be used to calculate teacher-level coordinates in order to draw a graphic that represents cross-level interaction in the final model. To draw the graph, this study used the standard deviation of SELFCONF (SD = 15.19), and because PHYED is a dummy variable, zero or one were used. These coordinates on the interaction effects can be calculated as follows:

1. One standard deviation above the average on SELFCONF and zero on PHYED

   The coordinate of student' achievement can be calculated physics achievement as follows (PhyAch) $=500.15 + 0.1(15.18) + (-0.15)(15.18)(0) = 501.60$

2. One standard deviation below the average on SELFCONF and zero on PHYED

   The coordinate of student' achievement can be calculated physics achievement as follows (PhyAch) $=500.15 + 0.1(-15.18) + (-0.15)(15.18)(0) = 498.71$

3. One standard deviation above the average on SELFCONF and one on PHYED

   The coordinate of student' achievement can be calculated physics achievement as follows (PhyAch) $= 500.15 + 0.1(15.18) + (-0.15)(15.18)(1) = 499.32$

4. One standard deviation below the average on SELFCONF and one PHYED

   The coordinate of student' achievement can be calculated physics achievement as follows (PhyAch) $= 500.15 + 0.1(-15.18) + (-0.15)(-15.18)(1) = 500.99$

Using the coordinates calculated above, the interaction effect can be drawn in Figure 8.4. It can be seen that there is an interaction effect indicated by teachers' major education on the effect of students' self-confidence on physics achievement. As shown in Figure 8.4, for students taught by a physics teacher who graduated from non-physics education (physics non-education and chemistry education), students' self-confidence in learning physics has a positive effect on their achievement. In other words, the more confident students are, the better they achieve in physics. However, for students taught by a physics teacher who graduated from non-physics education, the effects of students' self-confidence during learning physics are negative, indicating the opposite effect, compared to those taught by teachers with no qualification in physics education. This finding was checked during interviews reported in Chapter 9.

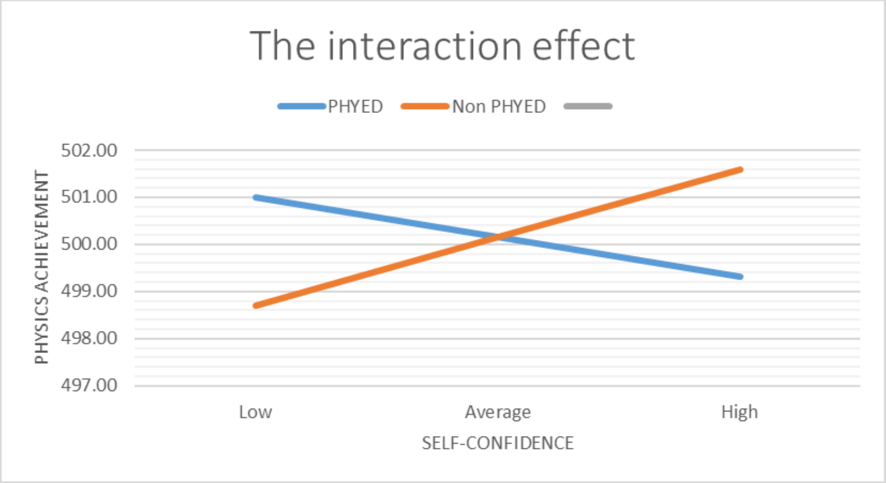


Figure 8.4 Cross-level interaction effect of teachers who graduated from physics education as the major study on the effect of student' self-confidence on students' physics achievement

Explained variance (R^2) for the two-level model

This study also provides additional information about explained variance in both levels in describing variance components in the models. The variance in the HLM is more complicated than in the regression analysis (Snijders & Bosker, 2011). If the variance in regression analysis describes the influence of predictor variables in the dependent variability, on the other hand, in the HLM focused on the reduction of variance components or the error of prediction the criterion by adding predictors in the final model (Raudenbush & Bryk, 2002; Snijders & Bosker, 2011).

Explained variance measures are calculated based on the null model and final model comparison as indicated by two formulations described below (Raudenbush & Bryk, 2002). The proportion of explained variance at Level 1 can be calculated through the equation.

$$R_1^2 = \frac{\left(\sigma_{null}^2 - \sigma_{full}^2\right)}{\sigma_{null}^2} \qquad (8.15)$$

where, R_1^2 is the explained variance at student-level; σ_{null}^2 is variance component student-level in the null model; σ_{full}^2 is variance component student-level in the final model. The explained variance in this two-level model indicates the reduction of prediction error at the student level by adding students' self-confidence during learning physics as a predictor. Furthermore, the proportion of the explained variance at the teacher level can be calculated through the equation below (Raudenbush & Bryk, 2002).

$$R_2^2 = \frac{\left(\tau_{00/null} - \tau_{00/full}\right)}{\tau_{00/null}} \qquad (8.16)$$

where, R_2^2 is the explained variance at teacher level; $\tau_{00/null}$ is variance component teacher level in the null model; $\tau_{00/full}$ is variance component level-2 in the final model. The proportion variance explained at the teacher-level in this study shows the reduction of prediction errors by adding the aggregated value of the frequency physics homework assigned by the teacher (THOMEWORK), teacher graduated from physic education as major education (PHYED), and average students' future education inspiration (TFUTED) as predictors in investigating the factors influencing physics achievement of Year 12 students in Malang, Indonesia.

Furthermore, the total variance explained by the final model can be calculated in equation 8.17 below (Snijders & Bosker, 1994).

$$R^2 = 1 - \frac{\left(\tau_{00/full} + \sigma^2{}_{full}\right)}{\left(\tau_{00/null} + \sigma^2{}_{null}\right)} \qquad (8.17)$$

Table 8.2 indicates the explained variance of the final model. The proportion of explained variance at the student level by adding THOMEWORK, PHYED, and TFUTED and as predictors. These variables reduced 5.58% of the measurement error of the factors influencing physics achievement of Year 12 students in Malang at the student level. Furthermore, PHYED, THOMEWORK, and TFUTED as additional variables at the school level reduce the error in predicting students' physics achievement (49.22%). These variables accounted for slightly under 50% of between-school variance in investigating students' achievement as outcomes.

Table 8.4 Estimation of variance components

Model	**Estimation of Variance Components**	
	Between Students	Between Schools
Fully Unconditional Model	56.41	59.63
Final Model	53.26	30.28
Variance available at each level by the null model		
Between Students	56.41/ (56.41+59.63) = 0.49	
Between Schools	59.63/ (56.41+59.63) = 0.51	
Proportion of variance explained by the final model		
Between students	(56.41-53.26) / 56.41= 0.06	
Between Schools	(59.63-30.28) / 59.63= 0.49	
Proportion of Total Explained Variance by Final Model		
(1 - (53.26+30.28) / (56.41+59.63)) = 0.28		

In addition, the total proportion of variance explained by the final model is 28%. In terms of its deviance value, the value in the final model (3273.395) decreased 36.1487 points from the null model (3309.5439) with two additional numbers of estimated parameters/degrees of freedom. The final model is considered as a better model in investigating factors influencing the physics achievement of Year 12 students in Malang, Indonesia based on the ratio of the decrease of deviance and increase of estimated parameters more than one (Bryk and Raudenbush, 1992).

Summary

This chapter described HLM analysis in examining factors influencing physics achievement. At the first stage, the null model was checked for appropriate use of HLM analysis to examine the effects of factors potentially influencing physics achievement in a multilevel model. The study found that HLM is necessary to investigate further the impact of factors within hierarchical analysis. The reliability value (0.99) also supports the ICC: that it is important to investigate the interaction between variables using HLM analysis.

In addition, the final model was investigated based on the hypothesised model designed in advance. The final model reveals that at student level there is only one variable, students' self-confidence in learning physics (SELFCONF), which significantly influences physics achievement. Furthermore, at teacher level, the final model indicated that aggregated value of frequency of physics homework assigned by the teacher (THOMEWORK) and aggregated value of students' inspiration in their future education (TFUTED) significantly influence physics achievement.

The final model also provides additional information about the interaction effect between teachers' major education (PHYED) and students' self-confidence during physics learning (SELFCONF). The interaction effect shows that teachers' major education influenced students' self-confidence during physics learning (SELFCONF) which influenced physics achievement. HLM analysis shows that students taught by physics teachers who graduated from physics education reveal the weaker effect of their self-confidence in physics achievement; however, their counterparts taught by the teacher who graduated from both physics non-education and chemistry education showed a stronger effect of self-confidence on physics achievement.

Furthermore, other information about variance explained in the final model is also provided by HLM. The variance explained by the final model indicated that students' self-confidence during physics learning (SELFCONF) as an additional predictor at student level can reduce 5.58 % of the measurement error. In addition, at school level, the variance explained showed that aggregated value of frequency of physics homework assigned by the teacher (THOMEWORK), teacher physics education as an education major (PHYED) and the aggregated values of students' future education aspirations (FUTED) as predictors have reduced the error in predicting students' physics achievement (49.22%). Moreover, the total variance explained by both levels reduces 28% of the measurement error. This shows that the model reduces properly the measurement error. The final model is also considered as a better model than the null model indicated by the ratio of deviance decrease and increase of estimated parameters more than one.

The findings in Chapter 8 are triangulated by the interview findings in Chapter 9. The interview as a qualitative approach was used to explore the views of teachers and students regarding several factors potentially influencing physics achievement. Interview findings were carried out to check background information that may underlie quantitative findings.

CHAPTER 9

INTERVIEW

Introduction

The previous chapters discussed findings from quantitative approaches. The construct validity and item validity of scales or factors were examined by using Confirmatory Factor Analysis (CFA) and Rasch analysis, respectively. The results of both analyses were reported in Chapters 5 and 6, respectively. Furthermore, the relationships among validated scales were investigated in three separate single-level models, namely student-, teacher-, and school-level using Structural Equation Modelling (SEM) in Chapter 7. In addition, further analysis was conducted by using a multilevel method, the Hierarchical Linear Modelling (HLM), in Chapter 8 in order to integrate student-, teacher-, and principal-level data into a single analysis. This method was undertaken to address the nested or hierarchical nature of the data in which students were nested within schools.

In addition to quantitative approaches mentioned above, qualitative approaches are also needed to analyse transcriptions of interview sessions regarding the extent of participating teachers' and students' opinions based on their beliefs and experiences (Vogt et al., 2014). Their beliefs and views, analysed qualitatively, have the potential to check quantitative findings. In exploring participants' views, this study employed two different methods to collect teachers' and students' data. The study used semi-structured interviews to explore the extent of eight physics teachers' views regarding their attitudes toward physics teaching and learning as well as professional development. However, this study also selected four groups of five students to participate in Focus Group Discussion (FGD). FGD was employed to explore the extent of students' views regarding their attitudes toward physics and physics homework.

Interviews employed to enrich data collection

The interview, as a research methodology, is often combined in conjunction with other approaches such as observations, experiments, etc. (Vogt et al., 2014). Therefore, in this study, the interview method was employed to complement and to add personal and individual insights to sets of quantitative data collected and analysed by using quantitative approaches in embedded mixed methods design as described in Chapter 3. This study employed interviews and FGD to explore the extent of teachers' and students' views, respectively. (The interview and FGD guides can be seen in Appendix E of this thesis.)

Semi-structured interviews explored the extent of teachers' views. The interview findings were coded using keywords. The interviews were carried out to investigate teachers' attitudes toward physics teaching and learning. These attitudes included teachers' strategy to inspire and help students to learn physics, teachers' beliefs of the most important aim for Year 12 physics, and the importance of physics homework. In addition, teachers' views regarding their professional development were also explored which included teachers' collaboration, teaching certification initiated by the Indonesian government, continuation of study, and their involvement in developing new strategies in teaching physics.

Furthermore, four FGDs were conducted to check students' beliefs and attitudes toward physics achievement and physics homework roles for learning physics concepts and its application and improving physics achievement. To explore students' perceptions regarding their attitudes toward physics, they were asked about their views on the difficulty of physics compared to biology and chemistry and the importance of physics in their life. The homework was explored by three aspects including what students were doing when there was no homework, homework types assigned by teachers, and their favourite homework types.

Respondents participating in the qualitative part of the study

Before the results of the analysis of interview data are reported, respondents participating in this qualitative part of the study are described and presented in Table 9.1. All teacher and student respondents are indicated by pseudonyms. Eight teachers participated in individual interview, and 20 students participated in FGD.

Table 9.1 Teacher and student respondents

Teacher		**Student**		**School**
Nina	Female	Anton	Male	Religion-based public school (School D)
		Fahmi	Male	
		Yeni	Female	
		Ani	Female	
		Dana	Female	
Susi	Female	No student participants		Private school
Nita	Female	Andi	Male	Private school (School C)
		Dina	Female	
		Toni	Male	
		Alfi	Female	
		Nisa	Male	
Rita	Female	No student participants		Public school
Indah	Female	Kayla	Female	Public school (School B)
		Roni	Male	
		Dila	Female	
		Kia	Male	
		Rino	Male	
Rani	Female	No student participants		Private school
Budi	Male	Faris	Male	Religion-based private school (School A)
		Roci	Male	
		Ridho	Male	
		Tino	Male	
		Ridho	Male	
Andi	Male	No student participants		Religion-based private school

The number of teachers participating in this study was selected based on their school type and importantly, that their school participated in the study. Six out of eight teachers participating in the interview were female. Gender was not considered during the sample selection, but gender difference may be used as a consideration during data analysis for interpreting the findings.

Furthermore, from teachers participating in the interviews, five students from each school type were selected for FGD as described in Table 9.1. Therefore, 20 students participated in FGD from four school types including public school, private school, religion-based public school, and religion-based private school. Gender, as used in teacher participant selection, was not considered for student participant selection. The study undertook FGD with students who were willing to join and share their views in groups.

Responses from physics teachers

Teachers' attitudes toward physics teaching and learning

Question 1

What is the most important aim in your class?

One of the important aspects in investigating the factors influencing physics achievement is the main objective of the teachers in physics teaching and learning in the class. The participants' responses about the main objective in their physics class can be divided into three themes, which include conceptual understanding, passing the final examination, and attracting the students to learn physics. Based on these three themes, most of respondent teachers, 63% (N=5), focused on how to help students pass their final examination. This could be caused by the teachers' beliefs that the final examination result would determine the students' decision on the continuation of their study at the higher educational level in the future. Two respondents (25%) considered that their main aim in teaching physics is to enhance students' conceptual understanding. Only one respondent (12%) believed that her main aim is to motivate students to learn physics. The description of teachers' main objectives in teaching physics can be seen in Table 9.2.

Table 9. 2 Main objectives of physics class

Main Objectives	Number of teachers	Teachers' name
Conceptual understanding	2	Nina, Budi
Passing the National Examination	5	Susi, Nita, Indah, Rani Andi
Motivating students in learning physics	1	Rita

In terms of conceptual understanding, the two teachers believed that teaching physics is about helping students to understand physics concepts. Both teachers, Nina and Budi, that focused on enhancing students' understanding of physics concepts were teaching at a religion-based school. It can be seen on Nina's views who believed that the additional physics tuition, another accessible learning source by the students, did not help the students to learn physics concepts. Nina thought that teaching students in understanding physics concepts is important in the class as students' primary learning source. It can be seen from Nina's views below.

> "If I am (teaching physics) in the class, my class will only embed the physics concepts. This is because the additional learning outside the learning time in the class only provides the mechanics of how to solve physics problems. However, the concepts should be learnt first. Thus, I focus on enhancing the understanding of the physics concepts in my class."

In addition to Nina's views, Budi, a physics teacher at a religion-based private school, thought that a student in his school should integrate the physics concept with religious lessons by telling stories about Muslim physicists. It can be seen from Budi's opinion below:

> "The most important aspect when I teach is that learning physics in the class is not about getting its practical benefits, but, gaining the knowledge instead. Because they are learning religious lessons here, they also need to know the contributions of previous Muslim scholars (in physics). I told stories about those. The stories are about physics phenomena and their history particularly in relation to Muslim scholars. They will wake up and ask. If I am teaching physics, the most important is understanding the Physics concepts."

Furthermore, Budi said that most important is that the students could learn physics easily by learning the physics problems frequently. This method could help students to love learning physics and integrate the physics concept and the application.

The second main objective is to help students to pass the final examination. The majority of the participants, five teachers, thought that the final examination is the most important focus for Year 12 physics students. The Year 12 level, as the final stage in senior high school, assesses the students' minimum ability before they are graduated as senior high school students. In order to graduate from senior high school, the Year 12 students have to pass the passing grade reflecting the basic competencies decided by the government. The students are tested by using various physics problems based on rubrics published by the ministry of education and culture.

One of the teachers' opinions in distinguishing teaching methods for Year 12 with previous two-year levels can be seen from Susi's views. Susi argued that Year 12 students should pay more attention to the national examination.

> "It cannot be rejected that Year 12 students should more focus on passing their national examination. So, for Year 12 students, I teach more about solving physics problems than imparting physics concepts like (I do) for year-10 and year-11 students"

Similar to Susi's views, Nita also focused on the national examination as a final test for a senior high school student and helping students to pass the university selection examination. Nita decided to choose different teaching approaches compared to year-10 and year-11 students in her physics class relating to her opinion regarding her main teaching objective.

> "The most important is that students achieved the national examination passing grade. So, the students should learn how to solve various physics problems. We discussed the physics problems to face the national examination and the university selection examination. Thus, solving the physics problems should be delivered in the class."

In line with the views of both Nina and Susi, Indah, a physics teacher at a public school, also supported that passing the final examination is the most important aim for Year

12 students compared to focus on learning physics concepts. Her views can be seen in the quotation below.

> “For Year 12, the students are taught to face the national examination. Thus, most time spent in the class was used to practice solving the national examination problems. The teacher should spend more time practising to solve the national examination problems than previous year levels which focus on teaching the physics concepts. If the student lack of solving physics problems practices, the students will not succeed in their final examination even though they have enough physics concepts.”

In addition to the previous views, Rani also argued that the most important objective for Year 12 students is to meet the passing grade in the final examination. It can be seen from her views below.

> “Number one is to know. Personally, for Year 12, the students have to know the rubric for the national examination. The students should learn the basic concepts based on the rubric. The students should also learn the mathematical equation through the concept cards to solve the physics problems. The final examination is a paper-based test. Therefore, the students should memorise the equations.”

In addition to the two objectives mentioned above, the third main objective is helping students to love physics. At this main objective, only one teacher, Rita, focused on how to engage students when learning physics. Rita argued that helping the students to enjoy physics learning and motivating the students to learn physics in the class is her main priority. It can be seen from her views below.

> “… Then, I always tried (to help) students by giving motivation, then I give the easiest method, the way to understand physics concept. this means that students could think physics without mathematical equation, but they learn physics logically instead. It is because physics problems can be solved logically. The most important is how to make students falling in love with physics. At least they are willing to learn physics. I only tried how to make students enjoy learning in physics class.”

Question 2

How are you doing to inspire and help the students to learn physics?

In inspiring and helping Year 12 students learning physics, the respondent teachers had various methods based on their class characteristics and the issues found in their classes. The teachers practised the methods to deal with the problems and issues experienced by their Year 12 students. In general, based on their responses, there are five main ways to help and inspire the Year 12 students to learn physics successfully namely (1) focusing on teaching the physics concepts, (2) motivating the students using story-telling, (3) learning strategy variation to deal with various problems and topics of physics, (4) engaging the students with daily activities, and (5) investigating and matching students' interest with the teaching strategies.

1. Focusing on physics concepts

Helping the students to understand physics concepts is still challenging. Nina found that her students who are learning at additional physics tuition do not involve learning activities that could enhance their conceptual understanding. They focused more on solving physics problems. Therefore, Nina focused on helping her students to acquire more physics concepts rather than solving physics problems. It can be seen in Nina' views below.

> "If I were in my class, I just impart physics concepts. It is because, in additional physics tuition, they only learn how to solve physics problems. However, the concepts should be understood. Therefore, I pay more attention to the students' concept."

2. Motivating students

Motivation is another aspect that Susi found important. She found that her students studying at the Year 12 level had low motivation. Therefore, she tended to use storytelling to help her students achieve more than the minimum standard of physics basic competence at the senior high school level. Susi inspired the student to learn physics by motivating the students and telling stories about previous Year 12 students and their achievement. It can be seen based on Susi's views below.

> "I do not have a special trick, I just motivate my students to learn physics. I just tell the previous Year 12 students' experiences about what they have done and their achievements. The stories may inspire my Year 12 students and motivate them. If they learn at particular standards, they will achieve the intended goals. If they do not do those standards, they may not achieve the goals like the previous successful Year 12 students"

3. Teaching strategy variation to deal with various problems and topics of physics

Physics has various topics that can be delivered by using different teaching and learning strategies. The role of teaching strategies was considered important to help and inspire the students to learn physics by three teachers (Nita, Rita, and Andi). Nita chose several teaching strategies to deal with various physics problems faced by the students. However, the focus differed with another teacher, Rita, who applied her various teaching strategies to motivate and attract her students for learning physics. In addition, Andi applied his various strategies to deal with his issues to help his students to succeed in their physics.

Nita applied various learning and teaching strategies based on the physics topics learnt in the classroom. Nita also provided various physics problems to be learnt and solved to face the national examination and the university selection test. This Nita's views can be seen in her opinion below.

> "For helping the students to learn physics, I applied various teaching models such as Jigsaw if the physics concepts were suitable for. Mostly, I provided problem-solving practices in various physics problems. I also demonstrated how to deal with those problems, because the students would not only face the national examination and the national standard school-based examination as the final examination, the Year 12 students would also face the selection test for the university level. Therefore, helping students to deal with various physics problems have to be delivered in the class"

Another teacher, Rita, viewed that her students had low motivation to learn physics. Rita applied a similar strategy to Nita to deal with the situation in her school. She always motivated her students to learn physics, providing the easiest strategy to solve physics problems, and applying various teaching strategies to understand physics easily to inspire and to help her students to love and learn physics.

> "Then, I always try to motivate my students, and to give the easier way, the way to understand the physics concept easily. So that, the students were interested to learn physics. For example, for doing the physics problems, I did like this sir, putting the problems in tress and I gave the activity title as finding fortune. The students can walk around the school while doing physics problems. I also did a lot of outdoor activities to attract the students for learning physics. I also used the faster method to solve physics problem logically. Because physics can be solved logically. At least, students still want to learn physics. To motivate students, I also asked students to solve the physics problems in front of the class and give points to them. Then, the points can be used to add their marks when there was a physics examination. Therefore, students were interested and compete to solve the problems."

It is different from Andi who integrated his teaching and learning process with Information and Communication Technology (ICT). Andi focuses on using several ICT facilities to help communicating and teaching physics topics. In his physics class, he focused on delivering the topic and doing physics exercises to help the students to pass their national examination passing grade. He also applied a peer-mentor strategy to help the students learning better and share their idea and challenges with their peer-mentor.

> "The issue in my class is they did not have materials to learn how to solve physics problems. A lot of physics problem exercises. Then imparting the physics concepts or how to apply the concepts in solving the problems particularly to choose the formula to apply with. That needs many practices so that they have the automatic decision in applying the formula in solving the physics problems. So, physics formulas are not to be written and to be memorised. But, when there are physics problems, the students are confused to choose the appropriate formula. I also used PowerPoint. I distribute the PowerPoint to the students' phones. So, all students read their WhatsApp (an instant message application). I just informed the students to check their apps and to study the materials distributed. I just explained a bit of the theory. Then, if there is no question, I provided as much physics problem-solving training. I also used a peer mentor who will help other students who are struggling in learning physics. I also showed a point list to the students at every meeting. Students, who did problem-solving in front of the class, will get an additional point. The students were motivated to solve a physics problem, even though they were taught by their peer mentor."

4. Engaging physics topics with daily activities

Integrating physics topics with daily phenomena is another issue for teaching physics in Indonesia. Many students still think that physics is just a subject in school (see FGD findings in next subsection), and it is important to introduce physics as an integrated knowledge that has important roles. To deal with this issue, two teachers, Rani and Indah, decided to integrate physics topics in the classroom into daily phenomena. Both teachers viewed that engaging with daily phenomena may help and inspire their students for learning physics.

Rani always integrated the daily physics classes to inspire students learning physics by watching videos and browsing physics topics through the internet. She also marked her roles during the learning process to facilitate her students. Rani's views as follows.

> "As a physics teacher, I just accompany the students in the classroom, only facilitate them to learn. I just asked students to learn, so that the students will develop their own ideas. Most importantly, I should show the physics roles and the physics tools. I also showed videos about physics or searching the physics topics on the internet."

In line with Rani, Indah also argued that showing the daily phenomena could encourage and inspire students in learning physics. To engage the students, Indah used ICT technology and did storytelling about physics roles. Indah's views can be seen below which shows similar views with Rani's.

> "Physics is the knowledge connected with our daily life phenomena. Therefore, during its learning, to attract students to learning physics, I showed examples of the physics roles of the topics taught in daily life. For example, I used an LCD projector showing the picture taken from the internet to live the topics taught in the class. It can be also storytelling, but students were more attracted using the pictures from the internet or the movies "

5. Matching the students' interest with the teaching strategies

Another strategy to help and inspire the students to learn physics is by matching the students' interest with the teaching strategy. It was applied by Budi. He was investigating students' interests and then matching the physics concepts taught to the interests. Budi also integrated the physics concept with religion through experiments and Muslim scholars' invention in physics because he taught at a private religion-based school where the students live in a boarding house. Budi's views can be seen below.

> "Firstly, I investigated students' interests in advance. Then, I chose the topics that benefit students' interests. Then, for example, there is astronomy in deciding the beginning of fasting month, lunar eclipse or other monthly astronomical phenomena. I asked them to go outside the classroom. I observed them, they were interested when there were these phenomena. I also showed an astrological sign at night, they were very happy. So, that is my teaching method. But, if they learnt physics problem with a lot of math formula, they disliked it. Thus, it is important to consider the method how physics is delivered in the class. It is not about its practical benefits. But, the knowledge is abroad. Furthermore, the students are also learning Islamic subjects. Thus, I also did a lot of storytelling about physics and Muslim scholars with a bit of physics concept, and some mathematic calculation. It is also impossible to do physics teaching and learning as it does in other senior physics schools which have complete facilities and students have high motivation to learn physics. I also granted a prize for the students who achieve high achievement to go outside the boarding school. I also invited the high achievement students to join astronomy training in a university weekly."

Question 3

Is it important to assign homework to the students?

When the respondent teachers were asked about their views regarding the importance of assigning homework to their students, the responses can be grouped into two large categories; those who assigned homework as an important activity and those who avoid assigning homework. No teacher rejected assigning physics homework to their students. The only difference was the importance of physics homework. Seven respondent teachers said that physics homework is important to be assigned to their students, and only one teacher avoided assigning homework. From the respondents who argued the importance of homework, all-female teachers focussed on the importance of the homework to help students in learning physics, while the male teachers noted the impossibility of giving high thinking order homework to their students. The brief description can be seen in Table 9.3.

Table 9. 3 Importance of physics homework

Assign homework	Reason	Teacher's name
Yes	It is important	Nina, Nita, Rita, Indah, Rani
	It is important to assign homework but cannot give a high thinking order type	Budi, Andi
Avoid	Instead of giving homework, the teacher focuses on giving an assignment in the class	Susi

Even though the teachers were teaching in different types of schools, they had different reason why homework is important. Nina, a physics teacher at a religion-based public school, viewed that assigning homework is very important to help students to learn physics appropriately. It based on her opinion about physics homework.

> "We learn at school from 06.30 am to 2.45 pm. If we do not assign homework, it is likely to be a lack of physics exercise for the students. Personally, it is an obligation. I cannot sleep without giving homework. Because if the students do not have enough physics exercise - they are Year 12 students"

Nita, who is teaching at a private school, also assigned weekly homework to her students. She thought that her students do not learn when she does not assign homework.

> "I assign homework at least one homework every week. Because without assigning homework, my students do not learn and open the book to learn (at home). In terms of the number of items, it depends on the item difficulty."

Rita teaching in a public school, where all students were living in a boarding house provided by the school, is also on the same page as Nina and Nita. She said that if there is no homework, the students will not learn.

> "I still assign physics because they will not learn if I did not assign physics homework. If there is no homework, students will only watch movies".

Another teacher, Indah, who taught physics at a public school also had similar views regarding the importance of assigning homework, although she found a lot of students copied their friends' work. It can be seen in her opinion.

> "Homework is important. Why? Because it will enforce students to learn, even though they are lazy. It is because there is homework and it will be marked, they are enforced to learn and do the homework. However, if the students did the homework by themselves, they will achieve better in physics. I found that a lot of students copied

> their friends' work, which is around 25% of students. I think if the students do the homework by themselves, it will help students to achieve physics better"

The last views of the female participant teachers are coming from Rani who taught physics at a private school with a full-day school. She always assigned homework or requiring unfinished classroom assignments as homework. It can be seen in her views.

> "I tried to assign physics homework. Because our school applies a full-day school, I will give homework if students have finished their work in the class. But if they have not finished the assignments in the classroom, the assignment will be their homework."

The second group is the importance of giving high order thinking skill homework to the students. Two male respondent teachers viewed the difficulty of assigning homework with high order thinking items. Both teachers are teaching at a religion-based private school. The first opinion is coming from Budi teaching at a religion-based school where the students are living in an Islamic boarding school. He said that it is impossible to assign critical homework. It is also argued by Andi. Andi's opinion can be seen below

> "Homework is beneficial. Even though there is homework, some of the students still did not learn. Therefore, they will not learn if there is no homework. Furthermore, I will not assign high quality homework. I will also discuss items if all students finish their homework, if they have not finished yet, we will turn to the next physics topics. Because Year 12 students will do the national examination, the majority of physics homework assigned are multiple-choice questions compared to the easy items. Even though the majority are MCQs, students will do the items in front of the class with the method of how to get the answer."

However, it is different from Susi's opinion. Susi argued that homework will not result in an intended purpose when the students copied another students' work. She focused on drilling the students during physics class and she hopes to minimise assigning any homework to her students because she found that the students may copy their friend's work. It can be seen from her opinion.

> "In terms of physics homework, I more focus on drilling physics exercises at the school. I also avoid assigning homework. So, I prefer the student to study at the school and I can check the students' work. Most of the students also copied the other students' answers and did not understand anything from their works when I assigned the

> homework. Even though I still assigned homework, but I tried to minimise assigning homework"

Professional development

Question 1

Do you have regular meeting to discuss physics teaching and learning with your colleagues?

The teachers had different situations influenced by their school types. Most of the participants teaching in a private school are the only physics teacher at their school except for Susi who has another physics teacher colleague. The number of physics teachers in a particular school influences teachers' collaboration and their way of meeting with their physics teacher colleagues to discuss physics and teaching-learning issues. Teachers who are the only physics teacher at the school and the collaboration undertaken to deal with their physics teaching and learning issues can be seen in Table 9.4.

Table 9. 4 Teachers' collaboration types

Teacher Name	Number of physics teachers at school	Collaboration
Nina	More than one	Collaborate with the teachers within schools to solve everyday issues in the classroom and between schools to get new update information regarding educational policy and teaching training
Nita	Only one	Raised her teaching issues in the classroom to other teachers from different schools directly, and she always came to physics teacher association meeting to discuss several topics in physics education
Rita	More than one	Rita cannot collaborate with other physics teachers within her school because they were very busy, and she thought that meeting between schools was also limited
Indah	More than one	Indah argued that physics teacher association meeting revealed various benefits for her to do administrative jobs and improve her teaching skills
Susi	More than one	Susi divided the roles of teachers' collaboration, she thinks that within school collaboration helped her to solve classroom issues, and between school, collaboration helped her to solve general teaching issues and get new information
Rani	Only one	Rani got a lot of benefits by coming to the physics teacher meeting
Budi	Only one	Budi got a lot of new information from the teacher association, particularly teaching methods because he graduated his study from a non-physics education program
Andi	More than one	Andi thought that the teacher association help him to prepare his students to meet the national examination

The physics teachers met with a particular schedule within the physics teacher association. The schedule was decided based on the agenda or the available program in the association. On the other hand, the teachers did not have any particular schedule to meet other teachers within the school or other teachers. The teachers discussed with other teachers if they faced any challenges during the teaching and learning processes in the class or they discussed any particular technical issues in their class.

Nina who taught physics at a religion-based public school attended regular meetings with other teachers in the physics teacher association and always discussed her issues with other teachers in her school. This can be seen from the seating arrangement in her school where the teachers were grouped based on the subject taught in the class. She had a seat in a physics teacher group where she was able to discuss easily with other physics teachers. She also had a team-teaching that helped collaboration among physics teachers within the school. The collaboration within school was primarily to discuss with her class teaching partner. She also discussed with other teachers when she could not solve a physics problem. Furthermore, she also always attended physics teacher association meetings within the physics teacher association in both Malang city and the religion-based school teacher association. The physics teacher association between schools helped her to get updated information about the government policy and any physics training. It can be seen in her views and experiences with her collaboration.

> "I am seating together with other physics teacher in my school. It helps me to communicate easily with other physics teachers. We also have a team-teaching, in which a class is taught by two teachers, we communicate with other physics teachers teaching in the same class to discuss the physics topics (taught in the class). Furthermore, I always come to the physics teacher association meeting in Malang. I attended both associations for the physics teacher association under the ministry of education and culture and ministry of religion affair. I think the meeting gives many benefits for me. I need new information."

In addition, Susi who taught physics in a private school also had similar experiences with Nina. However, Susi did not have a seat within a subject group. She always discussed her issues with another physics teacher within her school when facing any challenges. The meeting focus on the practical issues faced in the classroom. Furthermore, Susi always came to the teacher association meeting. She experienced beneficial meetings from the physics teacher association meeting regarding new updated information regarding physics education. It can be seen from her views.

> "Every day, if I face any issues in the class, I always discuss and share our experiences with another physics teacher in my school. The routine schedule only in the physics teacher association in Malang because there are a lot of teachers. The topics discussed in the meeting are the common issues in physics teaching rather than specific issues in a class. Both teachers' collaboration has different benefits. Within school collaboration helped me to solve the issues faced in the class, however, the between-school collaboration tends to solve more general and complex issues in physics teaching."

Andi, who taught physics in a religion-based private school, also thought that the physics teacher association is very beneficial for him. He could do any activities, such as doing try-out activities, to prepare the students to face the national examination run by the physics teacher association in Malang, Indonesia. It can be seen from Andi's opinion when comparing teachers' collaboration within the school and between schools.

> "Regarding a routine meeting (meeting of physics teachers within school) which is officially scheduled, it is not. It is only because we meet daily. When we face any challenges or problem in the class, we share with each other. We share physics topics, share how to face students to avoid any problems."

The benefits of meeting regularly with other physics teachers in the physics teacher association was also revealed by Indah who teaches physics at a public school. Her experiences in the meeting can be seen in her opinion.

> "Teachers' collaboration between schools has helped me to do my administration duties such as creating a lesson plan, yearly program, semester program. I just copy-paste the example of them from other teachers and adapted to my class. That is better than creating by me which will spend much more time. Teachers' collaboration has also helped me to enrich my knowledge by inviting education experts from the university. I

> can modify my teaching model and improve my pedagogical skills by coming in between school collaboration meeting."

The benefits of teachers' collaboration become more important to the teachers who are the only physics teacher in their school. They could address their problems in physics teaching and learning by coming to the regular meetings conducted by the physics teacher association. They could get new updated information regarding physics education policies, could prepare their students by doing any preparation facilitated by the association, and could also upgrade their teaching skills through the meeting. Nita, Rani, and Budi were the only physics teacher in their schools, a religion-based private school and a private school.

Nita who taught physics in a private school revealed the importance of regular meeting in the physics teacher association.

> "If I face any teaching issues in my class, I always ask other teachers from other schools. When I come to the physics teacher association meeting, I asked other teachers about my teaching issues. However, the meeting is rarely conducted, it is routine if there was a project. But, physics teacher association meeting is better than other subject teacher association, because physics teacher meeting is more routine than other subjects, even though it is still rare. The time is also limited to discuss the urgent issues, but if we discuss how to deal with national examination physics problems the teachers will meet frequently. It is like discussing the national examination items, teaching training, and inviting the education expert from the teacher training university. These are important programs. I am trying to come to the meeting and ask any questions."

In addition, Rani who taught physics at a private school also experienced a lot of benefits from a teacher association meeting. She could collaborate with other physics teachers and could improve her teaching skills. It can be seen in her comments below.

> "Because I joined the physics teacher association, I could learn the national examination rubrics and the easy methods to deal with the physics problems in the national examination. I have taught the methods I got in the meeting to my students. If I did not join and come to the physics teacher association meeting, I do not know how to deal with the national examination test items. The collaboration is much beneficial for me. I have got a lot of updated information from the meetings. It is very important to collaborate with other teachers for advanced physics education. So, other teachers always give feedbacks and innovation in physics teaching, for example, the teacher's experience in teaching telescope. I just imagined, how to teach it? I just knew that it

> was easy after coming to the meeting. Within the teacher meeting, we can share and discuss how to teach an interesting and enjoyable physics class."

Budi who graduated as a physics major (non-education major) and the only physics teacher in his school also got many benefits from the physics teacher association meeting. The collaboration on the association has helped him to improve his teaching skills and updated his information regarding new updated physics education policies.

> "It is more than enough. There was an inquiry approach in teaching physics training. I was graduated from non-education physics which did not learn how to teach physics. The teacher association meeting gives a lot of benefits particularly for providing the updated information about the national examination. I can also come to the training in the physics teacher association meeting."

It is different for other teachers, Rita who had other physics teacher colleagues at her school thought that the meeting had the minimum impact on her because the meeting time provided by the teacher association was limited and the teachers at her school were very busy. Thus, she motivated herself to improve her teaching skills by attending paid teacher training events. It can be seen from Rita's view as follows.

> "I do not have an opportunity to discuss with other physics teachers within the school. It is because other teachers are busy, one is a vice headmaster, and another one is very busy in teaching. Physics teacher meeting between schools is also limited."

Question 2

Do you have any plan to improve your teaching strategies?

When the participant teachers were asked regarding their plan to improve teaching strategies, the teachers' responses can be grouped into two themes. First, the teachers will upgrade their skills through teachers' collaboration. Another group is that the teachers will continue their study at the Master degree to improve their teaching strategies.

The first theme can be seen in Nina's views. Nina said that she was always motivated to improve her teaching strategies. She improved teaching strategies through teachers' collaboration with her physics teacher colleagues from her school and other schools. She discussed her teaching issues regarding the methods, evaluation and strategies with her team teaching and physics teacher colleagues in her school. She also collaborated with other teachers within the physics teacher association in Malang city to discuss physics teaching issues and to invite the physics experts from the university that have expertise in education.

The second group is improving teaching by pursuing their study into a Master degree. The majority of the teachers who have this idea are junior teachers. They think that teacher training or collaboration has a smaller effect than learning at university. The teachers who had the views were Susi, Nita, and Budi.

Susi planned to continue her study to improve her learning strategies. However, she still did not decide when she will execute her plan, besides she always came to the training events.

> “If I talk about a plan to study further, I have planned to continue my study at Masters level. But, I did not decide when I will execute it. If there are invitation letters to come at training events at the schools, I will come to update my skills.”

Nita also had similar views with Susi. In addition, she thought that teachers’ collaboration cannot give a similar effect compared to learning at the university. It can be seen in her views below.

> “I want to continue my study, but I still do not have spare time. I need to refresh my knowledge. It is because if I joined teaching training events, the events cannot solve my problems. I found the events did not have clear objectives; these were only the government programs. The programs discussed lesson plans or other administrative tasks, but I have not found yet that there are objectives to improve the teaching and learning quality such as making simple physics application tools. Even though this training program is important, but there is no training to create the tools to be applied in the students’ daily life. There was also low intention to enhance teaching strategies through training events in the teacher association meeting.”

Question 3

What do you think about teachers' certification and its impact on teaching and learning quality?

Teaching certification as the government policy to improve the education quality in Indonesia has several impacts on the physics teachers. Several teachers think that the effect of the teaching certification program depends on the certified teachers' attitudes. However, all certified teachers participating in this study argued that teacher certification program helps them to improve their teaching quality. The teachers noted that the financial support for the certified teachers help them to focus on their teaching quality.

Two teachers believed that teaching certification effects are influenced significantly by the attitudes of the teachers. Nina, a certified teacher, viewed that the effect of the teaching certification program depends on the attitudes of the teacher. She said as follows.

> "The effects of the certification program depend on the person. For some, it motivates the teachers to be better, but for some, there is no difference."

Nina's view is also supported by other certified physics teachers. Indah and Rita also argued that in terms of the effect of the certification program, it depends on the person.

In addition, six out of eight teachers in this study are certified teachers. The benefits received by the teachers are additional incomes which help them to meet their daily needs and buy additional needs such as technology facilities to support their teaching and learning. The financial benefits can be seen in the certified teachers' opinions below.

- Nina thought that the teacher certification is very helpful for her and her teacher colleagues. Nina also noted that the program requires easy documents.

> "The certification funding is very helpful. Thank God, it is very helpful and thanks to God in the ministry of religious affairs the certification funding is received three monthlies. There are no issues. There are no difficult requirements. We have made the requirements every day. So, on the due date, we just take the document made every day"

- Susi also viewed that the certification program can help her to be a professional teacher and providing additional income

> “So, the certification program provides additional income. Another consideration is the teacher becomes more professional.”

- Rita who is a teacher at a public school argued that the certification program helped her to be a professional teacher by attending several paid training programs. She viewed that without the additional income, she may not come to the event.

> “It is so beneficial for me. For example, I can join a paid workshop in a school. The training helps me to research in English, for example, is doing action research in the class. I can join this event because it was paid for by certification funding. If there is no certification funding, I cannot join the event.”

- Indah who was a teacher at a public school also viewed that the program helped her be better in her life.

> “Certification programs are provided for the teachers. It increases teachers’ welfare. We can save our money, buy a lot of high-quality stuff.”

- Rani, a physics teacher at a private school, think that the certification program helped her to buy technology kinds of stuff to help her in teaching physics.

> “If we are talking about teaching certification, my students, my teacher colleagues, and I received the certification benefits. It motivates me to teach. As for me, I just bought a new laptop because my previous laptop was broken. I also bought a new wireless mouse. I can download new knowledge (through the internet). It can be concluded that the certification program is very useful.”

- Andi, a physics teacher at a religion-based private school, noted that based on his experiences, the certification program helped him to improve teaching quality and focus on his teaching strategies in his classroom.

> “The certification program improves the teaching quality. Why? Because financial supports provided by the program can improve the teachers’ facilities. For example, the teachers can buy an up-to-date smartphone. Then, sometimes, if we need to help students, it will be faster, because there is financial support provided by the certification program. Because if there is no financial support, we cannot do more to help students. This program is very useful. If I compared with the situation before the

> certification program, I have had to teach additional physics tuitions. Thus, the school duties cannot be done better”

Even though the majority of the participants were certified, two respondents, Budi and Nita, had not received a teaching certificate yet. Nita was supported by her principal to join the certification program, but at the time during the interview conducted, she had to do the competency test for the second time before she received a teaching certificate because she failed the first test. Nita’s view regarding the teaching certification program can be seen below.

> “I hope, I can receive the teaching certification this year. I am still trying to do the competency test again. In my school, only three teachers have been certified. It motivates other teachers to try the certification program. My school principal supports the teachers to join the certification program. It is because our school is a private school which can pay less than public school. So, the certification program could provide additional income to the teachers. Furthermore, the teachers are prepared for a professional job.”

Furthermore, Budi, a teacher at a religion-based private school and graduated from a physics non-education program think that it may be difficult for him to get a teaching certificate in physics. It can be seen in his opinion below.

> “Yes, I hope I can receive a teaching certificate. But, because I graduated from the physics non-education program. I refer back to this education major. The majority of the certified teachers is seniors. It is because they have a longer teaching service, they received easier requirements. However, the younger teachers should meet more difficult requirements. What can I see is that, when I come to a physics teacher association meeting, the difficulties of certified teachers are to operate a computer. It is normal because it is about the computer, PDF, or installing computer software where they need my help. I also found they forgot some physics concepts such as parabola motion. It is because they memorise them rather than understand the concepts.”

Students' views of Physics

Attitudes toward physics

Question 1

Compared to other science subjects, how difficult is physics?

Twenty students were asked their opinion regarding the difficulty of physics compared to the other two natural science subjects (biology and chemistry). The responses of the students can be seen in Table 9.5. Eleven participants argued that physics is the easiest subject, and the rest of the participants (nine students) think that physics has medium difficulty compared with both biology and chemistry.

Table 9. 5 Participants' views regarding physics difficulty

School	Students' Response
School A	All participants thought that physics is more difficult than biology, but it is easier than chemistry
School B	All participant students at school B thought that physics is the easiest subject compared with other natural science subjects
School C	Alfi and Dina chose physics as their national examination subject. The other three participants, Andi, Toni and Tina, thought that physics is more difficult than chemistry. Furthermore, they argued that biology is the most difficult because it has a lot of theory to memorise.
School D	Four participants choose physics as their elected subject in their national examination rather than chemistry and biology. Both Yeni and Ani choose physics because there are few topics to be memorised and limited calculation. Furthermore, Dana and Fahmi chose physics because everything is exact, and they love numbers. However, there was only one participant who chose biology as his elected subject in his national examination and thinks that physics is the second easier after biology.

Five student participants learning in school A, a religion-based private school, were asked their views to compare physics to other science subjects, biology, and chemistry, in terms of their difficulty. The five participants argued that physics has a medium difficulty compared to both chemistry and biology. They thought that physics is easier than chemistry, but it is more difficult than biology. The students argued that physics combines both memorising the physics concepts and applying them by calculating the physics units. Biology is the easiest subject because its characteristics are just memorising the concepts and the easiness to associate into their academic life in an Islamic boarding school in memorising

Islamic books or Quran. Compared to chemistry, the teacher factor influences the difficulty of the subject. All participants viewed that the chemistry teacher rarely came to their school, therefore chemistry is more difficult than physics. The interesting findings in physics at this school A can be seen in Faris' comment, he said that "If (I) do the physics exercise, physics is a difficult subject. But, during teaching and learning process, it is an easy subject". It is supported by Ridho who argued that physics combines memorising (the theories) and calculating.

Furthermore, five students learning at school B, a public school chose physics as their national examination subject rather than biology and chemistry. One student, Kayla, chose physics as her elective subject because physics can be observed and learnt in her everyday life. Another student, Roni, chose physics as his elective subject because he would continue his study in medical study and because physics is logical and can be proven compared to biology that requires memorising the concepts. Another student, Dila, chose physics as her elective national examination subject because it is the easiest subject. Another student, Kia, chose physics because it is easy and can be more predictable compared to both chemistry and biology which he should memorise the majority of the topics.

Distinct from school A and school B, the student participants learning at a private school, school C showed a different view. Two participants, Alfi and Dina, chose physics as their national examination elective subject. Both students thought that physics is an interesting subject. At school C, the participants, who did not choose physics, chose chemistry as their elected national examination subject. Furthermore, they think that physics has a medium difficulty as is argued by participant students at school A. It is different with the students at school A who choose biology as the easiest subject, the three students chose chemistry as the easiest subject because they do not like to memorise biology concepts.

In addition, similar to the participants at school B and school C, four students at school D, a religion-based public school, choose physics as their national examination subject. The four students choose physics because physics has limited things to be memorised, limited calculation, and exact solutions. But, one participant, Anton, chose biology as his science national examination subject and chose physics as a second easier. He thought that physics can be difficult or easy based on its topics.

Question 2

Do you think that physics is important?

Participants' responses regarding the importance of physics can be seen in Table 9.6. 16 participants viewed that physics has important roles in their life. Interestingly, three students studying at school A concluded that they cannot decide on the important roles of physics in their life. On the other hand, only one student studying at school A thought that physics is not important.

Table 9. 6 Participants' views regarding the importance of physics

School A	Student participants at school A indicated different views. Only one participant argued that physics is an important subject (Adi). The other three participants thought that they cannot decide yet (Faris, Roci and Tino). However, Ridho thought that physics is not important because he does not like it. He would also continue his study in the agribusiness department.
School B	All students at school B thought that physics has important roles in their life and their future studies. The students tended to relate the physics roles with their future studies.
School C	Student participants at school C thought that physics is an important subject. However, the participant students do not know the real physics, they just imagine that physics as just a school subject.
School D	Anton thought that physics is important because he will study in the engineering department. However, Fahmi, Ani, Nada, and Yeni thought that physics has an important role by connecting physics roles with the technology needs in their life.

Student participants at school A indicated different views. Only one participant argued that physics is an important subject (Adi). The other three participants thought that they cannot decide yet (Faris, Roci and Tino). Adi thought that physics is important because his hobby is making an electric circuit. In addition, Adi had future education aspirations to enrol at a polytechnic university, which correlates with physics. Therefore, he determined that physics has an important role in his life. However, the other three students, Faris, Roci and Tino, cannot decide the important roles of physics because there is no relation between physics and their future education aspirations. Both Faris and Tino would continue their study at a religion-based university and Roci wish to be a soldier. At this point, Faris, Roci and Tino limited physics to a subject in their senior high school without any consideration that physics can be applied in their daily life. On the other hand, there was one participant, Ridho, who thought that physics is not an important subject because he did not like it. He would also continue his study in the agribusiness department where he thinks there are no physics roles.

It is different with five participant students learning physics at School B, a public school. All of the participant students viewed that physics has important roles in their daily lives even though they had various future education intentions. It can be seen from Kia's views, who had decided to continue his study in physics education, and who argued that there are always physics applications in his everyday life. It is supported by Rino's opinion. Even though Rino would continue his study in a medical doctor, he thought that physics will need to be faced and learnt in his future education. Furthermore, Roni who would learn an interior design study in his undergraduate study supported the views that physics plays an important role in his life. He thought that physics will help him to choose the appropriate colours in his building and during the bid process that he learned about from online searching and reading. In addition, Dila, who would- learn in industry engineering thought that the social and science subjects are balanced. She thought that the next study still needs physics. Furthermore, Nike already investigated the importance of physics rather than chemistry in her future education. The last one, Kayla, would like to continue her study in Mathematics.

Compared with other natural science subjects, Kayla thought that physics has similar characteristics to mathematics such as a lot of constants, formula, and needs experiments.

A different finding can be seen from the five participants who learnt at school C, which is a private school. Toni thought that physics is an important subject because he will continue his study in engineering, he thought that physics is important and needed in human life. It was different for both Tina and Andi. They had different views regarding physics. Tina believed that physics is important, but she has not applied physics yet. Furthermore, Andi argued that physics can be important depending on the person. If the person is common people, he thought that physics is not important, but for the physicist, physics is important. Another student shows the effect of parents' suggestion. Alfi viewed physics as an important subject because her parents asked her to be a physics teacher. In addition, there was a participant, Dina, who noted the physics roles can be seen in our daily lives. She gave an example of the important physics role - to help the policeman to analyse a criminal case.

It is different with the five participants at school D, a religion-based public school, who could all imagine the roles of physics. For example, it is the view of Fahmi that our life needs technology, and this technology requires physics to operate. Thus, he noted that physics is important. Another participant, Anton, wished to continue his study in engineering and thought that physics will be learnt at the university level. Therefore, Anton argued that physics plays important roles. In addition, all female participants said that physics is important because human life cannot be separated from technology.

Homework

Question 1

Does the physics homework assigned by your teacher trigger you to learn?

When the participant students were asked how homework triggers the students to learn physics at their home, the majority believed that homework plays important roles to help them in learning physics. The important role of homework can be seen from the number of the participant students who learnt physics if they were not assigned the homework. There was only Fahmi who would always learn physics even though there was no homework assigned. The majority of the participant students were assigned paper-based homework, and the only participants who received project-based homework were students learning at school D. The brief information about the roles and the types of physics homework assigned to the students can be seen in Table 9.7.

Table 9. 7 Homework types and their impacts on student learning

	The roles of homework	Types
School A	Homework helped the students to learn physics at home	Paper-based homework
School B	Only one student learnt physics without homework, however, other participants said that they will learn physics if there is homework	Paper-based homework
School C	All participant said that if there is no homework, they will not learn physics at home.	Paper-based homework
School D	No homework, no learning (Dana). Homework will motivate the student to learn if the items are not too much (Fahmi).	Paper-based and project-based homework

Students learning at school A, a religion-based private school, showed their views regarding the importance of assigning homework. The main issue of the students at this school was managing the time because they had to learn both school and religion-based school subjects. Two students, Faris and Roci, said that the teacher should assign no homework. Faris believed that learning should be done in the school only and he had limited spare time at his house to play around. Therefore, he argued that the spare time is used only for taking a rest or playing around instead of learning. On the other hand, other students stated that homework is important to help them to learn physics. Tino said that homework helped him to learn when done together with his friends. This view was supported by Adi and Ridho who believed that it is important to give homework but with a few items. Furthermore, Ridho argued the importance of discussion when doing physics homework. He said the benefits of homework are to help him in learning physics, but this depends on the situation. Homework helps him to learn when he learns together with his friends.

Students learning at school C, a private school, said that sometimes the teacher assigned the homework weekly. Sometimes, the teacher did not assign the homework. Interestingly, there was one student, Toni, who did not do some of his homework. In addition, he also thought that time at home is to take a rest. He will also not learn if there is no homework. It is similar with Tino, but the other three students Dina, Dev, and Alfi said that they may learn if they were not assigned homework. Another student, Dina, noted that she sometimes learned physics if there is no homework but there is no more motivation after doing homework. Furthermore, another student, Andi, thought that physics homework enforced him to learn, not to motivate. He thought it gives a little bit of motivation to learn physics. They suggested getting a few items to minimise the time spent doing the homework is important

Students at school B, a public school, were assigned homework after each topic was finished. Therefore, the homework was not assigned every week. The homework was assigned from the worksheet. The weakness of the homework is that it was the same as was assigned to the students from the previous year. Therefore, the students can learn from their senior how to solve the problems or copy their seniors’ work. It was found that Rino was happy when he can solve the problems. An interesting finding is the influence of students’ attitudes toward physics. Satrio said that he will learn physics only when there is homework because he does not like physics. It is different from mathematics which he learnt every day because he loved it. Anwar, another student, would learn physics if there was physics homework and an examination. Kia learns whether he has homework or not, however, Roni, Rino, Dila and Kayla will not learn if there is no homework.

Students learning at school D, a religion based public school, also expressed their opinion regarding physics homework. They did not learn if there is no homework, and they will only learn if there is a physics test. They want to get physics homework. They think that homework is important for them to relearn their physics study. In addition, Fahmi, a participant learning at school D thought that homework is important and suggested giving a short homework with rare frequency.

Question 2

What is your favourite homework type?

After the students were asked about their opinion on the importance of the homework, their views regarding the favourite homework types were explored. The study found that the types of school influence students' preferences for doing physics homework. The favourite homework can be seen in Table 9.8.

Table 9. 8 The favourite homework types

School A	Project-based homework
School B	Paper-based homework
School C	Paper-based homework (Alfi, Toni, and Andi), project-based homework (Tina and Dina)
School D	Project-based homework

Based on the school type, it can be concluded that students learning at religion-based schools (School A and School D) tended to choose project-based homework. At school A, all students who learnt and lived at a boarding house thought that project-based homework was their favourite type. Faris who studied at school A argued that it was interesting to make physics tools, their application compared with paper-based homework. His opinion can be seen below.

> “My friends and I learn physics and other subjects in the classrooms every day, therefore we just see a pencil, an eraser, a pen, and so on. Therefore, we want to have an outside activity when we learn every subject.”

It is also similar to other students learning at school D. They chose to do project-based homework. More than half of students learning at school D were living at a boarding house provided by the school. Furthermore, two students learning in school C chose to do this project-based homework. They think this homework type can help them to learn physics.

However, it was different with students learning at school B. They thought that paper-based homework by doing exercise in physics problems which would be found in the national examination was their favourite homework type. The students learning at this school thought paper-based is enough for them. They did not need another type of homework. Similarly, three students learning at school C, chose paper-based homework as their favourite homework.

In conclusion, more than half of the participant (12 students) chose project-based homework as their favourite homework. Project-based homework can be defined as homework in which the students are assigned a project to solve particular physics problems or focus on particular topics by doing several activities. In addition, paper-based homework is doing particular activities by using a piece of paper and a pencil to solve several physics problems. The students just need to read the questions, and write the answers on the paper.

Summary

The views of teachers and students regarding several issues in physics education were explored in this study using the qualitative approach. The exploration of the views was used to enrich the quantitative findings in the previous chapters. Eight teachers and 20 students participated in this study from all four school types to ensure the findings can be used to determine the views of the physics teachers and students in Malang, Indonesia.

In terms of the main objectives of the teachers to teach physics for Year 12 students, the majority (five participants) focus on how to help the students pass their physics national examination. This main objective is in line with the finding of the homework type assigned by the teachers. The majority of the teachers assigned paper-based homework which may help the students to learn many kinds of national examination problems and to improve the students’ skills to solve the physics problems. However, only students learning at school D received some project-based homework.

The study revealed that the teachers assigned physics homework to help their students in learning physics, and there is no teacher rejects the importance of assigning physics. The majority of the teachers also believed in the importance of homework even though they could not assign high order thinking homework.

In addition, the number of physics teachers in the schools could also be considered for defining the roles of physics collaboration in Malang, Indonesia. The study found that three out of eight participants were the only teacher in their school which influenced the teachers’ objectives in their meeting with other colleagues. The physics teacher association meeting still focused on the national examination preparation and administration duties, even though they met regularly compared to other subject teacher associations. On the other hand, the study found the important role of teachers’ collaboration in improving teachers’ skills for delivering physics in the classroom. It is supported by the finding that even though several junior physics teachers have planned to improve their teaching strategies, all teachers used the meetings as a facility to improve their strategies in addition to their plan to pursue their study in a Master degree. In addition, the senior teachers viewed that the meetings played a key role to improve their teaching skills and to update their knowledge.

Another important finding is teachers' view about certification which reveals that the majority of the teachers thought that this program brought a lot of benefits. The benefits were the financial supports and the government expectation to enhance education quality. However, the majority of teachers believed that the certification effects depended on the teacher attitudes. They revealed that there was no direct effect of the certification program to improve the teachers' quality.

In terms of teachers' strategies to inspire and help the students to learn physics, the teachers have at least five different strategies including focusing on physics concepts, motivating students, teaching strategy variation, engaging physics topics with daily activities, and matching the students' interest with the teaching strategies. The strategies were chosen based on the teachers' situation in the classroom.

In addition, it is also important to consider the findings of students' attitudes toward physics before the teachers try to help or inspire the students to learn physics. 12 out of 20 participant students chose physics as their elective subjects on their national examination, and the rest of the students who chose physics decided that physics has medium difficulty compared to other natural science subjects. Furthermore, the majority of the students also agreed that physics is an important subject, even though some of them still connected the importance of physics roles only with future study. They rarely mentioned the benefits of physics to help their activities or to explain daily phenomena.

In terms of students' views about homework, the participant students determined the important roles of physics homework for helping them to learn physics. The study found that the majority of the students would not learn physics when the teacher did not assign physics homework. Furthermore, when the participant students have explored their views about their favourite physics homework type, 12 out of 20 participant students from three different schools chose project-based homework, and only students learning at school B consistently chose paper-based homework as their favourite homework.

The findings in this chapter are discussed and compared to other quantitative findings in Chapter 10. Chapter 10 contains both discussions and conclusions of the study to be considered based on the investigation of the factors influencing the physics achievement of Year 12 students in Malang, Indonesia.

CHAPTER 10

DISCUSSION AND CONCLUSION

Introduction

This study investigated factors that may influence physics achievement of Year 12 students in Malang, Indonesia. The rationale for this investigation was that Year 12 students' physics achievement plays a critical role for students in Indonesia. It can influence what program they will choose for future study at university level, and this year level can also influence their final decision in terms of future job choices. In order to assess students' success in physics learning, this study measured student performance by using a diagnostic test adapted from the 2014 physics national examination. The performance was then used as an indicator to estimate students' ability to succeed in their class.

To examine the factors that significantly influence physics achievement, this study employed mixed methods design. The quantitative approaches, including both Structural Equation Modelling (SEM) and Hierarchical Linear Model (HLM), were used to examine the significance of the relationships of various factors with physics achievement within a single level (SEM) and multilevel analysis (HLM). SEM analysis investigated causal relationships between potential variables or factors within three single-level analyses: student, teacher and school level. Furthermore, to complement single level analysis, this study employed HLM to analyse the causal relationships between variables within a multilevel model combining factors within both student and school level (combining teacher and school level). In addition, this study employed both semi-structured interviews and focus group discussion as qualitative approaches to explore participating teachers' and students' views in selected schools.

Discussion of findings will be presented in the first part of this chapter. The conclusion contains several highlighted findings from this study regarding the factors significantly influencing physics achievement, and recommendations can be considered for future similar studies, in particular, investigating factors influencing physics achievement of senior high school students.

Discussion

This study was conducted to answer several research questions as stated in Chapter 1. The research questions aimed to identify students' conceptual understandings of physics and to examine factors influencing physics achievement and interactions within single level and multilevel analysis. To enrich the findings regarding these factors, this study also explored the views of teachers and students about their attitudes toward physics, teacher certification, and the role of homework to enhance physics achievement.

Before causal relationships of factors were analysed, both construct validity and item validity of all scales were examined to check how well the items measured the factors. Construct validity of the items used to measure potential factors was examined using CFA. In addition, item validity, a measure that indicates how well items fit the Rasch model, was assessed using Rasch analysis. The results of these analyses were used in both Structural Equation Modelling (SEM) and Hierarchical Linear Modelling (HLM).

The findings regarding the causal relationships of factors which significantly influence physics achievement are discussed in two different subsections. Firstly, the causal relationship within a single level analysis is discussed in Structural Equation Modelling (SEM). Furthermore, findings from single level analysis can be compared with the results of multilevel analysis using Hierarchical Linear Modelling (HLM). Moreover, to explore the contexts behind causal relationships of factors significantly related to physics achievement, interview and FGD findings are discussed.

In conclusion, the discussion in this chapter is grouped into five subsections, including conceptual understandings of physics, factors influencing physics achievement, interaction of factors, variance in physics achievement, and students' and teachers' views regarding factors. Relevant article reviews are used to support and compare the findings with previous studies.

Conceptual understanding of physics

To check students' conceptual understanding in physics topics at senior high school level, this study used a physics diagnostic test. The 2014 national examination was adapted to check students' conceptual understanding of physics on several topics (see Chapter 5). Items were taken without any changes in terms of their words or contents.

To ensure items were valid, a pilot study was conducted in a public school in Malang, Indonesia before data collection began. The pilot study showed that items had a Cronbach's Alpha coefficient of 0.755 which indicates that items tested exhibited good internal reliability for checking student performance in physics.

The Rasch measurement model was employed to check how well the physics diagnostic test measured students' ability and item difficulty. During Rasch analysis, the study treated the test as a single factor that tested students' ability in general physics even though the items measured students' conceptual understanding on seven different topics. This was done because the majority of items were less than three items needed to consider a multidimensional model. In addition, after the items were validated by Rasch analysis, it was concluded that they fit the Rasch model and could be used to measure students' conceptual understanding.

The study found that the majority of students could not handle abstract topics such as Thermodynamics, Wave, Temperature and Heat, and Fluid. Even though these topics were delivered at both year-11 and Year 12 levels, there was no significant influence on the time when they were delivered compared to measurement which was delivered at year-10. The most difficult item was ITEM12 (Dynamics). Several items including ITEM06 (Dynamics), ITEM14, ITEM15 (Fluid), and ITEM17 (Temperature and Heat) exhibited similar difficulty; these were the second most difficult items. Furthermore, both Temperature and Heat (ITEM16) and Dynamics (ITEM09, ITEM10) were considered difficult for students. In addition, Dynamics (ITEM05), Thermodynamics (ITEM18, ITEM19), and Wave (ITEM20) can be considered relatively difficult items, but relatively close to the base point. Another item that is very close to zero is ITEM04 (Kinematics).

Moreover, both Dynamics and Kinematics contained both difficult and easy items. It can be seen from the study that the topics considered easy for Year 12 students were measurement, kinematics, and dynamics. The easiest item was ITEM1 (-2.73), which was measurement. Furthermore, both ITEM3 (-0.952) and ITEM2 (-0.815) were relatively close to each other and can be considered relatively easy for students. ITEM3 (kinematics) and ITEM2 (measurement) were also easy items for students. Other topics that appeared easy for students were dynamics (ITEM8, ITEM13, ITEM7) and kinematics (ITEM4).

Gender difference and item bias

To ensure that the items used to examine students' ability treated the examinee fairly in terms of gender difference, further analysis, Differential Item Functioning (DIF), was employed to examine item bias. A DIF test was carried out using a cut-off value of 0,5 on logit value between gender on each item to indicate whether DIF exists between male and female students.

The study found that both ITEM01 (Measurement) and ITEM05 (Dynamics) exhibited DIF in measuring students’ ability. The logit differences estimated on these items were 0.52 and -0.548 for ITEM01 and ITEM05, respectively. These differences showed that females performed better than males even though they had similar abilities in the overall test. Therefore, these two items were deleted and were not used to measure students’ ability in subsequent analysis.

What can be concluded from both ITEM01 and ITEM05? DIF exhibited by the items should be considered during the topic’s delivery or creating test items. This means that the teacher could consider students, in terms of their understanding topics, during their teaching strategy in the classroom or assigning homework. Furthermore, creating test items on these topics should also consider gender difference so that items can examine fairly student abilities on these topics.

After DIF was conducted, it was found that female students performed better than male students. Dynamics (ITEM12) was the most difficult item for female students, and thermodynamics (ITEM20) and kinematics (ITEM04) were the easiest items. However, male students showed different patterns where the easiest items were dynamics (ITEM10, ITEM11, and ITEM12), and the most difficult item was thermodynamics (ITEM19). These differences showed that male and female students showed different interests and ability levels in physics. It can also be used to conclude that there is gender difference in students’ performance after items that exhibited item bias were removed from physics scores to indicate students’ ability for subsequent analysis.

Effects of gender difference on physics achievement

Instead of showing a direct effect on physics achievement (PHYACH), the study found that GENDER indirectly influenced physics achievement through six paths. Gender showed indirect effects on physics achievement through several variables including future education aspirations (FUTED), frequency of physics homework assigned by the teachers (HOMEWORK), liking of physics (LIKE), valuing of physics (VALUE), and self-confidence during learning physics (SELFCONF).

This finding confirms several previous studies (Cavallo et al., 2004; Hong et al. 2013; Khusaini & Darmawan, 2020). Khusaini and Darmawan (2020), who examined factors influencing the physics achievement of grade-8 students based on the TIMSS2011 dataset, found that gender difference indirectly influenced physics achievement through students' self-confidence during learning physics. This is supported by Cavallo et al. (2004) and Hong et al. (2013) who concluded that male and female students exhibited different attitudes toward physics and learning methods which impacted physics achievement. However, previous studies did not find the effect of student differences on students' future education aspirations and homework found in this study.

In addition, several studies argued the importance of delivering a subject with a particular strategy to deal with gender difference (Else-Quest et al., 2013; Friedler & Tamir, 1990; Pavešić, 2008; Quinn & Cooc, 2015; Shepardson & Pizzini, 1994). One of the alternative strategies is changing the physics curriculum to more accommodate gender difference and minimise the effects of gender difference on physics achievement (Pavešić, 2008). Pavešić, who compared the new and old science curriculum in Slovenia found that the new curriculum which provided more experimental work was associated with students' liking of science and students' achievement and could reduce gender difference.

In addition, several strategies can be used to minimise the effect of gender difference on students' achievement, such as investigating the factors causing the gender difference and narrowing the gender gap based on the findings, such as increasing the gender equity in education and minimising stereotypes about gender difference on science education and science-related jobs (Kamewendo, 2010; Quinn & Cooc, 2015). Furthermore, Quinn and Cooc (2015) viewed the importance of minimising the effect of gender difference on students' achievement as early as grade-3, by paying more attention to prior maths and reading skills of students, teacher quality, school quality, and curriculum.

Effects of age difference on physics achievement

Age difference showed both direct and indirect effects on students' achievement in SEM analysis. The direct effect showed that age difference exhibited a negative relationship with physics achievement where younger students tended to achieve better in their physics class. In addition, physics achievement was indirectly affected by students' age through their self-confidence in learning physics. This negative relationship showed that younger students in the normal age range at grade-12 showed more self-confidence and tended to achieve better in their physics class.

These findings are supported by Grissom (2004) and Nam (2014) who found that students' achievement was influenced by age difference at school level. However, this finding is contradicted by Grissom (2004) who found that the effect of age difference disappeared when students learning went beyond grade-10. In addition, the finding that younger students tended to perform better also differs from both Grissom (2004) and Nam (2004), who found that older students in the normal age range tended to perform better. Therefore, this finding can be used as additional information about the effect of age difference on students' achievement of Year 12 students in this study.

Effects of parents' highest education level on physics achievement

During SEM analysis, the study found that parents' highest education level showed both indirect and direct effects on students' achievement. The direct effect showed that students whose parents have higher education levels tend to achieve better in physics. This study found that the effect of parents' highest education level on physics achievement is in line with several previous studies. It has been asserted that students whose parents graduated at a higher level of education would live in a family with better attitudes toward learning and schooling and in turn, students would perform better in science (Damayanthi, 2008; Lawrenz et al., 2009; Ma & Klinger, 2000; Young et al. 1996). The effect of parents' highest education level, furthermore, was showed by the reducing effect of additional tuition on students' achievement when the variable of parents' education level was added (Damayanthi, 2008).

This study also showed that parents' highest education showed an indirect positive influence on physics achievement through four different paths when examined using SEM analysis. Parental education showed the indirect effect through two groups of factors: students' attitudes toward physics (liking of physics, valuing of physics, and self-confidence in learning physics) and future educational aspirations. This finding confirmed Brown and Iyengar (2008) who underlined the effect of parents' highest education level on students' achievement through three paths: parental beliefs and attitudes transmissions, parents' cognitive competencies transmissions, and increased opportunities for students to learn. In addition, the study conducted by Brown and Iyengar (2008) also revealed that although parental education may not always directly influence students' achievement, parents' highest education strongly influenced students' achievement indirectly through several paths including parental involvement.

Effects of liking of physics on physics achievement

The study did not find any direct effects of liking of physics on physic achievement. However, this study showed that liking of physics had indirect effects on students' achievement, where the more students liked to learn physics, the more they felt self-confident in learning physics, and finally, students who showed more self-confidence in their studies better performed physics.

These findings confirmed the study conducted by Woolnough (1994), who concluded that liking of physics should get more attention because it could influence students' future educational aspirations. However, this study did not show a significant effect of liking of physics on physics achievement as found in several studies (Cavallo et al., 2004; Haussler & Hoffman, 2002; Labudde et al., 2000).

Effects of valuing of physics on physics achievement

It is important to consider the findings of students' attitudes toward physics before teachers help or inspire students to learn physics. This is in line with the study conducted by (Prosser et al., 1996). They found that students only focused on learning to know the physical world and reproduce knowledge during assessment rather than thinking to understand the phenomena. This finding should be considered during physics delivery in the class to introduce physics not only as a subject, but also as knowledge to help them in their life.

Effects of self-confidence in learning physics on physics achievement

This study found that self-confidence during physics learning showed a positive direct effect on students' achievement on both SEM and HLM analyses. This means that students who demonstrate self-confidence in learning physics tend to have better physics achievement.

This study confirmed OECD findings on PISA studies that students who showed positive attitudes would perform better in their science studies (OECD, 2007). It is also supported by several studies that showed the positive effects of self-confidence during learning physics to enhance academic performance and reduce adverse effects of demographic background (Cavallo et al., 2004; Haussler& Hoffman, 2002; Labudde et al., 2000; Miyake et al., 2010).

However, Khusaini and Darmawan (2020), when analysing the TIMSS 2011 dataset, found the negative relationship of self-confidence in learning physics on physics achievement. They found that students who exhibited self-confidence in learning physics tended to achieve worse in physics. This is different from the finding in this study where students who showed positive self-confidence tended to achieve better in physics.

Effects of frequency of homework assigned by teachers on physics achievement

The frequency of physics homework assigned by teachers positively influences students' achievement in physics as students who were assigned more frequent homework tended to achieve better in physics when the data were analysed using SEM analysis. In addition, when HLM analysis was conducted, the study found that instead of influencing physics achievement at student level, the frequency of homework assigned by teachers influenced physics achievement through its aggregated value at school level (THOMEWORK). This aggregated value shows that the difference is the class where the students were taught by different teachers. The students who were assigned more frequent homework tended to perform better in physics. However, students who were learning in a class assigned less frequent homework showed lower academic performance in physics.

These findings confirmed several previous studies regarding the positive effects of homework on students' achievement (Khusaini & Darmawan, 2020a; Núñez, Suárez, Cerezo, et al., 2015). The time spent by students doing homework helped them achieve better in physics where the more time a student spends doing physics homework, the better students' achievement (Khusaini & Darmawan, 2020; Maltese, et al. 2012; Núñez et al., 2015). Homework also trains students to achieve the highest possible performance, particularly to prepare them for future careers (Corno & Xu, 2004).

Effects of future education aspirations on physics achievement

The findings regarding future education aspirations confirmed those of several studies that have shown a positive effect on students' achievement in physics. The finding of this study show that students with higher level education aspirations tend to perform better in physics when the data were analysed using SEM analysis. However, similar to the frequency of physics homework assigned by teachers (HOMEWORK), future education aspirations also showed a significant effect at school level. HLM analysis found that a teacher who taught a physics class with a higher level of future education aspirations tended to get higher students' achievement in physics.

Students' future educational aspirations influence how they behave and their attitudes toward physics (Oon & Subramaniam, 2013; Woolnough, 1994; Young et al., 1996). This finding suggests the teachers could introduce future related physics studies to their students to improve physics achievement.

Effects of additional tuition on physics achievement

Several studies have shown that students who take the national examination or university selection test tend to attend additional tuition (Nosek et al., 2009; Oktavianti et al., 2018). However, this study did not find any significant influence of additional tuition on physics achievement although it is a common and large industry in Indonesia. This finding did not confirm the several studies that found positive effects of additional tuition on students' achievement (Fransisca, 2004; Jamil et al., 2021; Suleman & Hussain, 2013).

This study confirmed the findings of Smyth (2008) and Wicaksono (2017) who argued there is no significant influence of additional tuition on physics achievement. Therefore, the objectives of additional tuition should be determined before its effect on students' achievement can be examined (Santhi, 2011; Smyth, 2008). Furthermore, this study also found that the majority of students participating in this study argued that they followed their friends and parental orders to attend additional tuition rather than perform better in physics. This finding may also influence the effect of additional tuition on physics achievement.

Effects of class size on physics achievement

This study did not find a significant influence of class size on physics achievement. This confirms the findings of several studies that argue there is no significant effect of class size on academic performance of students (Asadullah, 2005; Borland & Howsen, 2003; Hoxby, 2000). Therefore, it is not important to reduce the class size to improve students' achievement because it may need additional cost (Borland & Howsen, 2003). This is supported by Asadullah's (2005) findings that suggested encouraging school competition rather than reducing class size to improve students' achievement in developing countries where Indonesia is included. It is also important to consider other factors that may influence the effect of class size on students' achievement including teaching practice and student abilities (Bonesronning, 2003; De Paola et al., 2013). Therefore, other factors should be considered when examining the effect of class size on students' achievement.

Effects of teachers' highest education level and major education background on physics achievement

SEM analysis did not find any direct influence of teachers' highest education level or major education background on physics achievement. However, the study found a causal relationship between major education background of teachers with teaching certification and teachers' collaboration. The study found that teachers who graduated from a physics education study tended to receive teaching certification compared to others who graduated from either a physics non-education study or a chemistry education study. This may be caused by teachers who graduated from both major background studies as relatively younger than those who completed their studies in a physics education study, and the certification program also provides a limited quota for certification process. This is supported by Budi, a teacher who graduated from a physics non-education study, where certified teachers were senior teachers. Although they had less pedagogical and content knowledge, these senior teachers received easier requirements.

In addition, teachers who graduated from both physics education and chemistry education indicated more collaboration compared to teachers who graduated from physics non-education study. Furthermore, teacher learning physics education (PHYE) shows more collaboration than teacher graduated chemistry education (CHEME) as indicated by the standardised score.

This study did not support previous studies which concluded the positive effect of teachers' highest education level and teacher major studies on student academic performance (Boyd et al., 2009; Greenwald et al., 1996; Wayne & Youngs, 2003). Boyd et al. (2009) found the positive effect of focusing to prepare pre-service teachers for students' achievement and teaching skills. This finding is supported by (Gansle et al., 2012) who asserted the importance of teachers' highest education level on students' achievement.

Effects of teaching certification on physics achievement

This study did not find any significant effect of teaching certification programs on students' achievement in either SEM or HLM analysis. This finding did not confirm previous studies which showed a strong correlation between teacher certification and students' achievement, because certified teachers could ensure they are qualified in terms of content knowledge and pedagogical skills to deliver physics in class (Darling-Hammond, 2000; Goldhaber & Brewer, 2000; Wayne & Youngs, 2003).

In addition, a teacher who was undertaking the certification program examination believes that this program encourages teachers to improve their teaching quality. Furthermore, the majority of teachers believe that certification program effects depended on the teacher. They could not show the benefit of the certification program on students' achievement, but they could show the effects of the program on the requirements to be met to get the certification allowance.

Furthermore, Budi, a teacher who has not been certified yet, believed that certified teachers have less pedagogical and content knowledge, particularly in relation to how to use Information, Communication and Technology (ICT) for delivering physics in their class because the certification program had a limited quota and paid more attention to senior teachers. This view is supported by Siswandari and Susilaningsih (2013) who showed that only 37% of certified teachers could clearly deliver the topics, around 30% certified teachers could use media and teaching technology in their class, and 32% certified teachers were categorised into less than good in terms of their Continuing Professional Development (CPD).

In addition, the study found that certified teachers tend to undertake more collaboration with other physics teachers than uncertified teachers in SEM analysis. This confirms Siswandari and Susilaningsih (2013) who conducted a study to investigate the effect of teaching certification on teaching quality in the classroom. They found that the majority of teachers (70%) tend to collaborate on skills with other teachers within the school for professional development compared to other activities.

Effects of teaching challenges on physics achievement

SME analysis did not find any significant influence of teaching challenges faced by the teachers on physics achievement in either SME or HLM analysis. This study did not confirm the TIMSS 2011 study where minimum challenges faced by teachers would influence students' achievement (Hooper et al., 2015). The study found that teachers tended to face challenges by spending more time helping their students to learn physics, and keeping up-to-date with the curriculum, and administrative tasks. These three challenges should be solved to help students achieve better in physics because a manageable workload will help teachers work more productively (Johnson, Kraft, & Papay, 2012).

Effects of attitudes toward teaching and learning on physics achievement

The study did not show a significant effect on students' achievement. This study did not confirm the result that teachers' attitudes positively influence students' achievement and enhancing students' physics concepts, particularly in connecting their lessons with daily life (Sanders, Wright, & Horn, 1997).

In addition, instead of showing a direct or indirect influence on physics achievement, teachers' attitudes showed a positive effect on another variable at the Process stage at teacher level, that is, teaching practice in the class. The study found that teachers who showed a positive attitude toward physics teaching and learning tended to demonstrate positive teaching practice in their physics class.

Effects of teachers' collaboration on physics achievement

This study found no significant influence of teachers' collaboration on physics achievement. There was a causal relationship between teaching certification and teachers' major study on teachers' collaboration. Teachers' collaboration was likely undertaken by certified physics teachers and those who graduated from a physics education study or chemistry education study. In addition, this study did not confirm studies which showed a positive effect of teachers' collaboration on students' achievement (Fulton & Britton, 2011; Vescio, Ross, & Adams, 2008).

Effects of teaching practice on physics achievement

Teaching practice did not show a significant influence on physics achievement in either SEM or HLM analysis. This finding can be explained using teachers' responses in the teacher questionnaire which were analysed using the Rasch analysis. The analysis found that that the teachers tended to disagree to use high order thinking or actively exploring the physics concepts in their class. The teachers also tended to agree to use written tests or memorising the physics concepts or reading physics textbooks. These Rasch analysis findings showed that the teachers did not practice the inquiry method in their classrooms. These findings are in line with the interview findings that showed the five out of eight teachers aimed to help the students succeed in their national examination.

However, teaching practice could significantly influence students' achievement when the teachers encouraged the students to learn using inquiry-based learning methods in their teaching practice such as actively investigating the physics concepts and examining multiple representations of the data (Gess-Newsome, 2019). This study can be considered to apply inquiry-based learning methods for delivering physics.

Effects of school types on physics achievement

This study did not confirm the studies which have indicated the effect of school type on students' achievement (Epple & Romano, 1998; Gamoran, 1996; Sander, 1999), this study only finding was the effect of school types on their emphasis on student academic success. It was found that public schools showed less emphasis on students' academic success compared to other school types. It is supported by Epple & Romano (1998) who found that school type influences a difference in funding allocation to facilitate and support student academic success.

In addition, this study found the effect of school types on student enrolment and principals' highest education level. More students tended to enrol in both public schools and religion-based public schools than in religion-based private schools and private schools. It confirms that parental feelings of pride and school service and qualities significantly correlated with student enrolment on particular school types (Kurliyatin, Bafadal, & Zulkarnain, 2017). The findings of Kurliyatin et al. (2017) supported the finding of this study where both public schools and religion-based public schools showed that the parental prides and school qualities in both public schools and religion-based public schools. The parents tended to choose religion-based schools when they focus on religious factors and chose public schools when the parents focus on the school environment (Septhevian, 2014).

Moreover, the principals working at public school schools and religion-based public schools showed higher education levels than other principals working at religion-based private schools and private schools. It confirmed the study of Papa et al. (2002) the difference in facilities or salary provided by the schools could influence principals' highest level of education. In this case, the public schools and religion-based public schools would provide the principals' salaries and future careers as it was managed by the government who owns and manages the schools.

Effects of school location on physics achievement

The study did not find a significant influence of school location on students' achievement when the data were analysed in either SEM or HLM analysis. This finding did not confirm the study conducted by Papa et al. (2002) who found there was a different achievement of the students learning in New York City and suburban areas. However, we should consider the differences between Malang and New York were in this study, there was very little difference in school locations, most being relatively close to Malang.

Effects of availability of library on physics achievement

The study did not find a significant influence of a school library on students' achievement. This study did not confirm the studies that have indicated the positive effect of the library on students' achievement (Barrett, 2010; Haycock, 2011). In addition, to get the benefits of the library, the most important is to create an academic life in the library where the students become active users to deeply understand the information and learn actively to improve their achievement, and this is not necessarily the case in any school (Oberg, 2002; Scott & Plourde, 2007).

Effects of physics laboratory and availability of laboratory staff on physics achievement

This study found that the availability of a physics laboratory (LAB) significantly influences physics achievement (PHYACH) when the data were analysed using SEM. Students learning at schools with a physics laboratory tend to perform better in physics. The significant effect of availability of a physics laboratory is supported by Freedman (1997), who found that hands-on activities in the laboratory exhibited positive attitudes toward science and students tended to perform better.

However, the availability of laboratory staff did not show a significant influence on students' achievement, but significantly influenced school academic emphasis on academic success. This study confirms Donelly (1998) indicating that teachers felt anxiety during laboratory learning activities. The availability of laboratory staff was found to significantly influence academic emphasis on academic success caused by laboratory staff availability, which could decrease teachers' anxiety when preparing laboratory activities.

Effects of principal's education level and principal experience on physics achievement

The study did not find a significant influence of principals' highest education level and leadership experiences on students' achievement. This study does not confirm studies conducted by Firestone and Wilson (1989), Eberts and Stone (1988) and Papa et al. (2002) which showed the significant influence of principals' leadership and highest education level on students' achievement.

Moreover, this study found that principals working at public schools (PUBLIC) and religion-based public schools (PUBREL) show a higher education level than those working at religion-based private schools (RELPRI) and private schools (PRIVATE). This finding showed a significant relationship between school types and teachers' highest education level. It is in line with the finding of Papa et al. (2002) that some school factors including salary and school location can influence principals with a higher education level to work in those schools.

Effects of school emphasis on academic success on physics achievement

This study did not demonstrate a significant influence of school emphasis on academic success (SEAS) on physics achievement. However, causal relationships between school types and SEAS where the public schools exhibited worse school SEAS compared with other school types was found. In addition, schools which had laboratory staff (LABSTAF), indicated better SEAS than their counterparts.

These findings did not confirm any studies regarding the effect of parental involvement, or their emphasis on success on students' achievement (Brown & Iyengar, 2008; Jung & Zung, 2016). It has been asserted in these studies that parental involvement could positively influence students' achievement because students are motivated to achieve better when they want to please their parents and family rather than their teachers (Daniels & Arapostathis, 2005).

In addition, this study confirmed findings about students (Dooden et al., 2012). Dooden et al. compared the correlation of school environment and students' achievement and identified different findings between Saudi Arabia and Taiwan. They found some variables such as parental involvement showed a significant correlation with students' achievement in Taiwan, but it did not show a significant correlation in Saudi Arabia. It can be concluded that these findings may be correlated with countries where the study was conducted. Furthermore, this study also found using Rasch analysis that principals tended to agree that teachers were successful to apply the curriculum, and this finding confirmed Dooden et al. (2012) that although teachers' views that they were a success in applying curriculum and understanding curriculum goals, it did not assure a significant correlation with students' achievement.

Effect of interaction of factors influencing physics achievement

The final model also provides additional information about an interaction effect. The interaction effect shows that the teachers' major education influenced the effect of students' self-confidence (SELFCONF) in influencing physics achievement. The HLM analysis shows that students taught by physics teachers who graduated from physics education reveal the weaker effect of their self-confidence in their physics achievement; however, their counterparts taught by the teacher who graduated from non-physics education indicated a stronger influence in self-confidence on physics achievement. This is supported by the finding from semi-structured interview which revealed that Budi, a teacher who graduated from non-physics education, showed how he taught and engaged his students to understand physics topics using experiments and outdoor activities. These activities were also supported with his content knowledge of physics which helped to improve student self-confidence in learning physics. This is supported by Woolnough (1994) who argued that providing a strong physics environment in the school can help students' self-confidence in learning physics. Furthermore, Budi showed that teachers who graduated from non-physics education could learn pedagogical skills during the professional development program and get benefits from content knowledge which helped him to perform better in the class (Boyd et al., 2009).

Furthermore, other information about the variance explained in the final model is also provided by the HLM. The variance explained by the final model indicated that SELFCON as an additional predictor at the student level can reduce 5.58 % of the measurement error. In addition, at the school level, the variance explained showed that the aggregated value of the frequency of physics homework assigned by the teacher (THOMEWORK), teacher physics education as an education major (PHYED) and the aggregated values of students' future education aspirations (FUTED) as predictors have reduced the error in predicting the students' physics achievement to 49.22%. Moreover, the total variance explained by both levels reduces 28% of the measurement error. This explained variance shows that the model reduces the measurement error. The final model is also considered better than the null model indicated by the ratio of deviance decrease and increase of estimated parameters more than one.

The views of teachers and students on factors influencing physics achievement

This subsection discusses the views of the teachers and the students regarding particular factors found during the interview. The findings supported the quantitative data discussed in the previous subsections.

The teachers' views regarding factors influencing physics achievement can be seen in their objectives in their class. The majority of teachers, five respondents (63%), argued that the main objective of their physics class is to help students pass their national examination.

Therefore, this majority taught their students to deal with the national examination through telling them about previous students’ success and applied various teaching strategies to deal with physics topics listed in the national examination rubric. It is supported by another interview findings that teachers applied five different strategies to inspire and help the students to learn physics. They chose the strategies based on teachers’ situations in the classroom, but they did not talk about students’ views or feedback regarding the strategies. However, it is important to accommodate students’ feedbacks because teaching practice could positively influence students’ achievement when the teaching practice meet the students’ needs (Gess-Newsome, 2019). This feedback may provide important information to the teachers to help their students to learn physics.

Another important finding is about teachers’ views regarding teaching certification where the government uses this program to enhance the quality of education in Indonesia. The study found that the majority of teachers thought certification program brought a lot of benefits, particularly for certification allowance given to certified teachers. A teacher participating in the interview argued that she used the allowance to join teaching training. Another four certified teachers used their allowance to purchase technology tools to assist with their teaching strategies such as laptops or smartphones and for individual needs, and one of them believed that he could focus on teaching and help his students because he did not need to provide additional tuition to support himself. This is supported by Ikhsan et al. (2013) and Masruroh (2010). They found that the majority of certified teachers get most benefit from the certification program and additional allowance and used it for their individual needs, because the majority of Indonesian teachers were living with or even under the minimum wage. However, this study also found an interesting finding about the effect of this certification program on the education quality. The teachers believed that the effect of the certification program depends on the teachers' attitudes rather than the program. Therefore, the government should consider educating teachers who received the teaching certificate to perform better by changing their attitudes toward teaching and learning.

What about the teacher collaboration? Teachers participating in the interview showed similar views regarding the importance of teacher collaboration. They believed that teaching collaboration supported their teaching quality. In addition, the different number of physics teachers in schools should be considered with respect to teachers' collaboration as based on interviews conducted with teachers. Three out of eight participating schools had only one teacher which influenced their ability to focus on collaboration with their colleagues. With only one teacher in a school, teachers' collaboration with other teachers from different schools was used to help them solve teaching issues. However, teachers who have physics teacher colleagues used collaboration to update their information and collaborated with other colleagues in their schools. Furthermore, physics teacher association meetings still focused on the national examination preparation and administration duties, even though they meet regularly compared to other subject teacher associations. These findings confirm the essential role of teachers' collaboration to enhance teaching quality at an effective cost (Fulton & Britton, 2011). Moreover, collaboration should also be considered as an important focus, because interviews found that the majority of teachers used teachers' collaboration to improve their strategies in addition to the plans of younger teachers to pursue their study for a Master degree. This interview finding confirmed that teachers' collaboration positively influences teaching practice (Vescio et al., 2008). Furthermore, it was frequently undertaken by 70% of the certified teachers to improve their professional development in Surakarta, Indonesia (Siswandari & Susilaningsih, 2013).

This study also explored students' views to explain the findings on the quantitative data. The students' views were explored by using FGD. One of the findings of FGD is the explanation of effect of parents' highest education level on students' attitudes toward physics. FGD found that students tended to have positive attitudes toward physics or continue their studies on physics-based studies when their parents suggested they continue their studies in a particular direction. The students who received parents' suggestions tended to follow them. This FGD finding confirmed that studies found the ability to predict students' future education aspirations using their parents' highest education level (Dubow et al., 2009; Oon & Subramaniam, 2013). This is because students whose parents' highest education level tended to show a positive effect on students' attention to continue future education on physics would also show positive attitudes toward physics or positive beliefs in a physics-based future job (Brown & Iyengar, 2008; Oon & Subramaniam, 2013; Young et al., 1996).

Furthermore, while the most students participating in the interview agreed that physics is an important subject, three out of 20 participants could not decide on the importance of physics, and only one student thought that physics was not important because he did not like it. FGD found that all students learning in school C thought that physics was only a subject in the school. However, students learning in schools B and D connected the value of physics with their future studies and their daily life. This is in line with the study conducted by (Prosser et al., 1996). They found that students only focused on learning to know the physical world and reproduce knowledge during assessment rather than thinking to understand the phenomena and indicating the important roles of physics in their daily life. This finding should be considered during physics delivery in the class to introduce physics not only as a subject, but also as knowledge to help them in their life.

It is also important to consider the findings of students' attitudes toward physics before teachers help or inspire their students to learn physics. The study found that 12 out of 20 participant students chose physics as their elective subject on their national examination, and the rest of the students who chose physics decided that physics has medium difficulty compared to other natural science subjects, meaning they chose it because they thought they could perform better in physics. Furthermore, FGD found that more than 50% (11 out of 20) of respondents thought that physics is the easiest subject within the natural science subjects, and the rest thought that physics has medium difficulty. This finding suggested that it is important to motivate and introduce physics as an interesting subject to attract more students. This finding also confirmed the quantitative finding and the study conducted by Woolnough (1994), who concluded that liking of physics should get more attention because it could influence students' future educational aspirations.

In addition, FGD conducted to explore students' views, found that only one student at school B will learn in their home time when teachers did not assign homework. In addition, when semi-structured interviews were conducted to explore teachers' views, the majority of teachers assigned homework to help their students learn in their home time, because teachers thought students may not learn if there was no homework. Both findings indicated that homework shows a pivotal role to help students learning physics. Therefore, teachers could consider the frequency and the types of the homework to help the students during their learning physics.

What about the types of physics homework assigned by teachers? The majority of teachers assigned paper-based homework which helps students learn many kinds of national examination problems and solve physics problems, and only students learning at school D received some project-based homework. The interview also found that no teachers were rejecting assigning homework, but there were two different views, either assigning homework or avoiding it. Teachers who always assigned homework believed that students may not learn if they did not do their homework. However, one respondent found that some students just copied their classmates' work; therefore, she avoided assigning homework if topics could be covered in class. Furthermore, when they explored their favourite physics homework, 12 out of 20 students from three different schools chose project-based homework as their favourite type. This project-based homework can be a solution to prevent copying and pasting another students' work. In addition, it is important to consider homework types because they may influence students' achievement and attitudes toward physics. Homework should meet several requirements including similar perceptions on homework of students, teachers, and parents, integrating three aspects of daily experiences, proper knowledge and well-designed, and providing teachers' feedback (Coutts, 2004; Corno & Xu, 2004; Nunez, 2015b; Ronning, 2008).

Another interesting finding of FGD is the influence of future education on students' views about physics. Students tended to view a more positive value when they are planning their future study on physics-related subjects. The students who already received more information regarding future studies tend to value physics more than just a subject at school. This finding confirms other previous studies indicating the positive effect of students' future education aspirations on physics achievement (Jung and Zung, 2016, Khattab, 2015; McCulloch, 2017; Seginer and Valmust, 2002; Signer & Saldana, 2001). This finding regarding the effect of future education on student achievement can be considered by the teachers to introduce any future studies particularly which need physics.

Limitations and future research

This study contributes significantly to investigating the factors that may influence physics achievement of Year 12 students in Indonesia. This contribution becomes important when the information regarding the impact of factors has so far been limited in Indonesia. However, this study also has several limitations including the study sample, factors examined, methodology used, and physics concepts assessed.

First, the study was conducted in Malang city, Indonesia. It is a city in Indonesia which only has urban and sub-urban areas. Therefore, the findings cannot be generalised to the other areas in Indonesia which has 34 provinces and very diverse areas. Further studies with a larger area, at least in a complete province, are recommended in the future to obtain better findings. Furthermore, the study of other senior high school levels could also be conducted to enrich the information regarding the factors influencing physics achievement of the senior high school students.

Second, factors included in this study could provide information that physics achievement is affected by several factors. However, they are limited, and many other factors may influence physics achievement of Year 12 students. Thus, further studies are encouraged to investigate many potential factors that may influence physics achievement of senior high school level students, particularly at Year 12 level. Potential factors can be adapted from international studies, such as PISA and TIMSS, or new educational issues in Indonesia.

Third, this study employed mixed methods design that combined a survey study and interview/ FGD. The survey study benefits from a wide range of data from students, teachers, and principals. These survey data were supported by positive aspects of interviews and FGD used for exploring students' and teachers' views regarding factors included in the study. Additional research methods can be used in future studies such as policy analysis or other qualitative methods. Furthermore, this study also employed cross-sectional design. This may be beneficial to check trends of Year 12 students in Indonesia by conducting a longitudinal study to examine thoroughly the factors influencing physics achievement and students' performance.

Fourth, the topics included in this study could inform their difficulty level and students' ability. The items were adapted from the 2014 national examination. However, they covered limited topics of physics at senior high school level because of time limitation. It is important to add topic coverage with high order thinking level to assess student performance in physics at senior high school level and their way of thinking. Furthermore, it is also suggested to assessed physics ability using TIMMS or PISA test items or the items with similar characteristics with both tests.

Theoretical, practical, and methodological implications

The study provided information about factors influencing physics achievement. The study could provide general information regarding factors influencing physics achievement of Year 12 students in Malang, Indonesia. These factors were examined based on the student questionnaire, teacher questionnaire, and principal questionnaire. This examination could show factors that may influence physics achievement from different views instead of focusing on teaching method or students' abilities in physics.

The study provided theoretical models describing students' physics achievement. These models were examined empirically based on the data provided through the survey data. The study also provides a multilevel model indicating inter-correlation between levels to influence physics achievement.

The study examined several factors influencing physics achievement of Year 12 students. This included factors that can be used to formulate better educational policies in

Indonesia. The Indonesian government can also use these factors to evaluate the effects of factors for revising the curriculum in physics.

The study showed several methodological implications to conduct physics education studies in Indonesia. The use of Rasch analysis may enrich the data regarding physics achievement studies where the majority of physics education studies used raw scores for examining students' achievement. Another methodological implication is the use of Structural Equation Modelling (SEM) and Hierarchical Linear Modelling (HLM) for examining causal interaction between variables. Both analyses will benefit physics education researchers when examining the interaction of factors in multiple dependent and multilevel interaction instead of only one dependent variable within one level.

Conclusion

This study contributed to the investigation of factors influencing physics achievement of Year 12 students in Indonesia. This can be seen as a pioneering study with the main focus being Year 12 students, which has rarely been conducted in Indonesia, even though this year level plays an important role. This role can be seen when we talk about the highest level for senior high school where students will continue their study at university level and choose future jobs. The more we can identify factors influencing physics achievement, the better we can get new fresh students relating to physics or physics-related studies at university level.

This study found Dynamics, Kinematics, Fluid, Thermodynamics, Wave, and Temperature and Heat are difficult topics for students. It means that students generally could not handle abstract topics. Interestingly, both Dynamics and Kinematics are considered as both difficult and easy items which depend on the types of the problems. Furthermore, measurement can be considered as an easy topic for the students. These findings can be considered to modify the strategies used to deliver physics at secondary school level particularly for year 12 students.

This study provided additional information regarding factors influencing physics achievement instead of focusing on teaching methods or student only related studies. It can be concluded, based on the findings of hierarchical linear modelling, that students' self-confidence could significantly influence students' physics achievement. However, it is not the only factor that influences students' achievement in Year 12 physics. Other factors including the average value of the frequency of physics homework assigned by the teacher (THOMEWORK) and the aggregated value of students' aspirations in their future education (TFUTED). This finding showed us that education not only refers to one factor but more. Another interesting finding is the interaction effect between teacher's major education level and students' self-confidence. This interaction would finally influence students' physics achievement.

This study also provided additional information regarding the interaction between factors within a single level at the student, teacher, and school levels. The findings can be compared with hierarchical level model findings. There was a nexus between single-level analysis in the hierarchical linear model where students' achievement was influenced by self-confidence in learning physics. However, homework and future education aspirations influenced physics achievement at a different level. These findings indicate the importance of quantitative methods for analysing in different ways.

Moreover, the Indonesian government could also consider the findings in this study, contributing to exploring the views of teachers and students in Malang, Indonesia. This study found that the main objective of the teachers teaching at year 12 students is to help the students facing the national examination. As a result, most of the teachers assigned paper-based homework. It is supported by the finding of student's interviews which showed that only students learning at School D assigned with project-based homework which is the most participants' favourite homework type. The interviews also revealed that the certification program did not show a direct effect on the quality of the education, but it is influenced by teachers' attitudes. In addition, students thought that physics is an important subject particularly for their future studies, but they did not recognise the role of physics in their life. These views may represent the context underlying factors influencing physics achievement of Year 12 students. The findings can be used to formulate educational policies, particularly in physics education in Indonesia.

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APPENDICES

Appendix A. Student questionnaire

An Investigation of the Factors Influencing Physics Achievement of Year 12 Students in Malang, Indonesia

Information about this Questionnaire

This questionnaire is intended for Year 12 students in Malang, Indonesia. It contains items that ask for background information about the student and his/her attitudes towards learning Physics and how homework help the student to learn Physics.

Your response to the questionnaires contributes to investigate the factors influencing Physics achievement of Year 12 students in Malang, Indonesia. It is vital that you respond to each of the items very carefully so that the information provided reflects your situation. Your answers will be collated with other responses from other students in which no individual students/schools can be identified. All your answers and your identity will be kept strictly confidential.

General Instructions to Student Participants

1. Please read each item carefully and answer them accurately as you can. **Please do not leave any item unanswered.**
2. The questionnaire must be returned to the researcher as soon as it has been completed.
3. Complete the questionnaire during your class. The researcher distributes and explains the instructions.
4. Time allocated to answer the questions is 30 minutes

For Researchers Use Only:

School ID : ______________________________

Class ID : ______________________________

Student ID : ______________________________

Teacher ID : ______________________________

School Type : ______________________________

Instruction: Fill in the blank with words or sentences that correspond to your answer. For the items that are multiple choice questions choose the alphabet by giving a **Cross Mark** (**X**) that correspond to your answer. For items that have the given options in a table, check only one box with a **check list** mark (√) that correspond to your answer in the table**.**

1. Are you a Male or a Female?
   a. Male
   b. Female
2. When you born (Month and year) …………………………………..

3. What is the highest education level of education completed by your mother?
   a. Less than High school
   b. Some high school
   c. High school graduate
   d. Diploma's degree
   e. Bachelor's degree
   f. Master's degree or professional degree
   g. Doctorate
   h. I don't know

4. What is the highest education level of education completed by your father?
   a. Less than High school
   b. Some high school
   c. High school graduate
   d. Diploma's degree
   e. Bachelor's degree
   f. Master's degree or professional degree
   g. Doctorate
   h. I don't know

5. How far in your education do you expect to go?
   a. Finish High School

b. Finish Diploma degree
c. Finish Bachelor’s degree
d. Finish Master’s degree
e. Finish Doctorate

6. How much do you agree with these statements about Physics?

	Agree a lot	Agree a little	Disagree a little	Disagree a lot
I think learning Physics will help me in my daily life				
I need Physics to learn other school subjects				
I need to do well in Physics to get into the college or university of my choice				
I need to do well in Physics to get the job I want				
I would like a job that involves using Physics				
It is important to learn about Physics to get ahead in the world				
Learning Physics will give me more job opportunities when I am an adult				
It is important to do well in Physics				
My parents think that it is important that I do well in Physics				

7. How much do you agree with these statements about Physics?

	Agree a lot	Agree a little	Disagree a little	Disagree a lot
I usually do well in Physics				
Physics is more difficult for me than for many of my classmates				
Physics is not one of my strengths				
I learn things quickly in Physics				
I am good at working out difficult Physics problems				
My teacher tells me I am good at Physics				
Physics is harder for me than any other subject				
Physics makes me confused				

8. How much do you agree with these statements about learning Physics?

	Agree a lot	Agree a little	Disagree a little	Disagree a lot
a. I enjoy learning Physics				
b. I wish I did not have to study Physics				
c. Physics is boring				
d. I learn many interesting things in Physics				
e. I like Physics				
f. I look forward to learning Physics in school				
g. Physics teaches me how things in the world work				
h. I like to conduct Physics experiments				
i. Physics is one of my favourite subjects				

9. How often does your teacher give you homework?

A. Every day
B. 3 or 4 times a week
C. 1 or 2 times a week
D. Less than once a week
E. Never

10. When your teacher gives you homework, about how many minutes do you usually spend on your homework?
    a. My Teacher never gives me homework
    b. 1-15 minutes
    c. 6-30 minutes
    d. 31-60 minutes
    e. 61-90 minutes
    f. more than 90 minutes
11. During the last 12 months, have you attended extra lessons or tutoring not provided by the school?
    a. Yes, to excel in class b. yes, to keep up in class c. No
12. For how many of the last 12 months have you attended extra lessons or tutoring ?
    a. Did not attend
    b. Less than 4 months
    c. 4-8 months
    d. More than 8 months

Appendix B. Teacher questionnaire

An Investigation of the Factors Influencing Physics Achievement of Year 12 Students in Malang, Indonesia

Information about this Questionnaire

This questionnaire is intended for Year 12 Physics teachers in Malang, Indonesia. It contains items that ask for background information, attitudes toward Physics teaching and learning, and teaching preparation& Professional Development.

Your response to the questionnaires contributes to evaluate students' Physics achievement in Malang, Indonesia. It is vital that you respond to each of the items very carefully so that the information provided reflects your situation. Your answers will be collated with other responses from other teachers in which no individual teachers/schools can be identified. All your answers and your identity will be kept strictly confidential.

General Instructions to Teacher Participants

1. Please read each item carefully and answer them accurately as you can. For every section of the questionnaire, specific instructions of how to answer the items are given. **Please do not leave any item unanswered.**
2. The questionnaire must be returned to the researcher as soon as it has been completed.
3. Complete the questionnaire during your non-contact period in the school. The researcher will help distribute and explain the instructions.
4. Time allocated to answer the questions is 30 minutes

For Researcher Use Only

School Name : ______________________________

School ID : ______________________________

Instruction: Fill in the blank with words or sentences that correspond to your answer. For the items that are multiple choice questions choose the alphabet by giving a **Cross Mark** (**X**) that correspond to your answer. For items that have the given options in a table, check only one box with a **check list** mark (√) that correspond to your answer in the table**.**

1. What is the highest level of formal education you have completed?
    a. High school
    b. Bachelor's degree
    c. Master's degree
    d. Doctoral degree
2. ring your college or university education, what was your major or main area(s) of study?
   …………………………………………… (Physics Education, Physics, Other)
3. Do you have a teaching certificate given by the Ministry of Education and Culture?
   ………………………………………………………………………………………
4. How often do you have the following types of interactions with other Physics teachers?

		Very Often	Often	sometimes	Never/ almost never
a	Discuss how to teach a particular topic				
b	Collaborate in planning and preparing instructional materials				
c	Share what I have learned about my teaching experiences				
d	Visit another classroom to learn more about teaching				
e	Work together to try out new ideas				
f	Work as a group on implementing the curriculum				
g	Work with teachers from other grades to ensure continuity in learning				

5. Indicate the extent to which you agree or disagree with each of the following statements.

		Agree a lot	Agree a little	Disagree a little	Disagree a lot
a	There are too many students in the classes				
b	I have too much material to cover in class				
c	I have too many teaching hours				
d	I need more time to prepare for class				
e	I need more time to assist individual students				
f	I feel too much pressure from parents				
g	I have difficulty keeping up with all of the changes to the curriculum				
h	I have too many administrative tasks				

6. In teaching Physics to this class, how would you characterise your confidence in doing the following?

		Very High	High	Medium	Low
a	Inspiring student to learn Physics				
b	Explaining Physics concepts or principles by doing Physics experiments				
c	Providing challenging tasks for the highest achieving students				
d	Adapting my teaching to engage students' interest				
e	Helping students appreciate the value of learning science				
f	Assessing student comprehension of Physics				
g	Improving the understanding of struggling students				
h	Making Physics relevant to students				
i	Developing students' higher-order thinking skills				
j	Teaching Physics using inquiry methods				

7. In teaching Physics to the students, how often do you ask them to do the following?

		Every/ Almost	About half	Some	Never
a	Listen to me explain new science content				
b	Observe natural phenomena and describe what they see				
c	Watch me demonstrate an experiment or investigation				
d	Design or plan experiments or investigations				
e	Conduct experiments or investigations				
f	Present data from experiments or investigations				
g	Interpret data from experiments or investigations				
h	Use evidence from experiments or investigations to support conclusions				
i	Read their textbooks or other resource materials				
j	Have students memorise facts and principles				
k	Use scientific formulas and laws to solve routine problems				
l	Do fieldwork outside of class				
m	Take a written test or quiz				
n	Work in mixed ability groups				
o	Work in same ability groups				

Thank you very much for your time and effort in completing this questionnaire.

Appendix C. Principal questionnaire

An Investigation of the Factors Influencing Physics Achievement of Year 12 Students in Malang, Indonesia

Information about this Questionnaire

This questionnaire is intended for school Principals in Malang, Indonesia. It contains items that ask for School Characteristics and School Emphasis on Academic Success.

Your response to the questionnaires contributes to evaluate students' Physics achievement in Malang, Indonesia. It is vital that you respond to each of the items very carefully so that the information provided reflects your situation. Your answers will be collated with other responses from other principals in which no individual principals/schools can be identified. All your answers and your identity will be kept strictly confidential.

General Instructions to Principal Participants

1. Please read each item carefully and answer them accurately as you can. **Please do not leave any item unanswered.**
2. The questionnaire must be returned to the researcher as soon as it has been completed.
3. Complete the questionnaire during your non-contact period in the school. The researcher will help distribute and explain the instructions.

4. Time allocated to answer the questions is 30 minutes

For Researcher Use Only

School Name : ________________________________

School ID : ________________________________

School Type : ________________________________

Principal ID : ________________________________

Instruction: Fill in the blank with words or sentences that correspond to your answer. For the items that are multiple choice questions choose the alphabet by giving a **Cross Mark** (**X**) that correspond to your answer. For items that have the given options in a table, check only one box with a **check list** mark (√) that correspond to your answer in the table**.**

1. What is total enrolment of students in your schools in your school as of 2017/2018? ……………… students
2. What is total enrolment of 12-Year students in natural sciences, social sciences, and humanities sciences respectively? …. Students, ….. students, …. Students
3. What type of school is this?
   - a. Public school
   - b. Private school
   - c. Religion public school (Religiously affiliated)
   - d. Religion Private school (Religiously affiliated)
4. *4.* Which best describes the immediate area in which your school is located? TIMSS 8B
   - a. Urban–Densely populated
   - b. Suburban–On fringe or outskirts of urban area
   - c. Medium size city or large town
   - d. Small town or village
   - e. Remote rural
5. Does your school have a science laboratory that can be used by students?
   - a. Yes
   - b. No

6. Do teachers usually have assistance available when students are conducting science experiments? …………………………………………………………………………………...
7. Does your school have a school library? ………………………………………………
8. By the end of this school year, how many years altogether will you have been a principal?
9. By the end of this school year, how many years will you have been a principal at this school
10. What is the highest level of formal education you have completed?
    a. Did not complete Bachelor’s degree
    b. Bachelor’s degree
    c. Master’s degree or professional degree
    d. Doctorate
11. How would you characterise each of the following within school?

	Very High	High	Medium	Low	Very low
a. Teachers’ understanding of the school’s curricular goals					
b. Teachers’ degree of success in implementing the school’s curriculum					
c. Teachers’ expectations for student achievement					
d. Teachers working together to improve student achievement					
e. Teachers’ ability to inspire students					
f. Parental involvement in school activities					
g. Parental commitment to ensure that students are ready to learn					
h. Parental expectations for student achievement					

i. Parental support for student achievement					
j. Parental pressure for the school to maintain high academic standards					
k. Students’ desire to do well in school					
l. Students’ ability to reach school’s academic goals					
m. Students’ respect for classmates who excel in school					

Appendix D. Interview Protocol

PHYSICS TEACHER'S INTERVIEW PROTOCOL

Fieldwork Stage : Interview session –Teachers' attitudes toward Physics and teachers' views regarding professional development
Day :

Data Identity
Name :
Date :
Site/Venue :
Duration : 30 minutes

Interview Goal
To explore teacher's attitudes towards Physics and teacher's views regarding professional development

Type of Interview
Semi-structured Interview

Language Used
Bahasa Indonesia

Nature of Interview Questions
The following questions will be elaborated for the teachers' responses

No.	Questions	Note
1	**Attitudes toward Physics teaching and learning** • How are you doing to inspire and help the students to learn Physics? • What is the most important aim in your class? • Is it important to give homework?	

2	**Professional development** • Do you have a regular meeting to discuss Physics teaching and learning with your colleagues? • Do you have any plan to improve your teaching strategies? • What do you think about teacher's certification and its impacts to teaching and learning quality?	

Appendix E. Focus Group Discussion Protocol

STUDENTS' FOCUS GROUP DISCUSSION (FGD) PROTOCOL

Fieldwork Stage : Focus Group Discussion
Day : 1

Data Identity

Name : 1. ……………………
2. ……………………
3. ……………………
4. …………………....
5. ……………………

Date :
Site/Venue :
Duration : 60 minutes

Interview Goal

To explore Year 12 students' attitudes toward Physics in various school types
To explore Year 12 students' views regarding Physics Homework in various school types

Type of Interview

Semi-structured Interview

Language Used

Bahasa Indonesia

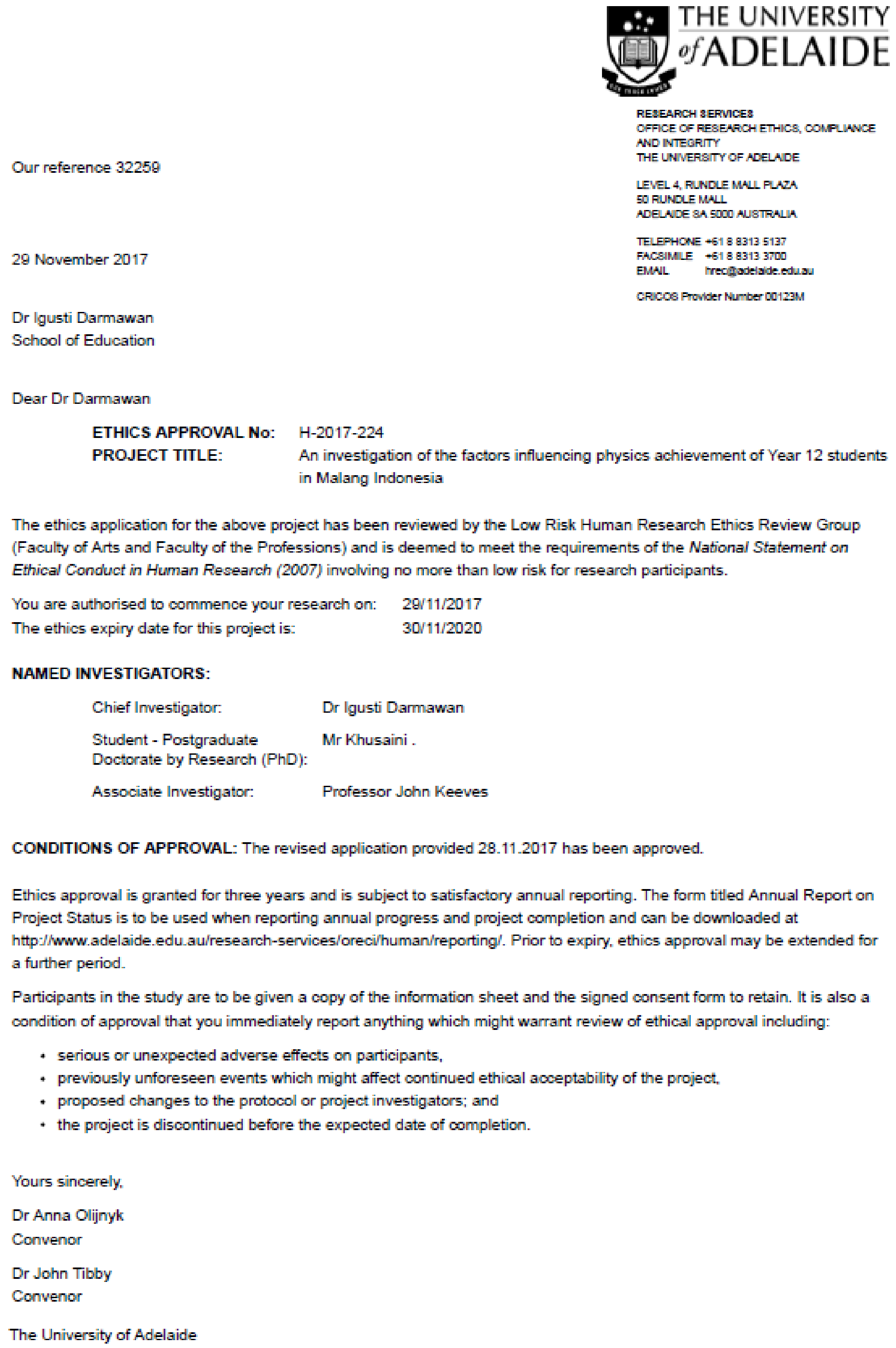
Nature of Interview Questions

The following questions will be elaborated for the students' responses

No.	Questions	Note
1	**Attitudes towards Physics** • Compared to other science subjects, how difficult is Physics? Why? • Do you think that Physics is important for your future? Why?	

2	**Homework** - Do you think that homework assigned by your teacher is relevant for daily life? - Do the homework trigger you to learn? - What is your favourite homework types? What is commonly assigned by your teacher?	

Appendix F. Ethics Approval



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CRICOS Provider Number 00123M

Our reference 32259

29 November 2017

Dr Igusti Darmawan
School of Education

Dear Dr Darmawan

ETHICS APPROVAL No: H-2017-224
PROJECT TITLE: An investigation of the factors influencing physics achievement of Year 12 students in Malang Indonesia

The ethics application for the above project has been reviewed by the Low Risk Human Research Ethics Review Group (Faculty of Arts and Faculty of the Professions) and is deemed to meet the requirements of the *National Statement on Ethical Conduct in Human Research (2007)* involving no more than low risk for research participants.

You are authorised to commence your research on: 29/11/2017
The ethics expiry date for this project is: 30/11/2020

NAMED INVESTIGATORS:

Chief Investigator:	Dr Igusti Darmawan
Student - Postgraduate Doctorate by Research (PhD):	Mr Khusaini .
Associate Investigator:	Professor John Keeves

CONDITIONS OF APPROVAL: The revised application provided 28.11.2017 has been approved.

Ethics approval is granted for three years and is subject to satisfactory annual reporting. The form titled Annual Report on Project Status is to be used when reporting annual progress and project completion and can be downloaded at http://www.adelaide.edu.au/research-services/oreci/human/reporting/. Prior to expiry, ethics approval may be extended for a further period.

Participants in the study are to be given a copy of the information sheet and the signed consent form to retain. It is also a condition of approval that you immediately report anything which might warrant review of ethical approval including:

- serious or unexpected adverse effects on participants,
- previously unforeseen events which might affect continued ethical acceptability of the project,
- proposed changes to the protocol or project investigators; and
- the project is discontinued before the expected date of completion.

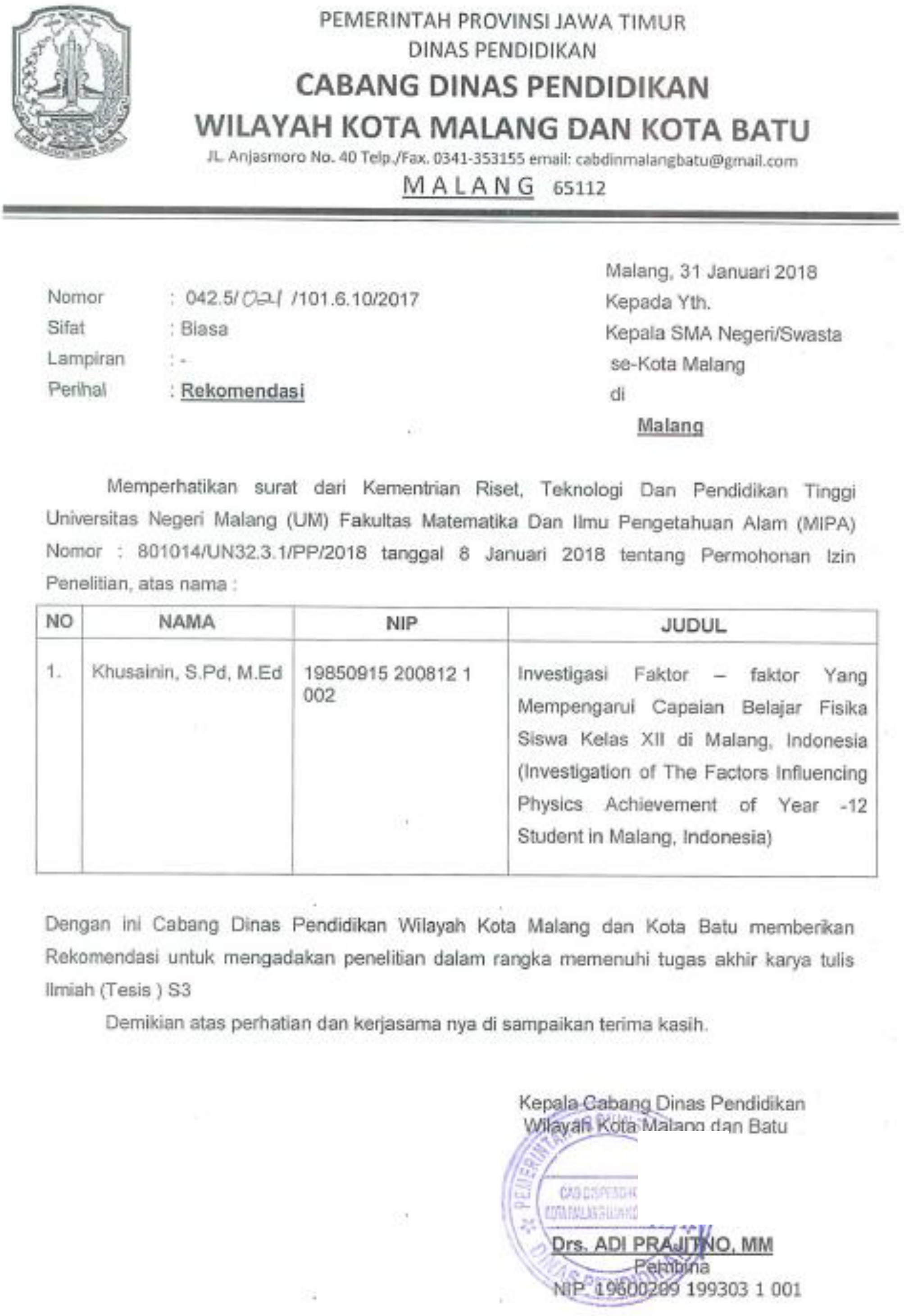
Yours sincerely,

Dr Anna Olijnyk
Convenor

Dr John Tibby
Convenor

The University of Adelaide

Appendix G. Approval of Ministry of Education and culture, East Java Province



PEMERINTAH PROVINSI JAWA TIMUR
DINAS PENDIDIKAN
CABANG DINAS PENDIDIKAN
WILAYAH KOTA MALANG DAN KOTA BATU
JL. Anjasmoro No. 40 Telp./Fax. 0341-353155 email: cabdinmalangbatu@gmail.com
MALANG 65112

Malang, 31 Januari 2018

Nomor : 042.5/ 021 /101.6.10/2017
Sifat : Biasa
Lampiran : -
Perihal : Rekomendasi

Kepada Yth.
Kepala SMA Negeri/Swasta
se-Kota Malang
di
Malang

Memperhatikan surat dari Kementrian Riset, Teknologi Dan Pendidikan Tinggi Universitas Negeri Malang (UM) Fakultas Matematika Dan Ilmu Pengetahuan Alam (MIPA) Nomor : 801014/UN32.3.1/PP/2018 tanggal 8 Januari 2018 tentang Permohonan Izin Penelitian, atas nama :

NO	NAMA	NIP	JUDUL
1.	Khusainin, S.Pd, M.Ed	19850915 200812 1 002	Investigasi Faktor – faktor Yang Mempengarui Capaian Belajar Fisika Siswa Kelas XII di Malang, Indonesia (Investigation of The Factors Influencing Physics Achievement of Year -12 Student in Malang, Indonesia)

Dengan ini Cabang Dinas Pendidikan Wilayah Kota Malang dan Kota Batu memberikan Rekomendasi untuk mengadakan penelitian dalam rangka memenuhi tugas akhir karya tulis Ilmiah (Tesis) S3

Demikian atas perhatian dan kerjasama nya di sampaikan terima kasih.

Kepala Cabang Dinas Pendidikan
Wilayah Kota Malang dan Batu

Drs. ADI PRAJITNO, MM
Pembina
NIP. 19600209 199303 1 001