Flipping the classroom:
Can changing delivery of the Australian Middle School Science Curriculum Improve Student Outcomes?

A dissertation submitted in partial fulfilment of the requirements for the degree of
Master of Teaching

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Due: 28th April 2022
Submitted: 29th April 2022
Word Count: 15221

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Abstract

Flipped Classroom (FC) pedagogy promotes active student learning and facilitates integration of technology within an 'inverted' learning environment. As such, this approach has experienced rapid global uptake over the past decade on the back of a rapidly evolving educational landscape. Through reversing conventional classroom and homework routines, a classroom 'flip' introduces students to new learning concepts outside of the traditional school setting, via online resources such as instructional videos, vodcasts, or interactive online platforms. Students may work through this novel content at a pace and frequency which suits their individual requirements. Subsequent within-class time is aimed at extending and establishing new knowledge through fostering an active, inquiry-based learning structure. The classroom setting in which inquiry takes place is student-centred, allowing the teacher to act as a guide or facilitator to group inquiry systems, assisting when needed, and whose presence provides a scaffold for student learning opportunities. This scheme is embedded within the framework of social constructivism, encouraging students to share, discuss, and reason within a communal framework to build knowledge. It firmly establishes students, both individually and collectively, at the centre of their personal learning. The FC model is encapsulated within one of six innovative pedagogical clusters recently identified by the OECD as focusing on developing 21st century skills and increasing engagement, motivation, and agency in students. The Australian F-10 science curriculum relies heavily on inquiry-based learning as a core construct, using scientific knowledge acquired through evidence, the development of communication skills and student collaboration to solve problems with real-world applications. When considered against the context of the Australian F-10 science curriculum, the FC presents an opportunity to prepare young learners to meet challenges facing both contemporary and future society.

The purpose of the present study was to assess whether flipping the classroom is effective across 3 determinants of student engagement and performance - academic learning outcomes (ALO), students' perceived learning outcomes (PLO) and student satisfaction outcomes (SSO). Further, with a primary focus on middle school science classes, it sought to resolve whether the FC strategy is suitable for widespread uptake in teaching of the years 7 to 10 Australian science curriculum. A qualitative systematic review of literature relating to the flipped classroom and its applicability towards science education was conducted. Only primary data, sourced from empirical studies published between 2012 and 2022, in peer-reviewed journals, dissertations or theses were considered. A total of 36 studies were included in the final review. Results showed that of the 3 determinants of student outcomes (ALO, PLO, SSO), no studies found a significant decrease in performance through use of flipped learning when compared to control groups. Further, ALOs significantly improved through use of the FC model when compared to control in 21 high school-based studies, with 8 showing no difference. PLOs including engagement, comprehension, autonomy, and completion of pre-learnings were significantly increased in 21 studies, with 3 showing no difference. SSOs, such as enthusiasm, motivation to learn and subject enjoyment, improved significantly in all of 14 studies when FC delivery was compared to control groups. Issues which may act as enablers or barriers to successful implementation of the FC were also identified and are reported on, including teacher proficiency in model delivery and technological competency for both student and teacher. The results of this inquiry align with other recently published systematic reviews and meta-analyses, adding to a burgeoning research repository demonstrating beneficial effects of the FC model. The

study concludes that flipping the classroom is a promising, learner-centred pedagogy suitable for developing active learners through delivery of the Australian middle school science curriculum.

Acknowledgements

I would dearly love to declare that I have enjoyed every moment of my journey towards completing this dissertation, with the end goal of obtaining a Master of Teaching degree now just around the corner. However, it has been arduous at times. Often, I felt as though I was swimming survival stroke through quicksand in attempting to cross a divide which for long periods, I felt unprepared for and incapable of achieving. Therefore, to now be submitting this work is deeply satisfying.

To those most special to me, Kate (my rock), Imogen and Wil, there is no way I could have reached the other side without your encouragement to keep my chin up and roll with the punches, but also to put my head down when needed, and just do *my* best. Your unconditional belief in me, when too often I had little in myself, has made all the difference. You are each an inspiration to me.

Thank you also Murray and Lynda, for your enthusiasm and belief in the craft.

Chapter 1: Introduction

Part 1. Background and Rationale

The 'Flipped Classroom' is realised through the practice of reversing conventional within-school student instruction with opposing homework routines, thereby inverting an established educational paradigm which has been universally applied across school settings throughout much of contemporary history (Kirmizi & Komec, 2020; Lage et al., 2000). The application of the classroom 'flip' requires pupils to access pre-class educational materials within their home (or at least, outside of the school environment), through utilising instructional videos, vodcasts, podcasts, or other online resources, prior to undertaking class work (Lo & Hew, 2017). The online learning materials are positioned as essential preparatory tasks for subsequent in-face schooling, and are ideally tailored to the students' needs (Bergmann & Sams, 2015). Following introduction to new theories online, extension and consolidation of knowledge occurs within the customary classroom space, but with distinct differences to teacher-led, lecture-style direct instruction which is often used to implement new learnings. Flipped classroom philosophy reformulates the within-class approach to foster workspaces promoting active, student-centred, cooperative learning opportunities through supporting socially scaffolded group inquiry (Fulton, 2012). Establishing cooperative learning environments is a strategy for engaging students and personalising their educational experience, and has been shown to subsequently lead to deeper student understandings (UNSW, 2020).

As an alternative to 'traditional' classroom focused teacher-student interactions, strong interest within the academic world has seen the flipped classroom (FC), or 'flipped learning' (FL) as it is also commonly known, rise to prominence during the last decade on the back of considerable research output. To highlight this, a recent simple Google Scholar literature search for publications within the last two years – since 2020 - relating to "flipped classroom" OR "flipped learning", generated 17 300 results (February 2022). The basis for this attention is multifaceted; however, advocates for the benefit of student-centred learning methodologies, such as collaborative and active learning, point to evidence that these strategies can be more successfully delivered through the application of flipped classroom pedagogy (Betihavas et al., 2016; Galindo-Dominguez, 2021). Interest concerning the applicability of the FC system within the entire educational spectrum has seen studies examining effectiveness of the flip conducted across all levels of schooling, from early to middle primary, across secondary school years, through to tertiary settings (Galindo-Dominguez, 2021; Slemmons et al., 2018; Strelan et al., 2020; Wright & Park, 2021).

Part 2. History of the Flipped Classroom

Inverting the conventional approach which has been applied to student learning throughout the second half of the 20th century was a concept which began to take shape during the 1980s and early 1990s, coinciding with the advent of personal computer technology. A cohort of innovative, practicing teachers recognised that computers could play a much greater role in education and began to integrate basic interactive teaching and assessment programs in to their classrooms (Mazur, 1991). Pioneers of the foundational theory of

inverted learning such as Alison King, subsequently postulated a move away from teacher-centred, within-class, lecture style instruction, suggesting that the provision of these materials could be realised externally to traditional classrooms, and focused on the use of computers to stimulate education (King, 1993). By the late 1990s, the work of Lage, Platt and Treglia had taken this philosophy further, proposing that student access to the internet, coupled with rapid advancements in the quality and accessibility of multimedia technology provided opportunities for practises which traditionally occur within the classroom to be re-focused entirely outside of the school environment, through engaging with new and innovative online learning platforms (Lage et al., 2000). At around the same time, education academic John Wesley Baker was formulating and propositioning his model for a classroom 'flip', whereby essential curricular content could be delivered to students online (Baker, 2000) and that subsequent, in-class efforts be redirected towards enabling social-constructivist based group learning, a strategy to assist with social development and the refinement of problem solving skills within the school setting (Baker, 2000; Xu & Shi, 2018).

In a relatively short period throughout the early to mid 2000s, further pioneering work by Jon Bergmann and Aaron Sams, two US-based senior school chemistry teachers, was critical in framing the future of inverted learning. Working together, Bergman and Sams challenged their traditional teaching systems through constructing a practical model for what they hoped would improve their students' learning proficiencies. The initial focus was simply on improving engagement levels, due to lower than expected class attendance numbers (Bergmann & Sams, 2007). They approached this by pre-recording online lecture content for students to access outside the school and then changing their classroom teaching approach from 'instructor' to one of 'coach', or 'guide', to facilitate running within-class, active group based learning routines (Bergmann & Sams, 2007). This innovation realised immediate benefits within their own classes, and gradually gained attention across the educational sector. Their model became widely recognised and popularised as the prototype for what is now known as the '*Flipped Classroom'*, with this success ultimately resulting in it gaining status as a valuable and respected pedagogical technique (Waterloo, 2015).

In many ways, Bergmann and Sams' practical success was realised through the simplicity of their approach, utilising widely used, commercially available software (Microsoft PowerPoint), to extensively pre-record lecture style short videos and associated learning materials. They subsequently delivered this educational content to classes exclusively online, irrespective of whether the students were attending in-class lessons or not (Bergmann & Sams, 2007). It must be noted that in early iterations of flipped learning, teachers were commonly tasked with personally constructing the learning resources such as videos and online lectures. However, these resources may now be selected from a dearth of readily available online content (Bergmann & Sams, 2015). A successful aspect of Bergman and Sams' new and innovative pedagogy was in encouraging student independence and personal responsibility. This was realised through the choices afforded to the students regarding when and where they could access the pre-class learnings. In addition, their requirement that all students undertake the foundation work *pre-class* resulted in rapid uptake of the system, due to the additional stipulation that students could not join in with the more engaging, active, and fun group inquiry classroom practices until the pre-work had been completed (Bergmann & Sams, 2007).

Most importantly though, a significant facet of the attention and professional notoriety which Bergman and Sams' flipped classroom methodology produced was through academic investigation and validation. This momentum was driven on the back of empirical research, which generated evidence-based outcomes substantiating demonstratable academic improvements for students (Bergmann & Sams, 2015; Fulton, 2012; Schultz et al., 2014). Fast forward to 2022, and an extensive and multifactorial evidence base now endorses flipped learning philosophy and justifies its place within recognised pedagogical frameworks, supporting uptake across global systematic educational boundaries (Han & Røkenes, 2020; Nouri, 2016; O'Flaherty & Phillips, 2015).

Part 3. Theoretical background of the Flipped Classroom – roots in Constructivism

Critical to studying flipped classroom pedagogy is determining a theoretical background/s within which it is founded. A theoretical background (also known as a theoretical framework or theoretical basis) for a study describes the key theory underpinning the research topic. As Swanson and Chermack succinctly stated, a theoretical framework is "the structure that can hold or support a theory of a research study" (Swanson & Chermack, 2013). It is recommended that all research should be underpinned by a theoretical framework to justify the importance and context of the study (Lederman & Lederman, 2017).

Flipped learning relies heavily upon both technology and social/cultural influence to provide a scaffold for student learning. Its professional ascent and uptake across schooling systems has been greatly influenced by the rapid technological advancements which underpin online delivery of novel information to students. The reliance on out of school learning in leveraging evolving technologies is therefore unique when considered amongst the historical context of educational models. Equally important though is the 'flipside', the time students spend in the classroom being part of a cooperative, with learning occurring within a communal setting. Generally, students undertake active, group-based inquiry when in the classroom, contrasting distinctly with the individualised online approach to education outside of the school environment. Critically, both aspects of the flipped model – the home pre-work and in-class activities - are focused on the learner, not the teacher. In this respect, the Flipped Classroom method resides within the spectrum of learner-centred pedagogies, which have long been proposed as strategies for improving student engagement with learning (Persky & McLaughlin, 2017). Educators, "should know that students are at the centre of our teaching philosophy" (Patel-Junankar, 2017), with adoption of learner-centred pedagogy focused on the provision of resources and environments which assist students to investigate, understand and respect multiple perspectives in order to create their own realities (Karagiorgi & Symeou, 2005). Learner centred pedagogies are distinct from teacher-centred approaches with both student and educator assuming less formal or hierarchical roles, as can be seen in Table 1 (Patel-Junankar, 2017)

Table 1: Differentiation between teacher-centred and learner-centred pedagogies

Teacher Centered	Learner Centered
Focus is on the instructor	Focus is on both students and the instructor
Students work individually	Students work in groups or alone, depending on the activity
The instructor observes and corrects students' responses	The instructor provides feedback and corrective action when needed
Only the instructor answers students' questions	Students may answer each other's questions and use the instructor as a resource
Only the instructor evaluates students' learning	Students evaluate their own learning, which is supported by the instructor

At its foundation, flipped learning is an example of blended learning (also known as hybrid learning), which is also a learner-centred pedagogy. This approach to education stipulates a convergence, or 'blend' of online and traditional classroom-based learning methods. However, blended learning is distinguished from flipped learning in that it does not specifically require the transposition of customary within-school and homework structures, only loosely stipulating a mixed approach to content delivery and knowledge construction which includes online and in-face aspects (Bonk et al., 2005). When participating in blended learning, students have greater autonomy over their education through controlling their interactions with online teaching tools (Xu & Shi, 2018). The personalised management of the work which is undertaken online has been shown to benefit students, including opportunity to define the environment within which they may study, the rate of delivery of new concepts and frequency of access to the instructional materials, i.e. how often students wish to circle back on new concepts (Fulton, 2012; Lothridge et al., 2013). The interwoven freedom afforded by their online learning is an important aspect of place-based pedagogical process. This involves students attending the conventional school setting to extend on these learnings, but not for tuition processes which would typically be centred around 'traditional' direct instruction, but for group-inquiry based learning.

To successfully facilitate construction of new knowledge, a key tenet of the classroom flip requires students to take an active role in their learning, especially during time spent within the school environment. Active learning describes a raft of different processes which are frequently and readily encompassed within flipped methodology. The essential ingredient being that students proactively participate in the practices which foster engagement. Not only with their own education but with each other, and through supporting others' efforts in building new learnings. Students are expected to collaborate and share thoughts and knowledge, which assists in the construction of new knowledge. This is in contrast to practices which only support passive and individualistic uptake of information, such as direct instruction (Erbil, 2020). Class attendance during a flip is structured to offer a safe place for students to feel valued by others and commit to their own learning and that of their peers, through social connectedness and cooperation, (Sigurðardóttir & Heijstra, 2020). The communal setting which is created within the physical classroom following a flip supports many aspects of active learning pedagogy, with practical approaches to this knowledge creation process including group discussions and brainstorming, collaborative problem solving (problem based learning; PBL), examination of case studies (case-based learning;

CBL) and role playing (Persky & McLaughlin, 2017). Critically, active pedagogy within the flipped classroom is almost always centred around a form of Inquiry-based learning (IBL).

IBL is a student-centred pedagogical approach which "encourages students to conjecture, discover, solve, explore, collaborate, and communicate, without a teacher laying out all of the formulas, theorems, and examples as previous knowledge" (Capaldi, 2015). Others have stipulated that two key facets of IBL include students assuming responsibility for the acquisition of knowledge, through guiding the pace at which it occurs, and, that students are responsible for validation of the ideas presented, i.e. they do not assume their teacher is the sole authority within the class (Love et al., 2015). As previously discussed, flipping the classroom helps in establishing dynamic learning environments, with education stimulated by social connectedness and students actively engaging with each other and with their learning. Group interaction and cooperative learning together make an effective foundation for IBL, with studies showing IBL can improve outcomes, in particular for low achieving students (Capaldi, 2015).

Collectively, the sum of this array of pedagogical ingredients serves to provide a formula for the theoretical framework within which this dissertation will be grounded. Flipped learning and the active, learner-centred, inquiry-based, socially scaffolded and interactive within-class learning environments with which these pedagogies leverage value can be considered as being substantiated within constructivist theory (Bada & Olusegun, 2015; Patel-Junankar, 2017). Constructivist theory, or 'Constructivism' is a term made popular during the late 20th Century through the philosophical works of pioneers in the fields of psychology and education, such as Dewey, Bruner, Piaget and Vygotsky (Bada & Olusegun, 2015). Constructivists propose that humans are 'perceivers', who interpret information and construct meaning from all experiences, both new and past (Patel-Junankar, 2017), opposing the theory that learning is a passive process of information 'upload' through mere instruction. It advocates for the learner as an active proponent in their own acquisition of knowledge, with learning constructed through the lived experience of the individual, through building new knowledge upon the platform of their previous understandings (Bada & Olusegun, 2015). This model proposes that students acquire new knowledge through the process of connecting novel information with what is already understood. This can be thought of much the same as building a brick wall, with each piece of new information at a time (the 'bricks') being laid upon a foundation which encompasses the individual's pre-existing knowledge base. Over time, the wall grows in stature, much like the sum of our learnings. Constructivist learning processes help to foster critical thinking and create motivated and independent learners (Patel-Junankar, 2017).

Dewey and Vygotsky were even more fervent in emphasising the importance of social influence in learning, advocating for recognition of knowledge building and the cognitive development from with it is borne, as social constructs. These theorists espoused the virtues of what is known as social constructivism. Essentially, they argued that learning is something which is fostered through interaction with others, and that the classroom should act as a social entity through which students may work to problem solve as a community (Williams, 2017). This theory is consolidated when considered in conjunction with Vygotsky's additional sociocultural learning perspective, the Zone of Proximal Development (ZPD) theory. Guided learning, enacted by the physical presence of the 'guide' (teacher) has

a distinct role in fostering cognitive development of students through physical presence and social interaction, providing a platform for learning between what the learner can do unaided and what they cannot yet do (Vygotsky, 1978). The constructivist teacher can move in and out of the ZPD to scaffold student learning when required, acting as a 'guide on the side', much the same as the very early models of FL and in stark contrast to the role a behaviourist teacher would approach learning (Bergmann & Sams, 2007; King, 1993).

Importantly, this perspective is not to be confused with social constructionism, which occurs within a similar sociocultural setting but with a clear delineation in the measure of the tasks. Both sociological theories of knowledge stipulate a teacher who acts as a facilitator/guide (King, 1993) and learners who investigate, create, and solve problems, and also have a strong focus on learner collaboration and engagement. However, social constructivism focuses on the learning of the individual which occurs within the group interactions, as opposed to social constructionism, which focuses on the output or the artifact which is a result of the learning which has occurred during the social situation, such as production of a poster, presentation or project report (Mohammad & Farhana, 2018).

When enacted within the flipped classroom context, guided student learning which occurs through active, group-based inquiry may be viewed as a process of sharing, discussing, and reasoning through a social framework for the construction of knowledge. At the individual level, social constructivist theory is a fitting basis through which to view the effects of the flipped classroom on student outcomes. A summary of this theoretical basis can be visualised in Figure 1.

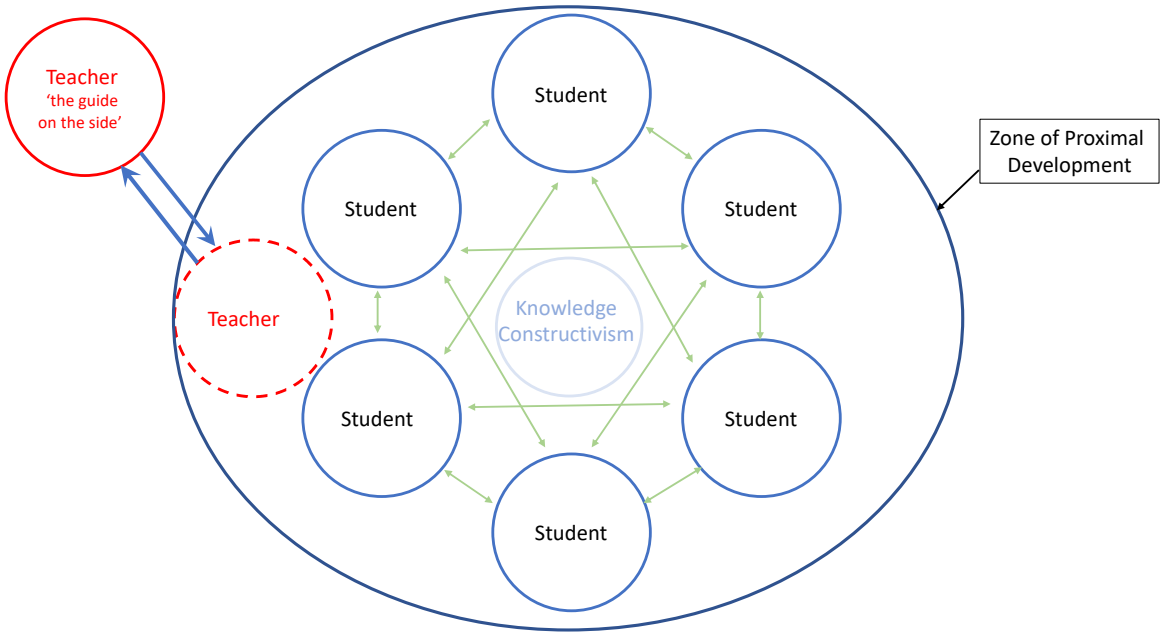


Figure 1: Within class, learner-centred, social-constructivist dynamic

Part 4. Personal Narrative

The basis for this investigation developed through the combined effects of inter-related personal experiences. Firstly, through my own learning journey as a secondary student of the 1990s, in which education was constructed around teacher-centred, lecture style in-class content delivery. Instruction was then extended upon through the application of significant homework time to reinforce knowledge through rote learning, coupled with undertaking task work and major assignments most frequently completed at the individual level. This model was widely applied for young learners of the time and as a cohort we remained naïve with respect to the potential for alternate approaches which could have provided innovative opportunities to assist our efforts to acquire new knowledge. Never an ardent fan of quiet, individual study, contemplation regarding my personal learning experience as a higher school student and the dissatisfaction I felt with certain aspects of this process came to the fore, influenced by the new life path I am currently on, in working towards entering the teaching profession. This reflection has led me to consider the scope of learning opportunities available which could result in improved student learning outcomes, in particular relating to maximising the benefits from within-class social connection and interpersonal learning skills developed through group-based inquiry.

The second significant influence in directing this line of inquiry is the result of subjective, but qualified advice received during the first year of the Master of Teaching post-graduate degree. Many times, the suggestion, or argument has been made by course facilitators of the potential trap for pre-service teachers (PSTs), particularly those who are not of the same generation as today's higher school students (including me!), in approaching our future practice with the conviction of 'teaching as we were personally taught' – a warning against over reliance on traditional 'direct instruction' pedagogy and lecture style content delivery within classrooms. On clarification of the reasoning behind this recommendation with tutors, the consensus was that PSTs traversing this path will likely struggle to engage with their pupils and subsequently be responsible for both lower student satisfaction levels and inadequate learning outcomes. Teaching pedagogy has progressed, and it is strongly encouraged that PSTs grasp the unique and exciting opportunities afforded to us so that we can best support the pupils who are preparing for life in a new age of technological accessibility, and who will be tasked with the added burden of societal advancement. This anecdotal evidence peaked my personal interest and led me down a path of examining new pedagogies which may be applied in modern learning environments, culminating in the discovery of the Flipped Learning model.

In addition to these individual interests, I recognise that for the purpose of professional dissertation studies, personal development is critical. Therefore, generating both personal growth and professional capability outcomes were identified as cornerstones of this research. I approached this course of investigation as a future middle and senior school science teacher with the following professional goals:

- Maximising professional value from the time invested in dissertation studies, ensuring transferability of knowledge and capabilities to personal teaching practice
- To seek strategies for maximising engagement and learning opportunities within the courses in which I will guide students

- To prepare effectively for the rigours of future in-class practice. It is highly probable that I will encounter use of flipped classroom teaching, and possibly be mandated to apply this pedagogical approach by the school in which I work, within my early graduate teaching years.

Part 5. Aim and Objectives (Dissertation Goals)

The overarching purpose for this dissertation was in seeking to answer whether there is sufficient evidence to support the assertion that Flipped Learning pedagogy offers the opportunity to improve outcomes for Australian science students within middle years schooling. As such, the systematic review process for this dissertation has focused on the practical considerations, potential applications, and the benefits and/or barriers relating to this model in teaching Australian middle school science lessons. In doing so, I have sought to determine whether the most effective strategies for the delivery and student uptake of Australia's middle years science curricula, as developed by the Australian Curriculum and Assessment Reporting Authority (ACARA), are currently used within our schooling systems.

Primary Research Question:

Flipping the classroom: Can changing the delivery of the Australian Middle School Science Curriculum Improve Student Outcomes?

To determine an effective response to this primary research question, it was essential that all applicable aspects of the flipped model were thoroughly examined to ensure study validity and outcome merit. To refine this examination, the following research sub-questions were developed and applied to guide the investigative process:

SQ1. Can flipped classroom pedagogy increase student satisfaction and perceived outcomes in learning?

SQ2. Is flipping the classroom as effective as 'traditional' teaching methods when comparing academic results?

SQ3. Is flipped learning appropriate for years 7 to 10 Australian students?

SQ4. Is flipped learning a suitable pedagogy for teaching of the Australian general science curriculum?

Enablers and barriers to implementation and success of the FL model were also investigated and will be reported on.

Part 6. Is this relevant? Is there a real need to consider change?

The lived educational experience for pupils as recently as during the late 20th century is far-removed from numerous and widely accepted current pedagogical approaches applied to

learning, most noticeably through the incredible impact that rapid technological progress is having on the education system (Ali, 2019). This view is extended within the recent literature, with research determining that inquiry-based learning, strongly supported through the within-class practices adopted by the flipped learning model, has challenged, and now overtaken the direct instructional model of teaching as the primary strategy for improved academic outcomes (Abdi, 2014; Duran & Dökme, 2016; Khalaf, 2018). This evidence encourages us to address the potential problem of whether the teaching profession is presently most effectively structured to foster the development of current and future generations of both socially cultivated and digitally literate students. Essentially, is there a better way to build our future knowledge brokers?

In addition to the question of whether there are alternative, practical approaches to teaching the curriculum and nurturing students to thrive as independent learners, there is arguably the greater issue relating to teacher readiness – the profession's collective ability to deliver change as means to champion student development. Irrespective of whether existing teachers and PSTs are ready for disruptive, institutionalised transformation in the approaches we take to our teaching or not, the profession must be focused on evidence-based research to guide best-practice implementation of learning strategies. It is true that teachers ply their trade primarily as individuals within their designated classrooms, but critically, we are all minor parts of a far greater, and interdependent co-operative, jointly charged with student development. Teachers are not, and never should be considered as lone practitioners. As a collective we rely on policy makers to objectively analyse the research repository, be fluid in their thinking, and exhibit responsibility for learning. This may be seen through responsiveness to the current and future needs of the young people whom we are charged with engaging, encouraging and developing academically, so that greater society may progress. The teaching profession has a duty to ensure best-practice curriculum delivery, and that its practitioners follow evidence-based guidance in moulding their pedagogical approaches to maximise growth and development potential in all students.

Key Terminology:

The Flipped Classroom

There are many definitions for what a 'Flipped Classroom' entails within the literature, each with subtle variations. In its most simple of forms, Lage *et al* provided the following:
"Inverting the classroom means that events that have traditionally taken place inside the classroom now take place outside the classroom and vice-versa"(Lage et al., 2000)

In keeping with the foundation of Lage *et al,* but in recognising the key theoretical frameworks inherent within the inverted classroom, I have added my own context:

The Flipped Classroom is established through reversing conventional within-school student instruction with homework routines. Content familiarisation occurs prior to lesson through use of online resources, with active, social learning routines utilised within class to build knowledge.

Throughout this dissertation, the terms 'flipped', 'inverted' and 'reversed' may be used interchangeably, representing accepted literary synonyms for the nature of this educational paradigm (Persky & McLaughlin, 2017). However, the ensuing terms 'classroom', 'learning' and 'instruction', even though sometimes used as equivalents within the profession, do not describe the same processes with respect to the flipped model. As such the following definitions apply:

*Flipped/Inverted **Classroom**: The environments which encompass embrace the 'flip'. This includes the students, and the school and home/external settings.*

*Flipped/Inverted **Instruction**: Refers specifically to the 'input' - the educational tools and content provided within the flipped classroom.*

*Flipped/Inverted **Learning**: Describes the 'output' or inherent expectations for when both the environment and the 'input' work in unison; the knowledge which students working within this model can construct*

Collectively, this assortment of terms reference the scope of definitions used during the past two decades in which this pedagogical paradigm has become widely studied and popularised (Margulieux, 2014).

Student Outcomes

The term ***Student Outcomes*** is widely used within educational literature, with teachers and academics often referring to 'improving student outcomes' as a key indicator of success and/or pedagogical impact. The term is too frequently used in a non-descript fashion, without definition, but generally incorporates reference to not just one, but multiple parameters directly relevant to students and their learning. Researchers have shown that assessments may be made against *affective* (self-perception based), *cognitive* (knowledge, cognitive strategies) or *behavioural* (engagement, attitude) outcomes (Guo et al., 2020). Or, put more simply, may be instructional, educational, or societal (life-based, cultural) in nature. For the purpose of this investigation, I have chosen 3 key benchmarks which cut across these affective, cognitive and behavioural pillars when referring to student outcomes as influenced by the use of the flipped model (van Alten et al., 2019):

Assessed Learning Outcomes (ALOs): quantifiable measures which are determined by skills/capability-based performance in assessments (tests, exams, general grades).
Perceived Learning Outcomes (PLOs): incorporates student perceptions of their own learning. Qualitative measures such as engagement, comprehension, student autonomy, and own perceptions of the impacts of pre-learnings on knowledge construction.
Student Satisfaction Outcomes (SSOs): determined by measures including, but not limited to recognition of self-motivation, enthusiasm, subject enjoyment, and satisfaction with the quality of teaching delivery.

Chapter 2: Methodology and methods

In determining the most suitable approach to undertaking a rigorous investigative process, the researcher must first determine the *methodology* they will embrace. The term methodology encompasses the strategy the researcher assumes when shaping the use, and application of particular methods (Scotland, 2012). This lays the foundation for how the researcher can seek to find out all new and original meaning relating to the chosen topic which they intend to discover (Scotland, 2012). Therefore, this perspective needs to be tailored to the specific purpose of the investigator, and it is this strategy which leads to choosing and defining which *methods* to apply to the research process. Inherent within the methodology are the research methods which govern principles and practical considerations relating to the scientific enquiry (Slevitch, 2011). These encapsulate the where, why, what, and how of the investigation; they are the specific techniques and procedures employed to collect and assess the data (Scotland, 2012). Fundamentally, methods need to postulate a direct relationship between the research question, data collection and analysis.

Methodology

Qualitative research is used to study the nature of phenomena. It is concerned with the explanation of human behaviour and the social situations which influence that behaviour (Austin & Sutton, 2014), dealing generally with data in the form of words as opposed to numbers (Busetto et al., 2020). It is context specific but also influenced by the different perspectives from which the results can be perceived (Busetto et al., 2020). The current investigation on flipped classroom pedagogy has leveraged a qualitative methodological approach, encompassing a systematic review, which involves assessment by this researcher of pre-published study data.

The systematic review is characterised through comprehensive searches of pre-existing literature, focusing on a unique purpose or novel research question(s), distinguishing the systematic review from a narrative review through more formal and structured synthesis of the research findings (Bearman et al., 2012). When applying systematic review methodology, no primary data can be included within the investigation. Secondary data sets need to be leveraged, with results from recently published, peer reviewed literature utilised as reference sources.

Systematic reviews are a form of secondary research and permit further investigation of published data, providing the researcher with an opportunity to examine previously undertaken primary research through their own unique lens (Newman & Gough, 2020). When undertaken with rigour and clearly bound principles, systematic reviews clearly define robust criteria with which the author is able to govern, with minimal subjectivity, whether publications are suitable for inclusion in their study or not (Green et al., 2006). For instance, this methodology has provided a multi-targeted approach to determine whether flipped classroom pedagogy is not only an effective educational strategy capable of producing improved outcomes for students but is also appropriate for the age cohort (middle year secondary school) and lesson focus (science) which have been stipulated within the research question.

Research Philosophy

In addition to defining the methodology and methods which are used to navigate the literature, it is critically important for the researcher to delineate their research philosophy. The research philosophy guides the methodological direction of the research and is governed by the *ontological* and *epistemological* perspectives that the researcher embraces, or at least chooses to assume, before starting their investigation. The ontological and epistemological positions encompass the researcher's theoretical assumptions regarding knowledge and the nature of reality, which therefore makes these defining these perspectives a basic component of all qualitative research.

Ontology relates to *existence* - the study of 'being' and to human beliefs concerning reality, the type, and nature of reality, and what comprises it. It relates to the question of 'what exists in our world'. It also deals with the influence of the social construct, the manner in which human interaction and social entities influence the individual's perception of reality (Al-Saadi, 2014). Ontological positions include *objectivist* (reality exists independent of belief and personal understanding) and *constructionist* (reality is subjective and influenced by the human mind and socially constructed values). Epistemology refers to studying the nature of knowledge and the means by which it is acquired (Goertz & Mahoney, 2012). It deals with the question of 'how do we know what we know?'. Within this context are *positivist* and *interpretivist* streams. The former espouses facts and values to be distinct, objective and not influenced by social contexts, and that knowledge (our reality) is arrived at by gathering facts independent of, and unaffected by the researcher (Mohammad & Farhana, 2018). Alternatively, the interpretivist view dictates that the social world and researcher interact to form knowledge and that this is a personal, subjective, and unique process (Mohammad & Farhana, 2018).

As previously stated, constructivist theory concerns the ways in which we individually construct knowledge, and that this knowledge is beholden to the influence of others and the social experience from within which it is formulated. This current investigation was undertaken without the ability to generate any primary data, and as such I was required to engage personally with the published work of academics in this field. As such, my interpretation of their 'reality' – methodologies, results, discussions, outcomes, and recommendations - in seeking answers to the research questions which I have formulated, has been influenced by my knowledge and personal views of the social construct. I have interacted with their truths on a personal and subjective level, which in turn has subsequently influenced the formation of outcomes and recommendations from my study. As such, it can be asserted that the research undertaken for this dissertation has been influenced and directed by social constructivist and interpretivist philosophies.

Methods

Manuscript selection

To achieve the desired depth and breadth of literary assessment within the overarching scope of this systematic review, it was necessary to firstly identify all *relevant* literary

perspectives related to flipped learning. As such, very loosely defined searches were undertaken across both peer-reviewed sources and grey literature, to understand the extent of investigations and viewpoints which have previously been published in this area. Due to the volume of data obtained, selection of 'key words' from carefully selected pre-readings was undertaken (Cresswell, 2009), which helped to guide subsequent data discovery.

In addition to the list of key words generated, criteria relating to the research sub-questions were devised to assist refinement of the results. Literature searches across key education related databases were undertaken according to the parameters defined in Table 2. Important overarching themes were identified, the data stratified against these key themes/topics and then it was critically appraised for relevance to the research sub-questions. This allowed for the most relevant foci in each paper to be defined, analysed for relevance, and contextualised at length. Results were then synthesised against the critical foundation of student outcomes, to determine clear findings and recommendations for the future.

For the purpose of building a knowledge base suitable for completing this systematic review, I employed extensive literature search strategies which encompassed databases including ProQuest's 'ERIC' (which also incorporated results from ProQuest's 'Dissertations and Theses') Google Scholar, Education Research Complete and A+ Education, plus resources available through Government educational associations and relevant, independent industry websites. These included searches of the Australian Institute for Teaching and School Leadership (AITSL), the Australian Curriculum and Assessment Reporting Authority (ACARA), the South Australian Certificate of Education (SACE), the Australian Council for Educational Research (ACER), and the Organisation for Economic Co-operation and Development (OECD) websites. Searches included only Academic Journals, Conference Papers, Dissertations and Theses.

Data Collection

As previously mentioned, flipped learning pedagogy is topical across global educational boundaries. This provides the opportunity to view, digest and undertake secondary analysis of numerous and varied study outcomes and academic perspectives. An extensive research base has focused on FL over the past two decades, and as such, the dearth of literature available for this systematic review was both a blessing and a curse. Tens of thousands of publications for potential review afforded the opportunity to be critically selective in which literature was accepted for inclusion. However, it also required careful investigation to ensure that relevant texts were discoverable and did not remain hidden within the expanse of information related to the overarching topic of the flipped classroom. Without a reliable and reproducible process to assist in sifting relevant data from irrelevant, the literature searches on this topic were akin to a 'needle in a haystack'. Well-defined and robust search criteria were required to ensure consistency of text accessibility and the opportunity for review. The focus of the literature searches for this study centred on the flipped classroom model against 3 pillars of relevance: 1) within middle year secondary education, 2) against the backdrop of science coursework, and 3) within the Australian education system.

In addition to refining the database searches through use of the terms “middle school” AND “science”, further targeted fine-tuning of the literature was achieved by including “Australia*” as a search criterion to obtain locally relevant data. The application of the ‘CRAAP’ test to determine Currency, Relevancy, Authority, Accuracy and Purpose in screening which literature should be included within a systematic review, (Blakeslee, 2004), ensured that a thorough and reputable approach was taken to differentiate relevant and meaningful subject matter. Generally, due to the raft of recently published literature available on flipped learning, studies published within the period 2012 to 2022 were preferred for inclusion to align with the criterion of being ‘current’. An overview of the databases leveraged, search criteria used and search results for the systematic literature review are presented in Table 2.

Table 2: Search terms used to obtain literature sources

Search No.	Search Words	Google Scholar	A+ Education	Education Research Complete	ERIC
S1	“Flipped Class*” OR “Flipped learn*” OR “Inverted Learn*” OR “Inverted Class*”	11900	114	2092	1378
S2	S1 AND “Middle School” middle school or junior high or 6th or 7th or 8th	1030	113	74	29
S3	S2 AND “Science”	962	113	28	12
Additional search limits	By Date: range 2012 to 2022	962	70	28	12
S4	S3 AND “Australia*”	333***	0	3	1

****of the studies identified within the Google Scholar database following use of S4, the overwhelming majority of the 333 publications did not have any study correlation with Australian classrooms or curriculum, only very loosely, if at all connected to the Australian system.*

Rigorous inclusion and exclusion criteria were developed to assess the publications for usability within this systematic review (Cheng et al., 2018). The criteria included a mix of objective assessments (dates, literature type, full text availability etc) and subjective assessments (educational outcomes). For the latter, educational outcomes were deemed acceptable when they were presented from analysis of either quantitative or qualitative data sets and subsequently resulted in clearly stated and substantiated educational conclusions and/or recommendations from the authors. Overall, a total of 1072 articles were identified and screened for inclusion. Through applying the Preferred-Reporting of Items for Systematic Reviews and Meta-Analyses guidelines (PRISMA), these articles were

assessed and filtered through applying inclusion and exclusion criteria (Page et al., 2021). These criteria are defined in table 3, with a flow diagram of the process depicted in Figure 2.

Table 3: Study inclusion and exclusion criteria

Criteria	Inclusion Criteria	Exclusion Criteria
Date published	Published between 2012 and 2022	Published outside of this period
Literature type	Peer-reviewed journal articles, dissertations, and theses	All literature which is not a peer reviewed journal article, dissertation, or thesis
Study type	Empirical Study	Non-empirical study (i.e. theoretical study)
Language	English	Non-English
Accessibility	Full text is available	Full text is not available
Methodology and Research Design	Experimental or Quasi-Experimental design. Mixed methods, quantitative or qualitative data collection	Non-experimental design Theoretical data only
Implementation	Focused on Flipped Classroom pedagogy. At least one experimental group which is a flipped learning intervention	Does not follow Flipped Learning pedagogy in at least one experimental group
Learning Content	Experimental and control groups learn the same content	Experimental and control groups do not learn the same content
Participants	Students in year 6-12 classes	Students outside of this year level range
Educational Outcomes	Clear Educational outcomes	No clear educational outcomes

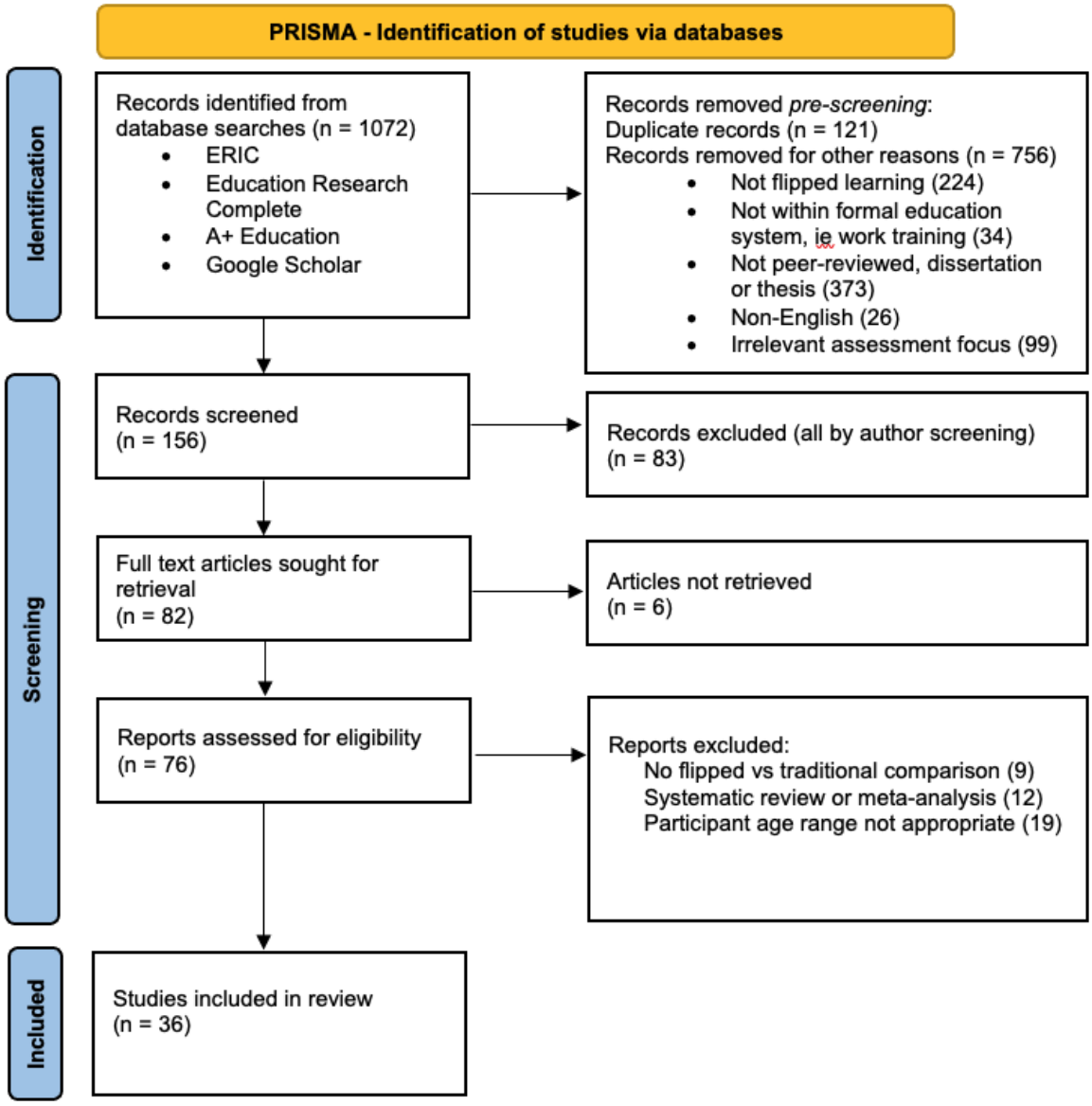


Figure 2: Flowchart of the study inclusion selection process based on PRISMA guidelines

Several articles were removed due to replication across databases. Additionally, a high number were removed (from the Google Scholar search list) as they were found to be irrelevant after having reviewed the title and abstract. Following the stratification process, a final list of 36 primary research articles were determined to be appropriate for inclusion in this review.

Data Stratification and Analysis

The origins of the data used within this study were from both quantitative (such as pre/post-test or exam scores) and qualitative (relating to outcomes which cannot be determined through objective academic assessment, such as levels of engagement,

motivation, and student effort and enjoyment) empirical studies, or a mixture of both (mixed methods). Having conducted a systematic review of these data, the way in which I have examined and evaluated the results was through using a qualitative methodological lens.

Acquisition of recent and locally focused (South Australian or Australian) studies for the systematic review would have provided a practical focus and refined relevance, with direct context from the Australian education system minimising the need for substantial extrapolation of international findings. However, the literature inclusion criteria required flexibility due to a limited volume of *focused* research available which incorporated all 3 relevant aspects of the learning system, (middle-school, science education, and Australia), especially with respect to the discoverability of Australian based studies. Mixed methods studies originating from Australia were particularly difficult to obtain. As such, inclusion of selected studies which encapsulated sub-aspects of these 3 criteria was deemed acceptable, dependent upon the research sub-question applicability. Table 4 details the breakdown of papers used in this review and alignment to the sub-questions.

In summary, the data collected for this study presented an opportunity to determine whether flipped classroom pedagogy may be extensively applied to the future delivery of the Australian Curriculum for middle school science education. If found to be an effective strategy, this would suggest an opportunity to generate greater student learning proficiency and autonomy, and therefore be of importance across state and national educational communities. Demonstration of improved academic performance, higher levels of in-class engagement and increased student and parent satisfaction are the measures of intent with which these outcomes were determined.

Methodological limitations and researcher bias

As this study did not involve generation or acquisition of primary data there was no requirement for obtaining human ethics approval. Inability to generate or acquire any primary data for this investigation is recognised as a limitation, as this study is wholly dependent upon data produced through the rigour and merit of other researchers, whose own personal biases, large or small, may have influenced approaches to their research. Consideration of the role that own personal biases play in influencing the outcomes generated by a systematic review is important. This type of inherent personal bias may present when critically appraising any of a number of variables concerning acquisition, assessment, and utilisation of evidence, when constructing a review (Moher et al., 2009). Rigour is essential in the preparation of a systematic review and is demonstratable through using explicit database search parameters and applying objective inclusion and exclusion criteria (Johnson et al., 2020). Ensuring that rigour was not only developed at the outset but maintained throughout the entirety of the review process was critical, with the goal of producing reliable and valid research outcomes. Application of my chosen search terms may therefore be recognised as a limitation, with the choice of these criteria potentially yielding skewed database discoveries and affecting outcomes. Finally, it must be recognised that the framing of the research sub-questions and the influence this had on determining database search criteria was in some way influenced by researcher bias and is a limitation of this study.

Chapter 3: Literature Review - Results

A total of **36** primary research publications were included in this systematic review. The breakdown was as follows:
1 study focused on an Australian middle school science course flip; 20 focused on middle school science flipped classrooms; 7 focused on flips within middle schools (non-science); 8 focused on flips within high school science/STEM courses.

An additional 19 publications were discovered which focused on undergraduate pre-service teachers reporting on science class flips (10 papers) and graduate or higher-level teacher implementation of flipped learning (9). Outcomes from these 'secondary' papers have not been used to generate results for sub-questions 1 to 4 (relating to ALOs, PLOs or SSOs) as they did not meet inclusion criteria. However, they have been used to acquire general principals relating to the use of flipped learning and to leverage observations and/or outcomes for subsequent theme related areas of discussion.

Brief summaries of outcomes relating to academic performance, perceived learning, and student satisfaction from all 36 items of literature are included in Table 4. Detailed summaries of the same publications, including geographic localities of studies undertaken (country, schooling system), level of schooling of the participants, experimental cohorts (age, number of students), experimental design, measures of variables, and key themes/findings of each paper can be found in Appendices A to E.

Enablers and barriers to implementation and successful application of the flipped classroom have also been investigated.

Table 4: Outcomes relating to academic performance, perceived learning, and student satisfaction

Outcomes for middle school learning, science courses			
Author & Year	**Key Findings ALOs**	**Key Findings PLOs**	**Key Findings SSOs**
(Alias et al., 2020)	Significant increase in assessable problem solving, evaluation, and planning skills over PBL and TL		
(Andersen et al., 2020)		Pre-learning material improves structure. Students felt more engaged and prepared.	
(Barlow & Fleming, 2016)		Improved effort and engagement. 17% increase in completion of some extension work, 9% increase in completion of all extension work. Positive correlation with test and exam results.	Students marked teacher higher on quality measures. Feedback pointed to higher motivation levels
(Chen, 2016)	No significant difference. Trend towards higher results for each FL class	FL class responded positively to video usage, group discussion time and interpersonal interaction	
(Duffy, 2016) (Dissertation)	No significant difference overall. Significant difference between individual education program (IEP) vs non-IEP students		
(Howell, 2013)	No significant differences	Students, parents, and researcher significant preference for FL.	

(Khairiah et al., 2022)	Significant improvement for FL group.		
(Lee et al., 2021)	Simple FL significantly higher post test score vs TL.		CFL significantly higher motivation level vs TL
(Leo & Puzio, 2016)	FL significantly better in 1 of 3 tests. Trend to better on each test, but not overall		Students enjoyed FL more
(Maddox, 2018) (Dissertation)	TL class initially performed better than FL class. Over duration of study no difference in test scores. Final test the FL class significantly outperformed the TL class		
(Putri et al., 2019)	Significant increase in post-test vs pre-test scores		
(Salhoobi, 2021) (Dissertation)	FL significantly higher post-test result than TL group for males and both genders overall. No significant diff for females	No difference. Overall, students from both groups felt high levels of autonomy, competence, and relatedness.	
(Say & Yildirim, 2020)	Significantly higher post test results for FL group than control	Subject outcomes perceived to be better overall in FL	Student satisfaction overall viewed as highly preferential to TL
(Schultz et al., 2014)	FL students performed significantly better on all 8 assessment tests		Significantly higher preference for FL model (22 of 29 with 3 neutral)
(Schmidt, 2013) Dissertation	Earth science (8th grade students) and chemistry (11th grade) had significantly higher post test scores following FL.	Earth Science and Chemistry spent same or significantly less time (80%/94%) in studying FL content than TL	Overall students in earth and biology significantly preferred FL
(Sezer, 2016)	Post test scores were significantly higher for FL		Significantly higher scores relating to motivation for FL.
(Shana & Alwaely, 2021)	Significantly higher (25%) post-test scores for FL cohort		Higher levels of enjoyment, attitude, involvement, and decreased boredom for FL. 95% of respondents preferred FL to TL
(Slemmons et al., 2018)	No overall difference in test scores post video watching (short vs long videos) (Data not included due to no control group – only comparison between 2 FL groups)	Focus, engagement, and information retention all significantly higher responses for short video length. Students re-watched shorter videos fewer times. No diff in video length preferred	
(Stratton et al., 2020)	No sig. difference in pre/post-test. Low ability students fared better with FL. High and middle ability slightly better with TL.	FL perceived that they learned more effectively and were more engaged. No gender differences	SSO motivation increased by FL. No gender differences
(Tan et al., 2020)	Both TL and FL groups improved post-test scores equally. One test of 4 significant improvement for FL over TL		
(Zummo & Brown, 2020)	Average normalised gain significantly greater for FL. No gender diffs	Significant improvement for PLO of FL group over TL	
Outcomes for middle school learning, non-science			
Author & Year	**Key Findings ALOs**	**Key Findings PLOs**	**Key Findings SSOs**
(Almasseri & AlHojailan, 2019)	Positive effect on achievement relating to applying, analysing, evaluating. Learners with low prior		

	knowledge displayed significantly greater improvement		
(Kirmizi & Komec, 2020)		Significantly improved own paced learning, autonomy, self-confidence, and perceived performance. Younger students significantly higher PLOs than older students	Significantly higher motivation for FL
(Kostaris et al., 2017)	FL group significantly higher post-test scores on 2nd and 3rd of 3 post-tests Low performing students in the FL group had greatest gains	Motivation and engagement levels both significantly higher in FL group than in control	Significantly higher motivation for FL
(Li, 2018)		FL perceived to heighten knowledge and foster active learning in class.	Significantly higher motivation for FL
(Wei et al., 2020)	Post test scores -significant differences overall FL>TL across all competency levels (H, M, L)	Positive anecdotal feedback presented; no formal stats.	
(Winter, 2017)		Significant gains for understanding of workspace, level of effort, and effort when not interested. Top performers rated effort higher in both individual and group spaces.	
(Yildiz Durak, 2018)		Engagement, attitude, self-efficacy, learner control and self-directed learning, technology self-efficacy, communication, motivation for learning and pre-work completion all highly correlated to FL	
Outcomes for high school learning, science related			
Author & Year	**Key Findings ALOs**	**Key Findings PLOs**	**Key Findings SSOs**
(Bond, 2019)		Positive effect on schooling, engagement, higher responsibility.	Positive effect on enthusiasm/enjoyment, motivation
(Chao et al., 2015)	Achievements for FL significantly higher than TL	Learning attitude, motivation, self-evaluation all higher	
(Dixon & Wendt, 2021)	No significant diff b/w pre/post-test for FL vs TL	Significant improvement in engagement with learning science	
(Finkenberg & Trefzger, 2019)	Significant improvement for FL model over control.	Significant difference in perceived outcomes and interest for FL vs TL (FL stayed same; TL decreased).	Significant improvement in motivation to learn
(Halpin & Gopalan, 2021)	Increased levels of understanding through group work assessment.	Increased engagement and confidence in knowledge post intervention.	
(Little, 2015)	Positive improvement overall but not significant due to limited sample size	Largely in favour of FL (not enough responses for significance)	
(Morris Siu-Yung, 2017)	Significant difference for both moderate and low achieving students	Low achieving student's self-efficacy score was significantly greater for FL over TL	
(Reinoso Tapia et al., 2021)	Significant difference between pre and post-test results.	Student's perceptions Significantly supported FL.	
Significant Differences: Improvements for FL over TL	**20**	**21**	**14**
Significant Differences:	**0**	**0**	**0**

Improvements for TL over FL			
Non-significant differences	**8**	**3**	**0**

Abbreviations used: FL – Flipped Learning; TL – Traditional Learning (direct instruction); AOL – Assessed Learning Outcomes (quantitative assessment); PLO – Perceived Learning Outcomes (qualitative assessment); SSO – Student Satisfaction Outcomes (qualitative assessment).

SQ1: Can flipped classroom pedagogy increase secondary student satisfaction and perceived outcomes in learning?

Review of relevant literature showed that the most common approach towards determining the success of FL is through simple study design comparing whether FL is a more effective pedagogy than 'traditional learning' (TL), using both intervention (FL) and control groups (TL). Traditional learning describes teacher-led lecture style direct instruction within the classroom followed by customary homework routines. This design provides a simple direct comparison of FL with the style of teaching that the flip was developed to provide differentiation against. The literature review showed that of the multiple variables available for researchers to assess, the most common approaches taken within their empirical studies were direct comparisons of a mixture of the 3 determinants (ALO, PLO and SSO), chosen for this review. Quantitative assessment of test scores (ALO) was the most frequently applied variable, followed by both qualitatively assessed determinants of performance - student perceptions of self-learning and student satisfaction with learning.

Of the 36 publications included in this systematic review, the assessment process identified 30 publications which report on one, or both of students' perceived learning outcomes (PLOs) and/or student satisfaction outcomes (SSOs). PLOs include measures such as engagement, comprehension, student autonomy, and perceived impacts of pre-learnings on knowledge construction. Of the 24 studies which reported on PLOs, significant increases in performance which were associated with FL implementation was reported in 21 studies, with 3 showing no significant difference (88%).

SSOs, determined by measures including, but not limited to motivation, enthusiasm, subject enjoyment, and satisfaction with teaching performance, improved significantly for students undertaking FL when compared to TL in all the assessed studies (100%; 14 of 14 studies).

SQ2: Is flipping the classroom as effective as 'traditional' teaching methods when comparing academic results?

As already mentioned, this variable was the most readily applied single determinant of the effectiveness of FL within the empirical studies used for this review. The data used to assess this parameter showed that ALOs significantly improved through use of the FL model when compared to TL, in 20 high school-based studies, with 8 showing no significant difference

(71%). No studies reported better outcomes (or trends towards better outcomes) for TL over the FL model.

In addition, of the 8 studies not demonstrating significantly positive academic effects overall for FL, only 2 reported absence of any positive trend or sub-effect (Dixon & Wendt, 2021; Howell, 2013). The remaining 6 studies reported on different aspects of success and levels of effect, as summarised:

- Chen, (2016): trend towards significance for FL over TL; sample size too small to achieve significance
- Leo and Puzio, (2016): 1 of 3 test scores significantly different for FL. Further trends towards significance in remaining 2 tests and overall results, however not statistically significant.
- Duffy, (2016): Significant differences between individual education program (IEP) students and non-IEP students
- Little (2015): study demonstrated trends towards positive effects for the FL group however sample size was too small to achieve significance
- Tan (2020): one of four test periods used in the study achieved a significant result for FL but not overall for the duration of study
- Stratton (2020): when stratified by achievement level, significant positive effects were seen for low achieving students

Even though not unanimous in supporting the assertion that FL produces significantly better academic achievements in students than TL, the overall partial success rate was very high. With 71% of studies demonstrating significant academic improvements, and with a further 21% reporting on moderate impacts and/or trends towards significance through use of the FL model, 92% of studies reported some degree of improvement for FL over TL.

SQ3: Is flipped learning age appropriate for years 7 to 10 Australian students?

It can be stated clearly that insufficient data exists relating to use of the flipped learning model within the Australian middle school system which is also centred around success withing a science education context. Throughout the systematic review process and interrogation of multiple databases for includable data sets, only a solitary publication (Barlow & Fleming, 2016) was able to be discovered which originated from Australia and met inclusion criteria. This anomaly is supported by other recently published literature reviews. A recent bibliographic review reported that Australia is one of the highest publishing nations for overall FL contextualised studies, ranking 6th globally with approx. 220 documents (María Pastes Urbano et al., 2020). However, this same bibliographic review also reported on only one study which had been undertaken in Australia within a high school environment.

When attempting to determine appropriateness of flipped classroom pedagogy for years 7 to 10 Australian students from the publications selected for inclusion in this review, it was necessary to analyse equivalent studies which had been undertaken across different schooling systems and reported on internationally. Overall, of the 36 publications included

in this review which focused on FL application within middle schools or equivalent aged children, significant improvements for ALOs were reported on in 16 of 22 studies (6 reported no effect), or 73% of publications. PLOs were significantly greater for FL in 14 of 16 studies (88%), and SSOs significantly improved in all of 12 studies examined (100%).

Investigating further, multiple empirical studies included in this review (and many studies not included) examined the appropriateness and effects of FL across broad developmental and age ranges, from junior/primary schooling to middle and higher secondary schooling and tertiary education levels. Research outcomes which document issues relating to younger cohorts of students exposed to FL report on several important factors which may impact upon the successful application of the model. Of the reviewed studies, issues relating to student autonomy and parental permission to access online technology within the home so that they can undertake essential pre-learnings were identified (Akçayır & Akçayır, 2018), plus student proficiency in ICT use to access content out of school (Leo & Puzio, 2016). Yildiz-Durak stated the need to prioritise 2 key dimensions of student readiness for FL to ensure that younger students are capable of being autonomous outside of class - technology self-efficacy and communication self-efficacy (Yildiz Durak, 2018). In addition to those already stated, Howell identified important points when determining whether to instigate a flip within a younger teaching group - student comprehension of material when at home and how best to provide a scaffold for understanding of new concepts when the teacher is not physically present (Howell, 2013). Winter concluded that FL is a model pedagogy for middle school students as it provides important differentiation when documented disparity exists in the abilities of students at this age, but the implementation of FL must be accompanied by age-appropriate strategies (Winter, 2017).

Overall, this collective data represents a significant foundation with which an argument for FL as being age appropriate for years 7 to 10 Australian students may be made.

SQ4: Is flipped learning a suitable pedagogy for teaching of the Australian middle school general science curriculum?

As previously mentioned, the publications which have been included in this study contained insufficient data originating from studies focused on teaching of the Australian curriculum and were conducted within the Australian education system. As with the assessment parameters nominated for SQ3 however, researchers aligned across multiple international educational jurisdictions have produced outcomes focussing on the delivery of scientific coursework. Therefore, the opportunity exists to extrapolate outcomes relevant to local practice by using evidence from these closely aligned studies.

Australia's curriculum aligns closely with that of other high-performing international jurisdictions, with a recent independent report published by ACARA demonstrating equivalent depth, breadth and rigour of the Australian system to that of Finland, Singapore, New Zealand and British Columbia (ACARA, 2019). Of the studies reporting against outcomes for middle years science education, 13 reported significant improvements against ALOs, with 6 reporting no difference (68%), 9 demonstrated improvement in PLOs (90%) and 8 showed improvement in SSOs (100%). These results suggest that there is sufficient

support for a case to apply FL within the context of Australian middle school science education.

Supplementary Findings

Additional factors which may impact the value which can be realised from applying FL have been identified from the literature. These include fundamental aspects such as teacher proficiency in model delivery and technological competency for both student and teacher, both of which will be covered extensively in the following chapter. Examples and discussion of all influential factors are too numerous to appraise in detail. However, the following list of considerations which may act as either enablers or barriers to successful implementation of the FC have been identified through this investigation.

Successful implementation of FC pedagogy may be influenced by the following factors:

- Knowing your students. Students must possess of have the potential to quickly develop self-control and autonomy otherwise they will be left behind (Yildiz Durak, 2018)
- Appropriate content and length of online videos (Slemmons et al., 2018) – short videos are more effective for information retention, student focus and engagement.
- Guiding notes - should be added to videos to assist students with comprehension (Alias et al., 2020)
- The importance of maximising class time for collaborative and engaging student-centred practices, including assessment activities, hands-on competence building, student centred collaboration, student-teacher interaction (Kostaris et al., 2017)
- Understanding the academic capabilities of students at outset. Multiple studies reported on FL being significantly beneficial in improving low performing student outcomes (Almasseri & AlHojailan, 2019; Kostaris et al., 2017; Stratton et al., 2020; Winter, 2017)
- Sufficient emphasis on the group work component (not enough may result in this acting as a barrier). Group work increases fun and enjoyment and increases social comfortability (Love et al., 2015)
- Successful implementation is realised by learning being placed in the student's hands. The ability to pause, re-watch instructional videos. Multiple opportunities to learn content in class and out of class and greater time for effective teacher support in class (Schultz et al., 2014)
- Quality, portability, and adaptability of the multimedia tools to heighten interest in the online learning component which in turn increases engagement (Zummo & Brown, 2020)
- Students gain significantly from access to the syllabus in advance (may act as a barrier if not provided). This allows greater freedom in-class for teacher to work with each of the students more positively (Reinoso Tapia et al., 2021)
- Provision of supports for self-regulated learning (SSRL). SSRL in form of an online interface with self-reflection input options help scaffold learning, increasing engagement and self-regulation (Yoon et al., 2021)

Barriers to successful implementation may be exacerbated by the following:

- Problems encountered which are related to accessibility of the online technology – poor technological infrastructure (Say & Yildirim, 2020)
- Digital literacy of the participants. Those with higher digital literacy at outset exhibited significantly higher SSOs (Campillo-Ferrer & Miralles-Martínez, 2021)
- A disconnect between what teachers and schools perceive of student and parent understanding of the FL model and personal responsibilities for involvement in one (Bond, 2019)
- Insufficient emphasis of the importance in completing online pre-learnings prior to class work (Yildiz Durak, 2018). Recommend use of online programs which collate and report against access to and completion of pre-learning requirements
- Poor curriculum design and infrastructure deficiencies lead to implementation hindrance (Griffiths, 2019)

Chapter 4: Literature Review - Discussion

Theme 1: Social constructivism as a catalyst for improving student outcomes

Academic achievement and student satisfaction are recognised as two of the most important learning outcomes for school students, and are considered key determinants of the provision of education excellence (Doménech-Betoret et al., 2017). Significant effects have been reported within this study which relate to both quantitative and qualitative measures of FC success. Further, a significant subset of the included studies (18) demonstrated both increased academic improvement measures coupled with enhanced reports of student satisfaction within the same investigation, (see Table 4). These results align with literary evidence which suggests that academic achievement and student satisfaction can be recognised as inter-related and are co-influential parameters of success. Studies have shown that students with very high life satisfaction achieve to higher standard than those with lower life satisfaction in terms of academic performance, student engagement and academic self-efficacy (Antaramian, 2017). Further, promoting relatedness in students and in the student-teacher relationship is a means to enhancing the value that students feel from each other and their scholastic environment (Doménech-Betoret et al., 2017). The group dynamic afforded by the FC within which students interact, learn, and influence others to learn, is a construct which promotes differentiation and knowledge constructivism through the influence of the social setting within which it occurs, and brings with it increased success and satisfaction in the learning process (Erbil, 2020).

From their critical review of the literature and study of early-stage teachers in Australian science classrooms, Griffiths stipulated four key principles which help to define the success of learner- centred pedagogy: (a) differentiated instruction, (b) student choice and control, (c) active learning and (d) positive relationships. Providing differentiation and opportunities for active learning must be the focus for the FC teacher as part of their obligation to create an effective learning environment. Trust in students and providing opportunity for choice in how their learning progresses provides a strong foundation for positive relationships both amongst students, and between teacher and students. Together, generating positive academic outcomes and improved emotional connection to learning leads to increased student satisfaction with schooling. A safe, fun, and supported within-class socially constructivist environment plays a vital role in the success of group inquiry-based learning systems (Mohammad & Farhana, 2018). The flipped classroom model is dependent upon IBL as a key pillar of its within class pedagogy. IBL empowers student voice and increases choice, maximising opportunity for differentiation and heightened motivation (Gholam, 2019). Teacher-led scaffolding, coaching and guidance is required when reviewing the concepts explored in the flipped videos, especially during the initial stages of studying new topics. This supports students to begin their inquiry, and progress through to completion of the active learning tasks successfully (Tomas et al., 2019).

Evidence from the systematic review suggests that academically low achieving students have greater potential to gain from the FC model. Of the small subset of studies stratifying data based on academic capabilities, several studies reported on FL providing significant benefit towards improving low performing student outcomes (Almasseri & AlHojailan, 2019;

Kostaris et al., 2017; Stratton et al., 2020; Winter, 2017). It can be argued that opportunities afforded by FL, both in augmentation of differentiated learning and increased individual assistance from the teacher during in-class IBL are contributory facets for improving academic outcomes, in particular for low achieving students (Capaldi, 2015). The study conducted by Kostaris *et al* reported significant improvements for FL intervention in both academic and student satisfaction outcomes. They found motivation and engagement both intrinsically linked to the maximisation of collaborative and engaging student-centred practices during class time. Competence and confidence building through participation in hands-on active learning, student centred collaboration and positive student-teacher interaction provides pedagogical differentiation for low achieving students and leads to significantly improved assessment outcomes (Kostaris et al., 2017). FL increases opportunities to support student understandings through one-on-one time, or group based assistance when needed (Schultz et al., 2014), and as per Vygotsky's Zone of Proximal Development theory, provides for improved social constructivist knowledge building through effective and pro-active teacher practice (Erbil, 2020).

In examining the use and effectiveness of FL on science instruction within the social constructivist domain, the study conducted by Unal et al, of 57 graduate level educators reported on mathematics and science teachers utilising the FL platform more often and encountering significantly higher positivity scores than arts and humanities teachers (Unal et al., 2021). Students preferred the FC method of education because it gave them greater responsibility for learning, preparing for class and a social scaffold with which to use class time for effective inquiry. Further, math and science teachers viewed the model as providing more interactive inquiry time in class and removing passive learning through the advent of active inquiry opportunities. This positive outcome for science instruction within the FC context coherently aligns with and supports the global strategy towards fostering student agency in our next generation of learners.

Theme 2: Teacher and Student Competencies with Online Learning - the Role of Technology

Life for modern-day students is far removed from those of only a decade or two ago. Advancements in technology offer the ability for people of all ages across the globe to access online content '24/7', subsequently impacting upon many facets of our lives, including traditional workplace environments and educational systems (Berry & Hughes, 2019). This new age of immediate and unrestricted access to content at any time of the day or night necessitates consideration by education policy makers of how to ensure that relevant, future focused educational strategies can be made exclusively learner-centred in order to ensure uptake: essentially the delivery of *relevant content* within a *relevant context* (Broman et al., 2020). Further, it supports the argument for examining whether traditional models of school-based lecture style content delivery accompanied by out of school hours homework time for completion of assessment tasks has *any* role to play in developing future generations of students.

In addition to the influence that technology has had on our rapidly evolving educational ecosystems, the ongoing Covid-19 pandemic has been responsible for health and societal dilemmas on unprecedented levels, unilaterally and significantly - potentially forever -

impacting how education is delivered across the globe (Chaturvedi et al., 2021; Salhoobi, 2021). For many educational systems the imperative to change focus spontaneously and effectively to engage with students entirely through online communities was brutally impactful (Mouchantaf, 2020). The associated rapid emergence of new and novel technologies to maximise online learning integration during the Covid-19 pandemic has further challenged long-held beliefs on how education should be delivered (Gill et al., 2020). Schools and schoolteachers, irrespective of their capabilities and readiness to do so, were forced to immediately demonstrate high level flexibility and competency to accommodate students' needs. The proficient integration of ICT for extended periods of school closures across the globe resulting in subjects being taught exclusively through remote learning.

However, evidence of a significant problem lies herein. A recent report has shown that just prior to the covid pandemic, a large proportion of upper secondary school teachers – 43% - believed they didn't have the skills to effectively use ICT in their teaching, with a further 18% identifying an urgent need to obtain professional development for the purpose of proficiently integrating ICT within their classes (OECD, 2021). It is yet to be determined whether the wholesale move to remote learning across many educational jurisdictions induced by the pandemic has righted some of these issues. Clearly though, this represents a significant limiting factor in whether flipped learning may be effectively deployed within classrooms, particularly when it depends on the collective abilities of teachers in utilising engaging and learner-centred ICT resources and reporting tools to educate and assess their students. The question of whether flipped learning *can* be applied as a broad-spectrum approach to middle school science delivery must therefore be supplemented with an investigation into *how* it may be applied within a context that provides greatest opportunity for success. On top of this, an additional layer of complexity lies in determining appropriate levels of funding support from regional governments to facilitate workplace training (internal and/or external) which must be provided by local education departments. Schools and teachers would require support so that they may successfully apply flipped learning at their community level.

Theme 3: The Australian Science Curriculum

Student agency is a fundamental pillar of the OECD's Future of Education and Skills 2030 report. Fostering this personal developmental trait is congruent with the ethos of scientific inquiry. The principal responsibility implied by the term student agency is driven by the philosophy that students should be encouraged and supported to participate fully within society and influence others. Student agency is "about acting rather than being acted upon; shaping rather than being shaped; and making responsible decisions and choices rather than accepting those determined by others" (OECD, 2019). In essence this statement characterises the tenet of science education: promoting a classroom environment within which it is safe to question the status quo and allow students the freedom to seek answers. This is a strong foundation for fostering an inquiry-based learning ecosystem.

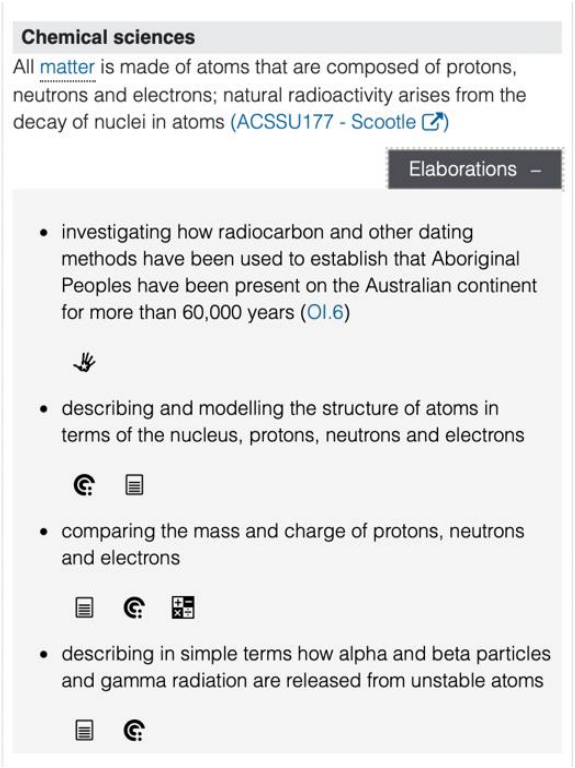
The current version of the Australian curriculum was published in 2014, and recently reviewed through ACARA's commitment to a rolling 6-year review cycle. Following recent review, ACARA boldly declares on page 10 of its Shape of the Australian Curriculum report (version 5, 2020), that "the primary audience for the Australian Curriculum is teachers. The

curriculum is written in plain and concise language while utilising the vocabulary appropriate for professional practitioners of each learning area. Consistency in terms of language and structure is used to support teachers in planning within and across learning areas" (ACARA, 2020). This perspective is logical – teachers are the conduits through which essential knowledge is dispensed. However, too often teachers may be viewed as infallible 'gurus' - expected to understand how to skirt the pitfalls of teaching practice, work efficiently against the complexities of differentiation, and introduce gold standards of knowledge building, all while creating curriculum synergy and personal harmony within the classroom. Students rely overwhelmingly on their educators to understand the content they are required to teach so that they know how to teach it with energy and dexterity. However, a parallel argument can be made that Australia's curriculum has not only been constructed for teachers to digest and understand, so that they can teach it well, but *written for the benefit of teachers,* not the benefit of students.

Placing a lens squarely over the years 7 to 10 science curriculum content, which is used as the basis for all state based public middle school science instruction, and is freely available through the ACARA website, it is evident that the framework is built upon 3 curriculum *Content Descriptors* - Science Understandings, Science as a Human Endeavour, and Science Inquiry Skills. Each descriptor clearly delineates its purpose against the backdrop of ***what*** knowledge or skill students are expected to develop. Certain elaborations also provide guidance on ***how*** this essential understanding may be conveyed. However, the curriculum struggles to clearly describe ***why*** the knowledge is important, or at the very least, provide a degree of relevance with which the 'essential' knowledge connects to young peoples' lives. The most basic of interrogative prompts asked by humans when trying to understand the nature of phenomena include 'what…?', 'how….?', 'where…?' or even 'when….?', with respect to an investigation to comprehend unknown principles. These prompts frame the foundations of analysis which correlate to engineering, mathematical or history-based inquiry, but the question of **'why….?**' is arguably the most vital with respect to the nature of scientific inquiry. This subtext is conspicuously absent within the Australian middle schooling years science curriculum.

It can be asserted that the years 7 to 10 Australian curriculum over emphasises the theoretical bases for, but not the relevant applications of, scientific inquiry. When considering innovative pedagogical approaches to facilitate learning in students, such as FL, the structure of the curriculum content appears to be excessively directive, aligning very closely to the precepts of TL rather than FL. An example of this structure is depicted in Figure 3. Griffiths found that early career teachers can implement effective, learner-centred teaching practices in their first years of teaching but must be supported with flipped learning curricular resources (Griffiths, 2019). The provision of such resources supports their professional learning, preparing them more effectively for innovative professional practice. Griffiths also found that teachers who hold more constructivist beliefs about learning implemented the most learner-centred practices (Griffiths, 2019), but unfortunately this is not fostered by the present structure and wording of the Australian science curriculum.

Figure 3: Example of Australian Year 9 Chemical Sciences Curriculum Content



When considered against the inquiry-based ideology with which the study of science is based upon, the curriculum falls short when compared to very high performing countries, such as Finland and Singapore. The Finnish curriculum has a heightened focus on *students* through enhancing engagement and flexibility, concentrating on cooperation over competitiveness and in placing strong emphasis on how students perceive educational relevance (Thompson, 2014).

Recent comparison of the Australian curriculum to the Finnish model reports on equivalent breadth, comprehension, and rigour of the 2 curricula, however the high global ranking Finnish curriculum "*reflects a deliberate shift from an information-centred, discipline-based curriculum to a learner-centred, competency-based design. The AC is considerably more prescriptive and detailed in relation to disciplinary content, although its three-dimensional design provides flexibility for teachers to adapt their programs for students with diverse interests and needs*" (ACARA, 2018). In addition, the same independent curriculum comparative report detailed a key finding which emerged that recognises the intricacies involved in balancing both departmental academic expectations and learner-centred pedagogy. The report surmises that for some reason, these aspects are viewed as fundamentally mutually exclusive, "*… that any significant reduction in curriculum content may lead to a loss of intellectual rigour and pedagogical integrity. These studies have identified an apparent tension between the volume of prescribed content and the capacity of teachers to deliver a 21st century curriculum in innovative and flexible ways*" (ACARA, 2018). Essentially there is recognition within the overarching system that the curriculum is prescriptive, and that any flexibility in modal delivery is beholden on local systems. ACARA states that implementation of the curriculum which considers local cultural and community contexts, individual student's needs and interests, and teachers' professional knowledge, is

solely the responsibility of the regional jurisdictions, systems, schools, and teachers. Not enough accountability is borne by the hierarchy, and it may be concluded that this places considerable burden on the expertise of the individual classroom teacher.

To facilitate change to promoting an enhanced learner-centred system, while also meeting the overarching goal of increasing agency in students, ACARA may do well to leverage value realised in international models, such as that of Finland and take an approach that would deliver a coupling of moderate curricular reform with a fine-tuning and/or restructuring of teacher education.

Limitations of the findings

This investigation has found that for such an extensively studied and widely published pedagogical approach, there are a distinct lack of studies undertaken on flipped learning which are focused on the same variables as the present study. Limited literature exists which is focused on the application of FC in middle school settings. Further, data focused on science classes in middle schools is *very* limited and almost no studies were discoverable which were based within Australia, meaning that extrapolation of available evidence was required to produce outcomes and discussion relating to some of the intended determinants. As such it is recognised that there are limitations to how the outcomes may be applied. However, the results of this study still satisfy an indisputable gap in the pre-existing literature base.

The included studies have highlighted a paucity of *genuine* longitudinal research in this area, with a common theme revealing duration of FL intervention for only one teaching topic or one term of instruction. This is recognised as a limitation of these studies and cautions against drawing conclusions relating to the long-term effectiveness of the FL model. It is possible that a 'novelty' effect relating to the relatively short to medium term FC interventions influenced students in their responses to questions assessing SSOs and PLOs (Antaramian, 2017). Undertaking extended longitudinal studies which cover more than one topic of instruction, such as incorporating delivery of an entire course, or undertake repeat measures for the same subject over a school year of flipped education, would ensure that any potential extraneous perceptions held by students which relate to the short-term novelty of the FL experience would be negated.

Other recognisable limitations include very few studies reporting on the critical variable relating to reliable and equitable student access to technology outside of school for the purpose of the self-directed online study. This limitation subsequently also becomes a limitation of this current investigation. In addition, only a small subset of the studies reported on analysis of gender as an outcome variable within their studies. Of those few which did report on gender related outcomes, most reported no differences, however one study did report on significant improvement for male students compared to female (Salhoobi, 2021). Future studies which place gender as a key analytical variable may provide insight as to whether gender influences educational outcomes relating to FL.

Finally although general guidelines and strategies for implementation are commonly understood and applied when flipping a classroom, no standardised framework currently

exists for FC pedagogy (Lo & Hew, 2017). The influence of the individual teacher on successful outcomes for FL in the studies examined herein therefore cannot be discounted as a potential confounding factor in the outcomes of this review. As the model is more widely studied going forward, it may be that a standardised approach to FC pedagogy is produced, allowing direct comparisons between studies which adhere to the framework, to be made.

Chapter 5: Conclusion and Recommendations

The results of this inquiry align with other recently published systematic reviews and meta-analyses, adding to a burgeoning research repository demonstrating beneficial effects of the flipped classroom model. This study contributes by taking a unique lens to the application of the flipped classroom and its effectiveness in improving learning outcomes through the assessment of science education within middle school settings. Additional focus on the Australian curriculum adds novel insight to a scarcely investigated area of this unique pedagogy.

The results presented in this review confirm that empirical research studies on flipped learning within middle school science settings produce significant improvements in both qualitative and quantitative educational measures. Students who are taught within flipped classrooms frequently perform better academically than those who aren't. In addition, students respond positively to the model, enhancing motivation and positivity and feeling more satisfied with their learning. Academic learning outcomes improved in 71% of reviewed studies. Further, 88% of studies reported on improvements in students' perceived learning outcomes, and of significant increases in student satisfaction in every study (100%) reporting against this variable. These results provide irrefutable verification that flipping the middle school science classroom can promote improved student outcomes.

These findings intend to guide both early career teachers and longstanding educators on their own future practice, in particular relating to the use of technology and learner-centred pedagogy through application of FL. They are valuable to my own future practice and provide an evidence base for teaching strategies to provide differentiation and student-centred learning within the classroom. It is evident that flipping increases the level of differentiation, with teachers able to tailor delivery of curriculum content to the requirements of their students, thereby better supporting every individual. I recognise that providing a supportive social construct to within-class group inquiry is a means to developing self-efficacy and student agency in my future classrooms.

Analysis of Australia's curriculum and identification of potential structural deficiencies which do not fully embrace the ethos of embedding student agency in our next generation of societal leaders has been presented. It provides counsel for policy makers to consider student-centred pedagogical initiatives which might be implemented to improve the effectiveness of future middle school education within Australia. However, before determining whether evidence for wide-scale *systemic* change in the structure and delivery of the Australian curriculum can be actioned, it is recognised that additional research needs to be undertaken on whether FL is effective over the longer term. If deemed to be, it would add another layer of evidence to support consideration of employing student-centred pedagogies within the bounds of the curriculum.

The following **recommendations** for future research are made:

- Extension of the intervention period for future FC research to determine genuine longitudinal success of the model
- Investigation of the influence of the individual teacher on FC outcomes

- Further research on the influence of gender and academic capability levels (high, medium, low) against the success of flipped learning

The following **recommendations** for future practice are made:

- Formulation of a standardised FC framework to ensure consistent application across schooling systems.
- Collective teacher training in ICT capability as a key to successful transition to future student-centred educational systems such as flipped learning
- Investing time in teacher and student *preparedness* for flipping
- Recognition of the importance and promotion of within-school initiatives which foster student agency

As we move further in to the 21st century, the education sector must be agile, embrace technology, be learner centred and provide differentiation for learners. FL is a pedagogy which can provide these critical facets - a strategy which permits the student to work through novel theories at their own pace (and frequency) at home, without feeling the pressure to move through new learnings more quickly than may be comfortable. However, the beauty of a classroom flip is NOT the novelty of its online learning, it is far more than that. FL places key emphasis on the social construct of group inquiry for success in consolidating new theories. Students own greater responsibility for their learning, personal development, and assessment of knowledge, with the in-class teacher taking a back step from being the 'sage on the stage' to becoming 'the guide on the side'(King, 1993). If adopted, this approach can help to develop student agency, which is a fundamental future educational strategy for all OECD countries over the coming decade.

This study concludes that flipping the classroom is a promising, learner-centred pedagogy suitable for developing active learners. It supports a case for implementation of FC pedagogy within Australian middle school science classrooms.

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Appendices

Appendices A to E: Summaries of primary research papers used within this systematic review.

Glossary Appendices A to E: FL – flipped learning; AOL – Assessed Learning Outcomes (quantitative assessment); PLO – Perceived Learning Outcomes (qualitative assessment); SSO – Student Satisfaction Outcomes (qualitative assessment).

Appendix A: Summary of systematic literature relating to middle school students and science curriculum

Author & Year	**Study Location & Cohort**	**Exp. Design**	**Measures**	**Key Finding/s**
Alias, M., Iksan, Z. H., Karim, A. A., Nawawi, A. M. H. M., & Nawawi, S. R. M. (2020).	Malaysia; Secondary school 120 students Science course	Quasi-experimental ; Quantitative	ALO (Problem solving skills) Compared to PBL and TL	FL cohort significantly improved test scores (focused onproblem solving skills – evaluation, planning, expectation) over PBL and conventional instruction post intervention. Recommend add guiding notes to videos to assist with comprehension
Andersen, M. F., Levinsen, H., Møller, H. H., & Thomsen, A. V. (2020).	Sweden. 7th grade, 22 students Science class	Case study centred on museum visit. Interviews, questionnaires	PLO Student perspectives on science centre	Flipped learning-inspired pre-learning material can structure and improve school visits to museums and science centres. Students were more engaged and prepared for the visit through FL pre work
Barlow, T., & Fleming, B. (2016).	Australia; 9th grade science class	Case study: measure of extension work completion	Gamification added to flipped learning class. PLO primary focus with ALO to correlate	Overall, Improved motivation key theme 17% increase in some extension work completion, 9% increase in completion of all extension work. Correlation with test and exam results. Students marked teacher higher on quality measures. Very positive anecdotal feedback pointed to higher motivation levels
Chen, L.-L. (2016)	USA; grade 9 Health class; 64 students (33/31);	Concurrent mixed methods; Quant post intervention tests and Qual. interviews	ALO PLO	ALO – No significant difference in post intervention test scores between groups. Trend towards higher results for each FL class though PLO – students in FL class responded positively to video watching at home. More group discussion time and interaction in FL class

Duffy, C. M. (2016). (Dissertation)	USA; 8th grade science class; 91 students	Quasi-Exp Quant. Design Pre/post test	ALO	No significant difference overall between pre/post-tests for FL vs Trad. Significant difference between individual education program (IEP) vs non-IEP students
Howell, D (2013)	USA; 9th grade science class	Mixed methods, pre/post-test. Assessment of students, parents	ALO PLO	No significant difference in ALO through means of pre/post-test analyses. PLO showed students, parents and the researcher all had preference for FL. Increased responsibility for learning and thought 'hands-on' inquiry helped. 6 themes for determining whether to flip: student accountability for ext. work, technology accessibility, tech considerations for video production, comprehension of material when at home, preference for FL method and pedagogy of FL
Khairiah, Tabroni, I., Herwanis, D., Indramawan, A., Suhartono., Nurrahmawati , Y.T. (2022)	Indonesia; 'Junior high school'; science class; 60 students (30/30)	Quasi-exp; Quantitative post-test only.	ALO	ALO significantly higher in FL exp group. Concluded that the FL model has a more profound effect on students' understanding of science concepts than direct instruction model.
Lee, G.-G., Jeon, Y.-E., & Hong, H.-G. (2021)	South Korea; 8th grade science; 65 students	Mixed methods; quant pre/post-test and qual. Motivation questionnaire	Cooperative flipped learning (CFL) vs 'simple' (SFL) vs Trad learning (TL)	Authors define cooperative flipped learning environment in class as being 'CFL'. Removed the cooperative focus to provide a SFL group. ALO – SFL significantly higher achievement post test score vs CFL and TL. SSO - CFL significantly higher motivation level vs SFL and TL FL significantly better results overall than TL
Leo, J., & Puzio, K. (2016).	USA; 9th grade biology class; 69 students (40/29 split FL/TL)	Quasi-experimental study; quant pre and post-tests; anecdotal evidence for qual only	ALO SSO anecdotal evidence only	FL performed significantly better for ALO in one of 3 quizzes during study. Also performed better on each test (2 not significant) but not overall (all 3 combined). Anecdotal evidence suggests students benefited from FL and enjoyed it more
Maddox, D. (2018). (Dissertation)	USA; 'Middle School' Science class	Quantitative only	ALO	TL class initially performed better than FL class. Over time though there was no difference in test scores for duration of study. For the final test the FL class significantly outperformed the TL class
Putri, M. D., Rusdiana, D.,	Indonesia; Year 8	Quant only; pre/post test	ALO	Design limitations as no control group was included in this study…..

& Rochintaniawati, D. (2019)	science course;	scores for ONE GROUP, NO CONTROLOL		Significant increase in post-test vs pre-test scores
Salhoobi, J. (2021). (Dissertation) Undertaken during covid	USA; Chemistry course; 90 students ages 15 to 17 (yrs 10-12); 2 equal number groups, 1/3 male; gender diffs assessed	Quasi-experimental; mixed methods; Quant pre/post-tests; Qual questionnaires	ALO PLO	ALO – FL significantly higher post-test result than TL group for males and for both genders overall. No significantly diff for females. No difference found in assessment of autonomy, competence, or relatedness. Overall students from both cohorts felt high levels of autonomy, competence, and relatedness.
Say, F. S., & Yildirim, F. S. (2020).	Turkey; 8th grade science course (chem); 63 students approx. 50/50 gender	Quasi-exp; mixed methods; Quant. Pre/post-test; Qual. Review form	ALO PLO SSO	ALO – Significantly higher post test results for FL group than control (25% higher) Student satisfaction was higher for FL. Overall viewed as greatly preferential to TL PLO – subject outcomes perceived better overall in FL group Problems encountered related to accessing the tech out of class – poor tech infrastructure
Schultz, D., Duffield, S., Rasmussen, S. C., & Wageman, J. (2014).	USA; year 10 to 12 advanced chemistry course; 61 students (32 control, 29 exp) even gender	Quasi-exp; mixed methods; Quant. Pre/post-test; Qual. Review form	ALO SSO	FL taught students performed significantly better on all 8 assessment tests across the units. Authors proposed that this is because 1) learning is placed in the student's hands – pause, re-watch instruction etc. 2) there were 2 opportunities to learn content in class and out of class 3) more time for effective teacher support in class Significantly higher preference for FL model (22 of 29 with 3 neutral)
Shana, Z., & Alwaely, S. (2021)	UAE; grade 6 science class; 39 students (25 exp/14 control)	Quasi-exp; mixed methods; Quant. Pre/post-test; Qual. Review form	ALO SSO	ALO – significantly higher (25%) post-test scores for FL cohort Positive changes in attitude were reported in this study; participants reported high level of enjoyment, increased involvement and decreased boredom, and greater task value when

				involved in FL. 95% of respondents preferred FL to TL
Schmidt, J. (2013). Dissertation	USA; Middle school – range of year 4 to 11; Math, science focus; non-equivalent groups	Quasi-exp; Quantitative post test only	ALO PLO	For both Earth (8th grade students) and chem (11th grade) had significantly higher post test scores through FL. FL content was Moodle based only. PLO - Biology students spent same time or more on FL content. (80%). Earth Science spend same or less (80%), Chem same or less time (94%) Overall students in earth and biology significantly preferred Moodle FL, chem preferred not to use Moodle (not significantly)
Sezer, B. (2016)	Turkey; 'middle school' (6th grade) science class; 68 students (35 exp/ 33 control)	Quasi-exp; Quantitative pre/post-test	ALO SSO	ALO showed that post test scores were significantly higher in the FL group over control (no diff pre-test scores) SSO – following FL tuition, students had significantly higher scores relating to motivation than control.
Slemmons, K., Anyanwu, K., Hames, J., Grabski, D., Mlsna, J., Simkins, E., & Cook, P. (2018).	USA; middle school science grades 7-9; 381 students	Quasi-experimental ; Mixed methods Quant. Measures of online quiz scores; Qual. Survey questions	FL but applicable to all Online Learning ALO PLO	Study focussed on optimal length of video instruction as defined by post-test scores. No control (TL) group – only FL groups x2 with long and short video length. ALO: No academic difference - Overall no difference in test scores post video watching. PLO: students 'focus', 'engagement', and 'information retention' all significantly higher responses for short video length. Students paused and re-watched shorter videos fewer times. No diff in what video length was preferred
Stratton, E., Chitiyo, G., Mathende, A. M., & Davis, K. M. (2020)	USA; 7th grade science class 154 students	Mixed – Quant. Pre/post-test and Qual. Perception Qs	ALO PLO SSO	No sig. difference in pre/post-test ALOs. Low ability students fared slightly better with FL. High and middle ability slightly better with Trad. Conclude that FL as effective as Trad. PLO and SSO increased by FL (% favourable response). Perceived that they learned more effectively and were more motivated, but this did not translate to performance diffs No gender diffs
Tan, R. M., Yangco, R. T.,	Philippines; Grade 9 science class;	Quasi-exp; Quantitative pre/post-test	ALO	FL did not provide significant improvement over TL across either parameter of conceptual understanding

& Que, E. N. (2020).	55 students 24 female, 31 male); looked at conceptual understanding and science understanding			and science process skills for post-test scores. Both TL and FL improved between pre and post-test scores equally. One test of the 4 topics covered significantly showed improvement for FL over TL
Zummo, L. M., & Brown, B. A. (2020)	USA; Middle and High School SCIENCE (95% of students in year 9 or 10); 303 students, equal gender and diverse (not equal) ethnic background.	Quasi-exp; mixed methods; Quantitative pre/post-test and Qualitative interviews (small sub-section of students approx. 24 each exp and control, hand-picked by teachers)	ALO PLO SSO	ALO – Found that the average normalised gain was significantly greater for FL model than TL. This was equivalent for both boys and girls. When comparing FL students who engaged with ALL online tools (71%) to TL (54%) it strengthened the data further Qualitative analysis of free input interviews showed that students offered 3 reasons for better learning outcomes – the multimedia nature of the tools used (active learning), the portability and adaptability of tools and subsequently, the heightened interest in the online learning activity. Engagement with the OL followed

Appendix B: Summary of systematic literature relating to middle school students, non-science curriculum

Author & Year	Location & Cohort	Exp. Design	Measures	Key Finding/s
Almasseri, M., AlHojailan, M.I. (2019)	Saudi Arabia; 8th grade; computer science class; 67 students (equal distribution FL and direct instruction)	Quasi-exp. Quant. Pre/post-test design.	ALO PLO Cognitive theory of multimedia – assessment based on Bloom's taxonomy	ALO – Positive effect on measures of achievement relating to higher order thinking skills – applying, analysing, evaluating. No difference between groups for academic achievement relating to remembering and understanding levels. Learners with low prior knowledge displayed significantly greater improvement in ALOs than learners who had high prior knowledge.
Kirmizi, O., & Komec, F. (2020).	Turkey; gifted students (113); 14 -16 years of age; ESL course	Descriptive study; Mixed methods	PLO	Students felt that the FL model helped. Outcomes incl. benefits to own paced learning, autonomy, self-confidence, and that video lectures helped with improved performance (perceived, not ALO) and higher motivation Younger students significantly higher PLOs than older students
Kostaris, C., Sergis, S., Sampson, D.G. Giannakos, M.N., Pelliccione, L. (2017)	Greece; Junior high school 8th grade; ICT course; 46 students	Action research Quantitative pre/post-tests and Qualitative questionnaires	ALO Clustered students in to low, med, high performing across both control and FL	ALO – FL group significantly higher post-test scores on test 2 and 3 of 3 post-tests (1 not significant) Low performing students in the FL group had greatest gains in ALO over the study – 22.5%. High had 12.7% and medium had 10.4%. FL group had significantly more exposure to student centred practices incl. assessment activities, hands-on competence building, student centred collaboration, student-teacher interaction. Motivation and engagement levels both significantly higher in FL group than in control FL maximises class time for collaborative and engaging work time and is most beneficial for improving low performing student outcomes.

Li, D. (2018)	USA; Middle School; Art class but focus on ecosystems; student numbers not specified but 'one class' of students	Qualitative only; assessment of artwork as whole class; Perceived learning outcomes from feedback	PLO Comparison of same class between flipped and non-flipped outcomes	Loose design overall due to assessment of artwork by class teacher only. Art was used as measure with inclusions of imagery correlated to how much students learned during the knowledge building phase. This aligned to the state education agency Outcome was that students who completed the FL class showed heightened knowledge and motivated learning to foster active learning in class.
Wei, X., Cheng, I.L., Chen, N-S., Yang, X., Liu, Y., Dong, Y., Zhai, X., & Kinshuk. (2020)	China; Math class; 6th grade; 88 students equal numbers control/exp	Quasi-exp; mixed methods; Quant pre/post-test and Qual. interview	ALO PLO students assessed as high, med, low achieving	ALO – post test scores showed significant differences for learning approach (experimental>control group) achievement Additionally, significant improvements seen across high, medium, and low achieving levels of competency for FL over control. Also, the improvement seen in the middle competency level was highly significant between pre and post - est. Only anecdotal data presented for interviews, no formal conclusions re perceptions. Used interview feedback for guiding recommendations.
Winter, J. W. (2017).	USA; Middle school (6th grade ages 11, 12) social studies course;	Quasi-exp; students separated in to high, med, low achieving (grades)	PLO	Student assessments were made, and the results alone not published – only in context to top/mid/low performance relating to PLOs Results showed (all significant): • high performers understood the collaborative workspace more than low • mid perf responded they worked harder than what low perf responded • mid responded they put best effort forth higher than low • high and mid responded they worked harder even when not interested than low • top perf rated their effort signif higher than low in indiv space • top perf rated effort signif higher than low in group space

				concluded it is an appropriate model for middle school and that it motivates students and is beneficial for ave. perf students
Yildiz Durak, H. (2018).	Turkey; Middle school (5th to 8th grade); 371 students; programming course	Quasi-exp; relational screening model (not cause and effect but influence of 2 or more variables); videos mostly outside as pre-work and some tasks and PBL inside class	Looked at readiness for the flip and how this relates to engagement, attitude, self-efficacy, and interaction	Found that all parameters' studies were significantly related to flipped learning readiness (FLR), except for communication self-efficacy, motivation, and preview work (home) influencing their **interaction** levels. Found that engagement, attitude, self-efficacy, were all highly correlated to FLR, learner control and self-directed learning, technology self-efficacy, communication, motivation for learning and pre-work completion. Prioritise 2 dimensions for readiness – tech self-efficacy and communication self-efficacy so that they can be autonomous outside of class

Appendix C: Summary of systematic literature relating to high school students; STEM related courses

Author & Year	Location & Cohort	Exp. Design	Measures	Key Finding/s
Bond, M. (2019).	South Australia; secondary school teachers, parents, students, school leaders	Case study 2 rural SA schools; mixed methods questionnaires, interviews	SSO PLO	School leader, parent, student and teachers agree FL offers a range of advantages and positive effect on schooling, motivation, engagement, higher responsibility. However, a disconnect b/w what schools think parents know and what they do exists. Limitation in volume of interview data as many parents were unable/unwilling.
Broman, K., Bernholt, S., & Christensson, C. (2020)	Sweden; upper secondary chemistry	Qual. Interview/questionnaire	PLO, SSO, ALO	Explored relevance (life application) and interest. Context based learning outcomes showed correlation with PLO, SSO and ALO
Chao, C.-Y., Chen, Y.-T. & Chuang, K.-Y. (2015)	Taiwan; 11th grade school engineering; 91 students	Quasi-Exp; mixed methods quant pre/post; Qual survey	ALO PLO	ALO – achievements in FL significantly higher than TL PLO – Learning attitude, motivation, self-evaluation all higher with FL
Dixon, K., & Wendt, J. L. (2021).	USA; 12th Grade science; Minority groups only	Quasi-Exp Mixed Meth. design Pre/post-test and Perception Qs	ALO PLO	No significant diff b/w pre/post-test for FL vs TL Significant improvement in PLO in motivation to learn. Intrinsic motivation did not correlate with achievement. (GOOD DISC)
Finkenberg, F., & Trefzger, T. (2019).	Germany; 11th grade physics	Quasi-Exp Mixed methods Design Pre/post test	ALO PLO	Significant improvement in ALO for FL model over control. Significant difference in motivation and interest for FL vs TL (FL stayed same; TL decreased). PLO significant increase for FL
Halpin, P.A. & Gopalan. C. (2021)	USA; No age group just 'high school'; Biology course	Quasi-exp; mixed methods; Quantitative pre/post-test and Qualitative questionnaire	ALO PLO Students were asked to 'dramatise' the group learning ie act out the role of the cell component	ALO – Increased levels of understanding through group 'dramatisation' work. PLO – increased engagement and confidence in knowledge post intervention.

Little, C. (2015).	UK; Case study; Year 12 psychology students; 9 students	Quasi-experimental ; quant pre/post-test and survey	ALO PLO	ALO – positive improvement overall but not significant due to limited sample size PLO – only 6 of 9 responded and largely in favour of FL (not enough responses for significance)
Morris S-Y, J. (2017)	Hong Kong; grade 11; 215 students; Liberal studies and guided social inquiry (liberal studies collectively includes science)	Quasi-exp mixed methods design; Quant pre/post tests and Qual. questionnaire	ALO Assessed guided social inquiry learning (GSIL) vs Flipped GSIL	ALO – No significant diff in results for high achieving students; significant difference for FL over control in both moderate and low achieving students. PLO – for low achieving students self-efficacy score was significantly greater for FL over control
Reinoso Tapia, R., Collazos Martínez, M. Á., Martínez Martínez, M. d. C., & Delgado Iglesias, J. (2021)	Spain; Anatomy course; 30 students completing first year of baccalaureate course age 16 average	Quasi-exp longitudinal study; mixed methods; Quant pre/post-test and Qual. Perceptions of methodology	ALO PLO	Once again, no control group. Authors only wanted to demonstrate that it was suitable to the baccalaureate course. ALO showed significant difference between pre and post-test results. Student's perceptions strongly supported FL. >85% of students gained from access to syllabus in advance of in-face and having free access to go back over. Also, that the teacher was able to work more effectively with each of the students (65% - strengths/weaknesses) and that the interactions had been more positive (62%)

Appendix D: Summary of systematic literature relating to undergraduate pre-service teachers and science courses

Author & Year	Location & Cohort	Exp. Design	Measures	Key Finding/s
Cabı, E. (2018).	Turkey; Undergrad 59 PSTs	Mixed – Quant. Pre/post-test and Qual. Perception Qs	ALO SSO	No statistically significant difference in pre/post-test ALO experimental vs control General positive assertion re SSO for use of kahoot, khan academy and moodle. Issues incl. insufficient resources, too much work/motivation
Campillo-Ferrer, J. M., & Miralles-Martínez, P. (2021).	Spain; Undergrad 179 PSTs. Social science course	Quasi-Exp Qual. design Pre/post-test and Perception Qs	SSO PLO	Improved motivation and PLOs, active participation. SSO improved due to wide range resources, peer to peer interaction. Those with higher digital competency at outset sign. Higher SSO. Overall, no gender diffs
González-Gómez, D., Jeong, J. S., Airado Rodríguez, D., & Cañada-Cañada, F. (2016)	Spain; Undergrad PST course for general science	Mixed method; pre/post quant. Tests and Qualitative questionnaire	ALO PLO	ALO: significant difference between groups – higher for FL outcomes. PLO: overall higher favourable perception of learning outcomes for FL. Mainly due to autonomy in learning externally plus increased teacher availability in class
Jdaitawi, M. (2020).	Saudi Arabia; Undergrad, 65 students; science class	Quasi-exp design; qualitative	SSO/PLO	Assessed 'positive learning emotions' which in my opinion cross over between SSO and PLO. Study showed significant increase in learning emotion following FL
Jensen, J. L., Holt, E. A., Sowards, J. B., Heath Ogden, T., & West, R. E. (2018).	USA; Undergrad general biology class; 657 students across 2 diff unis	Quasi-exp design; Quant assessment; 3 treatments of ext content delivery – video, 'textbook' style and 'tutorial style'	ALO	No diff in ALO between 3 treatment groups during the course. At completion of the course final exam administration showed video lecture group significantly outperformed both other groups. Findings – Video lectures offer small advantage. The ALO results differed by uni, therefore diff institutions influence outcomes, both unis saw equivalent gains after experiencing FL
Jeong, J., Cañada-Cañada, F., & González-Gómez, D. (2018).	Spain; Undergrad teaching; multi-year assessment of 153 students; general science topic	Quasi-exp design; mixed methods;	ALO PLO SSO	ALO – significant difference in academic achievement when flipped learning used (2 years) and not used (1 year) PLO showed general overall perception for FL. 97% agree video lectures very helpful pre class. SSO showed FL achieved higher scores for positive emotions than negative emotions

Love, B., Hodge, A., Corritore, C., & Ernst, D. C. (2015)	USA; Undergrad STEM course; 27 students	Qual. FL only, no TL	PLO	70% of students agreed that group or paired discussion helped develop deeper understandings. 78% stated group work made them more comfortable socially with classmates and 72% agreed working problems in group setting made the class more fun than TL. 22% of students preferred TL class to FL.
Nja, C. O., Orim, R. E., Neji, H. A., Ukwetang, J. O., Uwe, U. E., & Ideba, M. A. (2022)	Nigeria; Undergrad PST students (2nd year) undertaking chemistry course; 100 students	Quasi-exp mixed methods design; Quant pre/post tests and Qual. questionnaire	ALO PLO (attitude towards chemistry only 60 of 100 respond-ents)	ALO showed that those undertaking FL significantly outperformed those undertaking TL. PLO showed that students had a significantly positive attitude towards chemistry when undertaking FL course
Tomas, L., Evans, N., Doyle, T., & Skamp, K. (2019).	Australia; Undergrad PSTs;	Mixed methods; Quant assessment of (yes/no) survey, plus Qual. Narrative response	PLO	4 key findings: Majority of students watched videos more than once, and generally before attending class If students didn't watch videos prior, they perceived it to be due to lack of time Students felt the videos contained all required knowledge for them to prepare for class FL enhanced learning motivation but was not clear whether it was preferred over TL *Key finding 5: additional teacher-led instruction, scaffolding and guidance were required in- class to review the concepts explored in the flipped videos, and to support students to complete the active learning tasks successfully*
Yoon, M., Hill, J., & Kim, D. (2021).	USA; Undergrad PSTs; 45 students	Quasi-exp; mixed methods; Qualitative; questionnaire and quant pre/post-test (online quiz)	ALO PLO	Examined supports for self-regulated learning (SSRL). The SSRL was a learner interface (online) with self-reflection component to act as learning scaffold. Findings were that SSRL significantly positively impacted ALO quiz scores from pre to post (67 vs 28 final scores). This correlated with the completion rate of videos as well. Students who used SSRL demonstrated higher level of self-regulation. Students who used SSRL paid more attention to the videos which relates to engagement.

Appendix E: Summary of systematic literature relating to serving teachers' implementation of flipped learning and teacher competencies

Author & Year	Location & Cohort	Exp. Design	Measures	Key Finding/s
Barnard, M., Dehon, E., Compretta, C., Notebaert, A., Sparkmon, W., Meyer, E., Stray, S., Taylor, J., Sullivan, D., & Rockhold, R. (2020).	USA; focus is on teacher competency	Qualitative; questionnaire to determine competencies for STEMI professionals	Teacher competency in FL	27 required competencies identified. Grouped in 5 domains for modelling – Attitudes to FL teaching, Knowledge application, Instructional Professionalism, Learning Env. Mgt, Technological skills. Model for professional develop.
Bond, M. (2019).	South Australia; secondary school teachers, parents, students, school leaders	Case study 2 rural SA schools; mixed methods questionnaires, interviews	FL SSO PLO	School leader, parent, student and teachers agree FL range of advantages and positive effect on schooling, engagement, higher responsibility. However, disconnect b/w what schools think parents know and what they actually do. Limitation in volume of interview data as many parents unable/unwilling.
Gholam, A. P. (2019).	Dubai; Post-Grad. 8 student teachers	Mixed methods. Examined how to implement learning	IBL focus	IBL empowers student voice and choice, increasing opportunity for differentiation and heightened motivation. Curriculum design and infrastructure deficiencies lead to implementation hindrance.
Griffiths, S. (2019). (Dissertation)	Australia; Focus on Early career teachers	Longitudinal case study; Qual – interviews and observation	FL PLO	Early career teachers can implement effective, learner-centred teaching practices in their first years of teaching when they are supported with flipped learning curricular resource The provision of curricular resources supports early career teachers' professional learning and teachers who held more constructivist beliefs about learning implemented the most learner-centred practices Four key principles of learner-centred pedagogy were developed from a critical review of the literature: (a) differentiated instruction, (b) positive relationships, (c) student choice and control, and (d) active learning

Herreid, C., & Schiller, N. (2013).	USA; survey of 15000 STEM teachers	Qual. survey	FL; are teachers implementing in class or not?	200 case teachers responded in affirmative. Novel finding: for use of FL: 1 - more time to spend with students on authentic research; 2 - students get more time working with scientific equipment that is only available in the classroom; 3 - students who miss class for debate/sports/etc. can watch the lectures while on the road; 4 - the method "promotes thinking inside and outside of the classroom"; 5 - students are more actively involved in the learning process; and 6 - they also really like it.
Ouabo, L. (2021). (Dissertation)	Multi-country; 11 respondents; high school teachers	Qual only; survey of 11 HS teachers	FL PLO (teachers only)	Some students with disabilities struggled to focus but teachers still found the model effective with teachers adding extra scaffolding to help those students.
Sargent, J., & Casey, A. (2020).	UK; teacher focus only (2 teachers); PE background Assessed influence of digitech on FL	Qual. interviews	FL PLO	Interviews with teachers showed that both view FL as strategy needing to be established as routine practice and used consistently. Needs to be embedded to develop expectations. Tech used specifically in 'down time' such as in changeroom to review skills or at home. Dichotomy in seeking to minimise 'screen time' while also using tech for capability development.
Stöhr, C., Demazière, C., & Adawi, T. (2020).	Sweden; Postgraduate (M & PhD); 52 students (35 campus based/17 FL)	Quasi-Exp; longitudinal; Quantitative online quizzes	FL ALO	Focus on Transactional distance theory ALO – no significant difference between FL and control for test scores. However, results for FL showed much greater disparity (oscillation) in results (high/low). Authors link this to influence of transactional shifts and propose that tutors need to consider how to scaffold these periods.
Unal, A., Unal, Z., & Bodur, Y. (2021).	USA; Post-Grad teachers; 57 respondents	Qualitative assessment. Convenience sampling	FL PLO	Results are teacher's perspectives of their student's preferences based on subject area Maths and science teachers utilised the platform more often and had significantly higher scores on positivity than arts (English etc) teachers Maths and science teachers saw it as providing more interaction and inquiry

				time in class. Removed passive learning from class. Believe the students preferred it because it gave them greater responsibility for learning and preparing for class.