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A Systematic Review of the Effects of Innovative Learning Environments on Teacher Mind Frames

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A Systematic Review of the Effects of Innovative Learning Environments on Teacher Mind Frames

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Overview

Aim

The overall objective of the systematic review was to identify studies which provide evidence that innovative learning environments have an effect on teacher mind frames. For this review, an innovative learning environment is defined as the product of innovative design of space and innovative teaching and learning practices (Mahat, Bradbeer, Byers & Imms, 2018). Innovative learning spaces are physical educational facilities designed and built to facilitate the widest array of flexibility in teaching, learning, and social educational activity, while innovative teaching and learning practices are the sum of teaching and learning activities that, in combination, assist in the best possible learning outcomes and learning skills of students required in the 21st century. An innovative learning environment is produced when these two phenomena are successfully merged. Teacher mind frames can be defined as the ways that teachers consciously think about their teaching roles, the content and pedagogical knowledge, which in turn has an impact on their attitudes, actions and decisions that are likely to have significant impacts on student learning (Mahat et al., 2018). Within these parameters, the review identified, collected and synthesised available literature that examined and evaluated the way primary and secondary school teachers considered their role, work, and practice in relation to learning environments.

Method

The study adopted an interpretive approach but utilised the principles and techniques of conventional systematic review procedures involving 12 databases integrating fields of education and design. Eligible papers included those studies (quantitative, qualitative and mixed methods) that examined the impact of innovative learning environments on both primary and secondary school teacher mind frames from 1960 until 2016. The risk of sampling bias and quality of studies were assessed using the Cochrane Collaboration tool and the COnsensus-based Standards for the selection of health Measurement INstruments (COSMIN) checklist, respectively.

Results

Of the 2,943 studies retrieved, 12 were included in this review. Studies were published between 2000 and 2015 and applied different variations of conceptualisations of learning environments and teacher mind frames. For the most part, although innovative learning environments have a positive impact on teacher mind frames, there are intervening variables—the most significant being assessment regimes—that prevent teachers from engaging with or changing their practices in innovative learning environments.

Interpretation

The review presented very few studies with adequate quality, sampling and statistical evidence to evaluate the impact of different conceptualisations of learning environments on teacher mind frames. In particular, only one study investigated the impact of the physical space and only one study reported an effect size. In light of this, there is a pressing need to investigate the relationships between learning environments and the ways teachers actively think to guide, inform and frame their teaching practices.

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Introduction

The concept of 'innovative learning environment' (Organisation for Economic Cooperation and Development [OECD], 2013), along with nomenclature of 'flexible learning spaces' (New Zealand Ministry of Education, 2011), 'Modern Learning Environments' (New Zealand Ministry of Education, 2018), 'New Generation Learning Spaces' (Byers, Imms & Hartnell-Young, 2014), 'non-traditional classrooms' (Campbell, Saltmarsh, Chapman & Drew, 2013), and the re-emergence of 'open-plan' after a thirty-year educational hiatus (Prain et al., 2014; Saltmarsh, Chapman, Campbell & Drew, 2015), has become established and recognisable globally. The common narrative is that such spaces, often un-classroom-like in their form, will more readily accommodate the needs of 21st century learners.

Despite the increasing interest and significant investment in school learning environments, there is a lack of empirical data to adequately evaluate how learning environments impact on teaching and learning (Blackmore, Bateman, O'Mara & Loughlin, 2011; Brooks, 2011; Gislason, 2010). In a systematic review of the impact of learning environments on student achievement, Byers, Mahat, Liu, Knock and Imms (2018) found 20 eligible studies that investigate the impact of learning environment types on student learning outcomes. While the review acknowledged the paucity of quality studies, it also found emerging evidence that suggests physical spaces have a positive impact on student learning (Byers et al., 2018).

For the most part, the discourse in the literature and media has focused on the impact of learning environments on students, with much less emphasis on teachers. Teachers have a significant influence on the classroom learning environment, and hence, the student learning that occurs within it (Rowe, 2003; Tobin, 1990). This impact is dependent on the stable preformed cognitive characteristics of the teachers that the students interact with, since ways of thinking will inform teachers' decisions, and consequently, their behaviour and practice (Clark & Yinger, 1977; Hattie, 2012). The connection between learning environments and the way teachers think, however, remains somewhat elusive. Innovative learning environments by themselves are not a catalyst of change—making changes to the learning environment alone will not prompt changes in teaching approaches (Byers et al., 2014). Teacher mind frames (Hattie, 2012; Tobin, 1990), a more holistic term to describe teachers' cognitive views, can directly influence the manner in which teachers structure the learning environments (Mahat, Bradbeer, Byers & Imms, 2018). It is vital to assess how learning environments affect teachers and their mind frames.

The aim of this systematic review is to identify, collate, analyse and synthesise the best available contemporary evidence on the impact of learning environments on teacher mind frames. Literature reviews on both concepts have shown that these terms may mean different things to different people (Mahat et al., 2018). To ensure that a comprehensive breadth of articles was included in the study, the systematic review responded to two key research questions:

1. How are the key terms 'innovative learning environments' and 'teacher mind frames' defined in the literature?

2. What evidence exists that innovative learning environments have an impact on teacher mind frames?

Phoenix College, Y2 Architecture.
Zac Couyant photography

Methods

Systematic Review Design

Systematic reviews, as the name implies, typically involve a detailed and comprehensive plan and search strategy derived a priori, with the goal of reducing bias by identifying, appraising, and synthesising all relevant studies on a particular topic (Uman, 2011). Researchers conducting systematic reviews use explicit methods aimed at minimising bias to produce reliable findings to inform decision making. Whilst conventional systematic reviews have demonstrated considerable benefits in synthesising certain forms of evidence, they are better suited to the production of aggregate, rather than interpretive, syntheses (Dixon-Woods et al., 2006). Aggregate reviews are focused on assembling and pooling data, for example, using techniques such as meta-analysis. Interpretive reviews involve both induction and interpretation—their primary emphasis is with the development of concepts and theories that integrate those concepts, with the increased use of a range of forms of evidence included in the reviews (Dixon-Woods et al., 2006). As the aim of this current study is to construct a critical analysis of a complex body of literature, an interpretive analysis is more suited as it synthesises a diverse body of evidence that enables the generation of theory with strong explanatory power (Dixon-Woods et al., 2006).

As with all systematic studies, this review began with key research questions. However, the questions acted as a compass rather than an anchor (Eakin & Mykhalovskiy, 2003). This was to ensure that the definitions of the phenomena—innovative learning environments and teacher mind frames—were allowed to emerge from the literature. In the process of responding to the key questions, the review also benefited from the multidisciplinary perspectives of the project team, allowing a range of viewpoints to be incorporated into the process.

Review Methodology

The study adopted the principles and techniques of conventional systematic review procedures, which involved sifting abstracts, scrutinizing full papers and abstracting data. This highly structured search strategy suited this review as it ensured that the search strategies were explicitly defined and provided a clear account of how the relevant evidences were examined, such that the review methods could be reproduced (Egger, Smith & Phillips, 1997). The systematic review was exhaustive within these explicit criteria.

The review process involved eight researchers. One researcher performed the initial search and subsequent data extraction. Two members then checked each title and abstract to determine if those papers were eligible for full-text review. Consultation with a lead team member occurred if a difference of opinion arose. At least two other team members reviewed full papers, with agreement sought from the lead team member for any variations of opinions. Finally, two other team members checked 10% of the abstraction records for quality control. The inclusion of several researchers with different disciplinary backgrounds also ensured that selection bias was reduced. The final eligible studies included in the review were also assessed for risk of selection, detection, attrition and reporting bias (Higgins et al., 2011).

The complexity underlying the constructs of innovative learning environments and teacher mind frames, coupled with the breadth of studies retrieved in the search, necessitated a full-team discussion to determine the final list of included articles. The team members also sought feedback from the broader project team. This further moderated the potential selection bias due to the discipline of reviewers and an individual's specific understanding of the complexity of the definitions of constructs.

Search Strategy

The search for this systematic review was performed using databases, which integrated studies in the fields of education or design: EBSCOhost databases (Academic Search Complete, Avery Index to Architectural Periodicals, Education Research Complete, Educational Administration Abstracts, ERIC), Proquest databases (Education Database, Art and Humanities Database, Humanities Index, PAIS), OVID and Informit. Of interest to reviewers were articles addressing teacher mind frames in a range of environments. The search terms addressed the concepts of teacher mind frames and innovative learning environments.

The terms were developed using related literature and chosen by team consensus based on their theoretical and practical significance (see **Table 1**). Where available, exploded search terms (denoted by an asterisk) were used, as well as associated terminology in the title, abstract, and, where appropriate, the keywords of the articles. Boolean operators helped narrow the search to relevant research fields. The reference lists of each of the full-text articles evaluated for this review were examined to ensure that no related articles were missed.

Table 1. Study search terminology

Topic	Search Terms	Exploded search terms (abstract/title)
Population	Primary and secondary school teachers	“Primary school teacher*” “Elementary school teacher*” “Elementary teacher*” “Intermediate school teacher*” “Middle school teacher*” “Junior High teacher*” “Junior High school teacher*” “Secondary school teacher*” “Secondary teacher*” “High school teacher*”
	Educator	Educator*
	School teacher	School teacher*
Teacher mind frames	Mind frame	"Mind frame*"
	Mindset	Mindset*
	Frame of mind	"Frame of mind"
	Attitudes	Attitude*
	Beliefs	Belief*
	Way of thinking	"Way of thinking"
	Ways of thinking	"Ways of thinking"
Innovative Learning Environments	Innovative learning space Modern learning space Contemporary learning space Physical learning space 21st century learning environment Innovative learning environment Modern learning environment Contemporary learning environment Physical learning environment 21st century learning environment	“Learning space*” “Learning environment*”

Table 1. Study search terminology (continued)

Topic	Search Terms	Exploded search terms (abstract/title)
	Physical environment	"Physical environment*"
	Physical space	"Physical space*"
	School environment	"School environment*"
	School space	"School space*"
	Classroom environment	"Classroom environment*"
	Classroom space	"Classroom space*"
	Classroom layout	"Classroom layout*"
	Non-traditional classroom	"Non-traditional classroom*"
	Innovative classroom	"Innovative classroom*"
	Modern classroom	"Modern classroom*"
	Open classroom	"Open classroom*"
	School design	"School design*"
	School facilities	"School facilit*"
	Pedagogical space	"Pedagogical space*"
	School building design	"School building design*"
	Architectural design	"Architectural design*"
	School architecture	"School architecture*"

Selection Criteria

A preliminary exploration of published and unpublished manuscripts focusing on the literature on teachers' use of innovative learning environments was conducted to determine the period that should be covered in this review. Eligible studies, therefore, were those studies (both quantitative and qualitative studies) that examined the impact of innovative learning environments on teachers mind frames from 1960 to 2016. This period was selected because the number of scholarly studies increased as the open plan movement began in the 1960s. To ensure the inclusion of a wide breadth of articles, studies were included where broad definitions of innovative learning environments and teacher mind frames were utilised during the application of the selection criteria. As both primary and secondary school teachers were the population of interest in this review, the search was limited to these levels of schooling. As a result, studies that involved pre-service and early childhood teachers, and those in a post-secondary setting, were excluded. As the aim was to provide an interpretive review using a wide range of evidence, studies were included if they used quantitative, qualitative and mixed methods. The selection criteria are summarised in **Table 2**.

Table 2. Selection criteria

Search	Include	Exclude
Time frame	1960-2016	Prior 1960.
Population	Primary and secondary school teachers.	Early childhood (kindergarten, pre-school) and higher education (university, TAFE, etc.) educators.
Design of selected studies	Quantitative, qualitative and mixed methods.	Studies using the identified measure to validate a different measure not identified in the search as the hypotheses and results would pertain primarily to the other measure.
Publication type	Articles published as full texts in peer review journals.	Articles or abstracts not published in peer review journals; articles or abstracts published in languages other than English; conference proceedings; books; theses and other grey literature; Other systematic reviews or literature reviews, although reference lists were used to ensure all relevant publications are located; and Generalized discussion papers of participation measures that did not present new evidence from a scientific study.

Data Collection Tools

Covidence was the primary screening and data extraction tool used for the systematic review. It is a web-based software platform that streamlines the production of systematic reviews, enabling teams to work together seamlessly in identifying and screening records. The Cochrane Collaboration tool assessed the risk of selection, detection, attrition and reporting bias (Higgins et al., 2011). Although the tool was developed specifically for assessing randomized control trials, it presented a viable means to evaluate a wider variety of methodological designs of the selected studies. The work of Cook and Campbell (1979) informed the assessment of the internal validity (history, instrumentation, maturation and selection), while assessments of internal consistency and reliability were made on the relevant aspects of the COnsensus-based Standards for the selection of health Measurement INstruments (COSMIN) checklist (Terwee et al., 2012).

Synthesis of studies

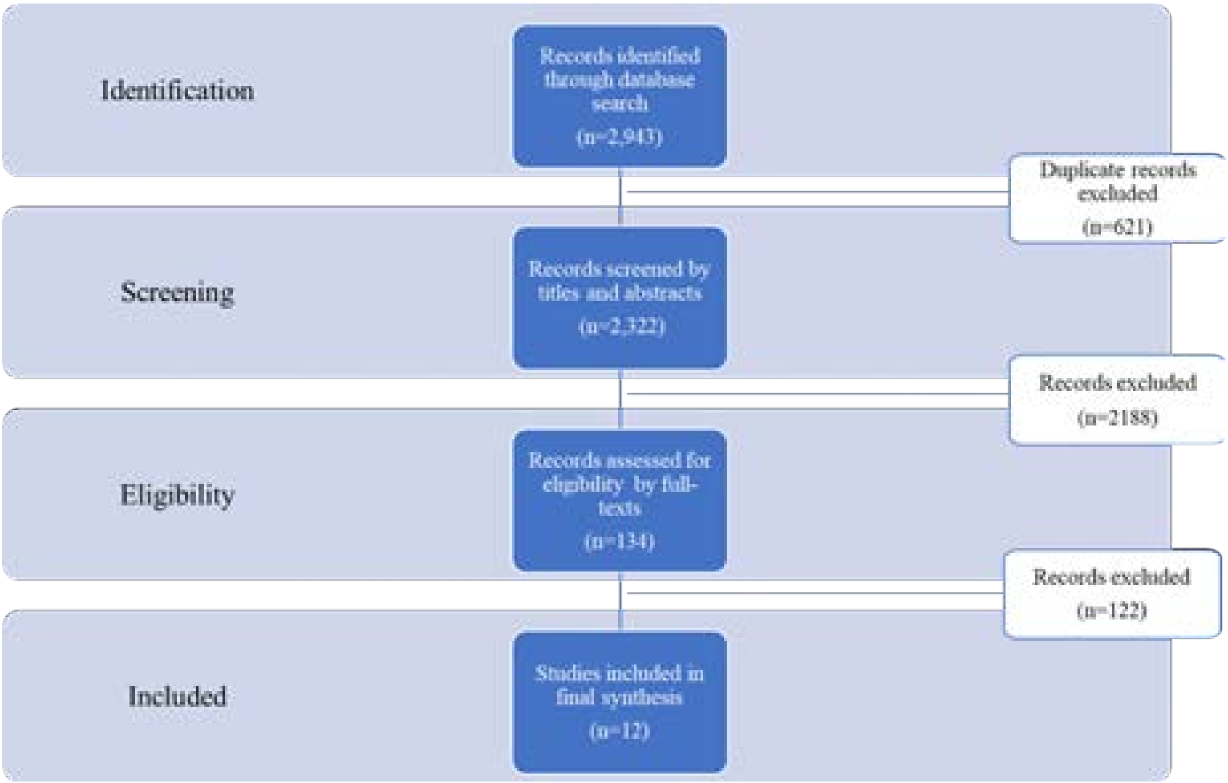
As the interpretive review consisted of a range of evidence (qualitative, quantitative and mixed methods), a thematic analysis (Braun, Clarke, Hayfield & Terry, 2019) was used to explore the impact of innovative learning environments on teacher mind frames. The thematic analysis was a hybrid approach which incorporated both a data-driven inductive approach (Boyatzis, 1998) and the deductive a priori template of codes (Crabtree & Miller, 1999). The hybrid approach preserved an explicit and transparent link between conclusions and the text of the primary studies. As a result, this enabled the researchers to stay 'close' to the results of the primary studies, synthesizing them in a transparent way, and facilitating the explicit production of new concepts and hypotheses. It also preserved the principles—i.e. clearly defined processes and procedures to ensure the review is both systematic and rigorous (Evans & Kowanko, 2000)—that have traditionally been important to systematic reviews. In doing so, the narrative was able to focus on the key research questions articulated at the beginning of the study.

St Columba's College, Hayball Architecture. Dianna Snape photography

Results

The initial database search revealed 2,943 articles after applying filters based on the selection criteria. After removal of duplicates (n=621), 2,322 articles were screened by titles and abstracts, of which 134 articles underwent full-text review. A total of 12 articles were included for final analysis. **Figure 1** illustrates the references yielded during the database and subsequent stages of the review.

Figure 1. PRISMA flow diagram during the systematic review process



Overview of the studies included in the review

The 12 studies were published between 2000 and 2015. Studies were divided between USA (6), Asia (China 1, Malaysia 1, Singapore 1, Taiwan 1) and Australia (2). Their contexts were school settings described as primary, middle and secondary school, or a combination of the above, e.g. K-12 schools. The studies involved teachers either in year level, subject-based, or specialist roles, for example teachers of gifted and talented students.

Of the 12 studies, five undertook quantitative cross-sectional analysis using between one to four survey tools (Bennison & Goos, 2010; Besnoy, Dantzler & Siders, 2012; Che Ahmad, Osman & Halim, 2013; Haney, Wang, Keil & Zoffel, 2007; Scott & Hannafin, 2000). Two studies utilised a survey tool with one or more data collection methods. These included qualitative interviews (Zhang & Liu, 2014), pre-participation essays and online discussion boards (Miranda & Damico, 2015). Five studies (Chen, 2008; Fitzgerald, Dawson & Hackling, 2013; Lim & Chai, 2008; Liu, 2007; Peters, 2010) focused solely on qualitative methods such as observations, semi-structured face to face interviews, focus group of students, journals and document analysis. An overview of all 12 studies is provided in **Table 3.**

Table 3. Overview of studies

No.	First Author, Year, Title	Country	Level & educational context	Innovative learning environment context
1	Bennison, A. (2010) Learning to teach mathematics with technology: A survey of professional development needs, experiences and impacts.	Australia	Secondary	Digital
2	Besnoy, K. D. (2012) Creating a digital ecosystem for the gifted education classroom.	USA	Gifted	Digital
3	Chen, C-H. (2008) Why do teachers not practice what they believe regarding technology integration?	Malaysia	Secondary	Digital
4	Che Ahmad, C. N. (2013) Physical and psychosocial aspects of the learning environment in the science laboratory and their relationship to teacher satisfaction.	Taiwan	Secondary	Physical and Psychosocial
5	Fitzgerald, A. (2013) Examining the beliefs and practices of four effective Australian primary science teachers.	Australia	Primary	Pedagogical
6	Haney, J. J. (2007) Enhancing teachers' beliefs and practices through problem-based learning focused on pertinent issues of environmental health science.	USA	Middle	Pedagogical
7	Lim, C. P. (2008) Teachers' pedagogical beliefs and their planning and conduct of computer-mediated classroom lessons.	Singapore	Primary	Pedagogical
8	Liu, T. C. (2007) Teaching in a wireless learning environment: A case study.	USA	Middle	Pedagogical
9	Miranda, R. J. (2015) Changes in teachers' beliefs and classroom practices concerning inquiry-based instruction following a year-long RET-PL program.	USA	Secondary	Pedagogical
10	Peters, E. E. (2010) Shifting to a student-centered science classroom: An exploration of teacher and student changes in perceptions and practices	USA	Middle	Pedagogical
11	Scott, B. N. (2000) How teachers and parents view classroom learning environments: An exploratory study.	USA	K-12	Pedagogical
12	Zhang, F. (2014) A study of secondary school English teachers' beliefs in the context of curriculum reform in China	China	Secondary	Pedagogical

Method	Teacher measure	Change in teacher measure (Yes/No)	Instruments used
Quantitative	Pedagogical beliefs	No, one point in time.	• School Technology Survey (STS) • Teacher Technology Survey (TTS) (Goos & Bennison, 2008).
Quantitative	Attitude	No, one point in time.	• Perceptions of Computers and Technology survey (PCT) (Hogarty, Lang & Kromrey, 2003).
Qualitative	Pedagogical beliefs	No, one point in time.	N/A
Quantitative	Satisfaction	No, one point in time.	• Physical Science Laboratory Environment Inventory (PSLEI), adapted from the computerized classroom ergonomic inventory (CCEI) (Zandvliet, 1999). • Checklist proposed by the National Science Teachers Association (NSTA) (Motz, Biehle & West, 2007). • Satisfaction Scale (SC) modified from the scale Test of Science-Related Attitudes (TOSRA) (Fraser, 1981). • Science Laboratory Environment Inventory (SLEI).
Qualitative	Pedagogical beliefs	No, one point in time.	N/A
Quantitative	Self-efficacy and beliefs	Yes-Intentional focus on teacher beliefs as part of shift into more constructivist practices.	• Science teaching Efficacy Belief Instrument (STEBI) (Riggs & Enochs, 1990). • Context Beliefs About Teaching Science Instrument (CBATS). Modified from Lumpe, Haney and Czerniak (2000). • Constructivist Learning Environment Survey (CLES) (Taylor, Fraser & White, 1994). • Best Practices Survey (BPS) modified from the Biological Sciences Curriculum Study (1994).
Qualitative	Pedagogical beliefs	No, one point in time.	N/A
Qualitative	Instructional beliefs	Yes, three time points-prior to, early stages, once integrated.	N/A
Mixed	Pedagogical beliefs	Yes- Deliberate focus and shift from teacher-centred to student-centred approaches.	• The Reformed Teaching Observation Protocol (RTOP) instrument (Sawada et al., 2002).
Qualitative	Instructional beliefs	Yes-Increased comfort with student centred methods-The school provided a context to explore this	N/A
Quantitative	Pedagogical knowledge beliefs	No, one point in time.	• Classroom Learning Environment survey (CLE) developed by Heller and Gordon (1992) and Hannafin and Freeman (1995).
Mixed	Extended definition of pedagogical beliefs	No, one point in time.	• Survey of Secondary School English Teachers' Beliefs (QSSETB).

Sampling bias

The Cochrane Collaboration tool assessed the risks of sampling bias. As recommended by Higgins et al. (2011), source of bias was assessed as 'low risk', 'high risk' or 'unclear risk' in the domains of selection, detection, attrition and reporting. The methodology of studies in the final selection of this review had a direct effect on the assessment of sampling bias through the Cochrane Collaboration tool (See **Table 4**). Studies with a quantitative orientation, through their design and sampling processes, moderated various domains of bias. A number of studies (Bennison & Goos, 2010; Besnoy et al., 2012; Che Ahmad et al., 2013; Haney et al., 2007; Miranda & Damico, 2015; Scott & Hannafin, 2000; Zhang & Liu, 2014) employed random selection of moderate to large groups from multi-sites which decreased the incidence of selection bias. Attrition, detection and reporting biases were countered through the application of single self-report, large-scale questionnaires and surveys. The surveys examined the relationship between contextual (i.e. access to resources, digital and physical infrastructure, leadership and school climate) and individual factors (i.e. beliefs, experience, perceptions, professional development experiences and subject-discipline) on teacher pedagogies and utilisation of technologies.

The sampling strategy of the remaining studies, best described as case studies or single-site qualitative studies, had an increased chance of sampling bias. The application of convenience sampling (at a single site) or purposeful small teacher samples, was assessed as 'high selection risk'. That said, the orientation of these qualitative studies sought to provide a deeper understanding of the interaction of contextual and individual factors with teacher pedagogies in a specific setting (i.e. experienced teachers, a focused professional development program or schools with moderate to high technology resources).

Table 4. Assessment of sampling bias of selected studies using the Cochrane Collaboration Tool

First Author (Year)	Selection	Detection	Attrition	Reporting
Bennison, A. (2010)	+	+	+	+
Besnoy, K. D. (2012)	+	+	+	+
Che Ahmad, C. N. (2013)	+	+	+	+
Chen, C-H. (2008)	-	?	+	?
Fitzgerald, A. (2013)	?	+	+	+
Haney, J. J. (2007)	+	?	?	+
Lim, C. P. (2008)	-	+	+	+
Liu, T. C. (2007)	-	+	+	+
Miranda, R. J. (2015)	+	+	+	+
Peters, E. E. (2010)	-	+	+	+
Scott, B. N. (2000)	+	+	+	+
Zhang, F. (2014)	+	+	+	+

Legend: + Low Risk | - High Risk | ? Unknown Risk

Quality

The assessment of internal validity and reliability established the quality of individual studies in this review. The studies in this sample ranged from large-scale quantitative studies in multiple sites to qualitative case studies. Due to this range, elements of common assessment of quality were synthesised, as there was no single approach that best matched this review's focus. Consequently, the internal validity guidelines of Cook and Campbell (1979) were applied to assess the threats of history, instrumentation, maturation and selection along with reliability (measures of internal consistency and inter-rater reliability) as dictated by the COSMIN checklist (Terwee et al., 2012). The review did not assess the quality of methodologies and measures typically found in the COSMIN checklist (typically used to assess large sample, randomized control trials), as these criteria were beyond the scope of the intervention-based design of the selected studies. The application of the COSMIN checklists four-point criterion of "excellent", "good", "fair" and "poor" for both reliability and validity provided an efficient means for establishing the overall assessment quality ("strong", "moderate", "low" and "unknown") of each study's design and measures.

The quality of the selected articles ranged from low to strong, with the majority falling into the categories of low and moderate (**Table 5**). Those articles that were identified with strong quality (Besnoy et al., 2012; Che Ahmad et al., 2013; Miranda & Damico, 2015) were best described as multi-site studies. These studies often had moderate to large sample sizes and included detailed information about the history (i.e. demographic, training, experience, subject discipline and school context) of participants. These studies utilised robust and reliable measures, some triangulated through mixed methods, and accounted for maturation of participants (Miranda & Damico, 2015). Not only were their designs rigorous, but they utilised and reported measures of reliability and internal consistency (typically Cronbach's alpha). Furthermore, these studies reported detailed rigorous statistical analysis that examined the interrelationship between teacher and context variables, and self-reported or observed measures of teacher pedagogical and technological practices (often related to digital technologies, with some focusing on spatial technologies).

Five studies were assessed as having moderate quality (Bennison & Goos, 2010; Haney et al., 2007; Lim & Chai, 2008; Liu, 2007; Peters, 2010). These studies often had rigorous elements to the validity of their design, methods and means of analysis, or application of measures of internal consistency and reliability, but not both. Some were small sample mixed methods studies, which often focused on a single site or context. Others failed to include detailed information about the history (i.e. demographic, training, experience, subject discipline and school context) of participants, or did not utilise or report those statistical processes and reliability measures that were evident in studies of strong quality.

The remaining articles suffered methodological, sampling and statistical deficiencies that lowered the quality of their findings. These studies were typically small sample mixed methods or qualitative studies. Correlation/s between the assessment of their low quality and the higher incidence of sampling bias were symptomatic with these studies, presenting little or no reporting of measures of reliability and internal consistency.

Table 5. The overall score for the quality of selected studies using the COSMIN 4-point checklist

First Author (Year)	History	Instrumen-tation	Maturation	Selection	Internal Consistency	Reliability	Overall Result
Bennison, A. (2010)	Excellent	Good	Good	Excellent	Good	Good	Moderate
Besnoy, K. D. (2012)	Excellent	Excellent	Fair	Excellent	Excellent	Excellent	Strong
Che Ahmad, C. N. (2013)	Excellent	Excellent	Fair	Excellent	Excellent	Excellent	Strong
Chen, C-H. (2008)	Good	Fair	Good	Fair	Fair	Fair	Low
Fitzgerald, A. (2013)	Excellent	Good	Fair	Fair	Good	Fair	Low
Haney, J. J. (2007)	Good	Good	Good	Good	Excellent	Excellent	Moderate
Lim, C. P. (2008)	Excellent	Good	Good	Fair	Good	Good	Moderate
Liu, T. C. (2007)	Good	Excellent	Excellent	Poor	Excellent	Excellent	Moderate
Miranda, R. J. (2015)	Good	Excellent	Excellent	Good	Excellent	Excellent	Strong
Peters, E. E. (2010)	Excellent	Good	Excellent	Fair	Excellent	Excellent	Moderate
Scott, B. N. (2000)	Good	Fair	Good	Excellent	Poor	Good	Low
Zhang, F. (2014)	Good	Good	Fair	Excellent	Fair	Fair	Low

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Discussion

The review sought to establish the existence of any evidence concerning the impact of learning environments on teacher mind frames. As the interpretive review consisted of a range of evidence (qualitative, quantitative and mixed methods), a thematic synthesis was used to combine the studies of the impact of innovative learning environments on teacher mind frames and identify key themes to explore. The narrative critique presented here was based on an analysis of the final selection of 12 studies, centred on two key research questions:

1. How are the key terms 'innovative learning environments' and 'teacher mind frames' defined in the literature?
2. What evidence exists that innovative learning environments have an impact on teacher mind frames?

How are the key terms 'innovative learning environments' and 'teacher mind frames' defined in the literature?

When investigating such complex terrain, a single definition can never truly capture all perspectives. One of the aims of the review was to document how researchers perceived innovative learning environments and teacher mind frames and, therefore, focused particularly on the definitions researchers provided.

Defining Innovative Learning Environments

Although researchers in these studies have situated their research in the field of learning environments, they have done so with very different, although legitimate, definitions. Disentangling the terminology utilized was a formative step in the review process. The considerable number of interpretations of learning environments can be synthesized and categorized as combinations of physical, digital, pedagogical and psychosocial. It was noted in some cases, studies focused on more than one interpretation of learning environments.

Physical

Physical learning environment describes the tangible and objective aspect of the space. Only one study explicitly investigated the impact of the physical environment. Che Ahmad et al. (2013) described the physical environment as consisting of furniture and equipment, space, technology, lighting, indoor air quality and safety aspects. Drawing on previous literature that have explored these factors, Che Ahmad et al. (2013) argued that the physical environment is important and can affect students' and teachers' understanding and behaviour. In particular, the researchers concluded that the physical environment can be regarded as a second teacher in an environment that can motivate students, enhance learning, and reduce discipline problems and undesirable behaviour.

Psychosocial

Che Ahmad et al. (2013) focused not only on the physical environment, but also on the psychosocial aspect. Psychosocial factors tend to focus on the social factors that relate to the learning environment. Exploring the Science laboratory learning environment, Che Ahmad et al. (2013) described the psychosocial environment as consisting of student cohesiveness, rule clarity, open-endedness, integration and material environment. The researchers further argued that a psychosocial environment can be improved through the use of inquiry strategies, which would increase the generation of ideas, active participation and interaction for knowledge acquisition among students (Che Ahmad et al., 2013).

Digital

A number of studies in the review outcomes investigated the impact of the digital environment. Studies that investigated teachers' and students' use of technology in the classroom were not included in this review—they tended to focus primarily on the integration of technology rather than viewing technology as a cohesive part of the broader learning environment.

In order to prepare students to become digital citizens, Besnoy et al. (2012) described the learning environment as a digital ecosystem "that allows for the confluence of student potential and marketplace demands" (p. 306). The researchers defined digital ecosystem as a process-oriented ecological environment that prepare learners to experience, create, and transform knowledge by engaging with a variety of technology applications—a combination of equipment and experiences that allow students to perform and redefine tasks (Besnoy et al., 2012).

Similarly, Liu (2007) described the learning environment as a 'wireless learning environment', which he contrasted with 'ordinary' and 'computer' classrooms. The wireless learning environment is defined as an environment where mobile devices, wireless communications and network technology are wirelessly integrated into learning environments to promote learning motivations and improve student achievements (Liu, 2007). Likewise, the study conducted by Lim and Chai (2008) was situated within a computer-mediated learning environment. The researchers perceived technology as an affordance—the perceived and actual properties of a 'thing' that determine how the 'thing' could be used (Gibson, 1977; Lim & Chai, 2008).

Pedagogical

Most of the studies examined the pedagogical aspect of the learning environment. Bennison and Goos (2010) extended Vygotsky's (1978) concept of the zone of proximal development (ZPD) to incorporate the social setting and the goals and actions of participants. The researchers used pedagogical technology knowledge (Thomas & Hong, 2005)—the integration of knowledge of content and knowledge of technology—to investigate Mathematics teachers' use of technology within the zone of proximal development (Bennison & Goos, 2010).

The constructivist approaches were a focal point for many of the studies. Haney et al. (2007) described the learning environment from a constructivist perspective—consisting of personal relevance, uncertainty, critical voice, shared control and student negotiation. Zhang and Liu (2014) described the pedagogical environment as traditional or constructivist. Constructivist philosophies consisted of student involvement and interactive learning, which bring energy and dynamism to the classroom, compared to the traditional teacher-centred, lecture-based classes (Zhang & Liu, 2014).

Fitzgerald et al. (2013) described the learning environment from a social constructivist perspective, i.e. creating and maintaining engaging and intellectually challenging learning environments that encourages active engagement with ideas. While many scholars investigated technology integration into the physical classroom, Chen (2008) investigated technology integration into constructivist practices of teaching—where teachers designed learning activities to engage students in active problem solving and genuine inquiry.

Scott and Hannafin (2000) used the term 'intentional learning environment' to describe the 'reformed classroom'. Although they extended the concept to include the role of technology, an intentional learning environment was also viewed as student-centred and open-ended. This environment was characterised by a high level of student exploration, highly interactive instruction, student collaboration on authentic and multidisciplinary projects, teachers as facilitators and coach, and predominantly performance-based assessment strategies.

Termed as the student-centred classroom, Peters (2010) defined the learning environment as one where "students can work together to construct knowledge" (p. 330). Practices within the student-centred classroom included strategies such as cooperative learning or research where students generated questions, background information, and possible solutions to the questions such as in inquiry-based discussions (Blanchard et al., 2010). Peters (2010) concluded that the design of the learning environment, including the physical set up of the space, might be the most important factor in successful student-centred classrooms.

In summary, the 12 studies examined in this review focused on four conceptualisations of the term 'learning environments'—physical, digital, pedagogical and psychosocial. In some cases, studies focused on more than one interpretation of learning environments. It is worthy to note that most of the studies focused on the pedagogical aspects of the learning environment. This reinforces the notion that an innovative learning environment is more than just the physical design but should also incorporate innovative pedagogies that, in combination, assist in the best possible learning outcomes and learning skills of students.

Defining teacher mind frames

Research on teachers' thinking and how it impacts on behaviour has had a long history which is interdisciplinary in nature. Reflected in this varied research was the suite of terms that has been used to describe teachers' thinking such as attitudes, values, judgements, beliefs and mindsets. In this set of review outcomes, researchers defined teachers' thinking as variations of teacher beliefs, attitudes or satisfaction.

Pedagogical beliefs— teacher beliefs about teaching and learning—were dominant in many of the studies (Bennison & Goos, 2010; Chen, 2008; Fitzgerald et al., 2013; Lim & Chai, 2008; Miranda & Damico, 2015). Using Guskey's model of teacher change (1986; 2002), which was later adapted by Rogers (2007), Bennison & Goos (2010) argued that teachers change their attitudes and beliefs, and consequently practices, when student learning has changed. This is similar to Hattie and Zierer's (2017) mind frames that see assessment as informing teachers' impact and next steps. Fitzgerald et al. (2013) also highlighted the cyclical nature of teachers' beliefs. The researchers argued that teachers' beliefs impacted on classroom behaviours and practices, and in turn classroom behaviours and practices continuously influenced the development of teacher beliefs (Fitzgerald et al., 2013).

Other studies extended the definition of beliefs to include more than just beliefs about teaching and learning. Scott and Hannafin (2000) defined teacher beliefs as beliefs about how knowledge was constructed and how content should be covered. Additionally, Liu (2007) discussed teachers' instructional beliefs as those that "reflect their own implicit theories and assumptions about the students, the subjects they teach, the teaching approach, and their teaching responsibilities" (p. 108), which were often considered to play an essential role in classroom practices. Utilising a naturalistic inquiry case study, Peters (2010) gathered data on one teacher's beliefs about her role as a teacher and her students' role within the environment. This was similar to Liu's (2007) definition of instructional beliefs which focused on theories and practices of students and teachers.

Zhang and Liu (2014) advanced Phipps and Borg's (2009) broad definition of beliefs as ideas and propositions that teachers held about all aspects of their work, which could exert a strong influence on teachers' pedagogical decisions, instructional practices, and professional development. The researchers found teacher beliefs to be multi-dimensional and could exist without undue conflict as they related to different teaching contexts and served different purposes (Zhang & Liu, 2014).

Haney et al. (2007) described both teachers' self-efficacy and beliefs about the learning environment. Teacher beliefs consisted of *enable beliefs*, the degree that identified factors enabled them to be effective; and *likelihood beliefs*, the likelihood that those factors will occur. Self-efficacy consisted of teachers beliefs about their ability to be effective teachers, and outcome expectancy, i.e. teacher beliefs about whether students could learn if effective teaching took place.

Two other studies investigated teachers' attitude and satisfaction. In their study, Besnoy et al. (2012) did not provide an operational definition of teacher attitude. The researchers, however, found that teacher attitude towards technology was necessary for teachers of the gifted to create a digital ecosystem learning environment (Besnoy et al., 2012). Che Ahmad et al. (2013) discussed teacher satisfaction as a factor that affected teaching and learning practice. The researchers argued that the (physical and psychosocial) learning environment could have an impact on teacher satisfaction, which in turn impacted on their attitudes to change their practices (Che Ahmad et al., 2013).

In summary, most studies examined in this review focused on teacher beliefs, which in general terms can be broadly defined as the tacit, often unconsciously held assumptions about students, classrooms, and the academic material to be taught (Kagan, 1992). In combination, teacher mind frames can then be defined as the ways in which teachers consciously think about their teaching roles, the content and pedagogical knowledge necessary for teaching. This, in turn, impacts on their attitudes, actions and decisions that are likely to have significant impacts on student learning.

What evidence exists that innovative learning environments have an impact on teacher mind frames?

The papers are divided into two broad groups: those that conducted cross-sectional studies, predominantly utilising (single or multiple) survey instruments to collect data on teacher positioning, and those that used longitudinal or repeated measures, and were consequently designed to find repositioning in teacher thinking (or practice). Although the cross-sectional studies lacked the benefit of discerning change over time, the results often highlighted relationships, reported on conditions or antecedents required for change and identified potential barriers. Also, the studies frequently utilised regression modelling to draw comparisons. Within the longitudinal studies, the change in teacher mind frames was sometimes the primary objective – at other times, an incidental finding. Consequently, the discussion in this section is organised into three subsections: positioning studies, repositioning studies and antecedent for desired change.

Studies with a 'positioning' focus

Positioning studies are those that measure teacher mind frames at one point in time. Except for Chen (2008), Fitzgerald et al. (2013) and Lim and Chai (2008), who used qualitative methods and Zhang and Liu (2014), who used a mixed method, all other studies in this sample (Bennison & Goos, 2010; Besnoy et al., 2012; Che Ahmad et al., 2013; Scott & Hannafin, 2000) used a variety of quantitative survey instruments to investigate the impact of learning environments on teachers.

Besnoy et al. (2012) used linear modelling to assess relationships between variables employed but did not report effect size. In the context of gifted education, the researchers investigated teachers' efficacy regarding the environmental conditions that were required before they would integrate

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technology into their practice. The study, from a moderate sample of teachers (n = 242), identified that personal use, professional development, attitude and infrastructure were the most significant predictors of computer integration. The impact of personal use of technology explained 18.5% of the variation in technology integration rates (Besnoy et al., 2012).

In their study, Che Ahmad et al. (2013) sought to establish the relationship between teachers' perceptions of the Science laboratory environment and satisfaction from teaching and learning. From a large-scale survey (n = 800), the researchers found that six variables correlated significantly with the level of teachers' satisfaction from teaching and learning in the Science laboratory. These six variables—material environment, integration, rule clarity, air quality, student cohesiveness, and safety aspects—were found to be strong predictors of teachers' satisfaction from teaching and learning Science in the laboratory with a significant level of $p < 0.05$. The regression modelling explained 53.0% of the variation in teachers' satisfaction from teaching and learning in a Science laboratory ($R2 = 0.530$). Of all the variables, material environment, described as "the extent to which the laboratory equipment and materials are adequate" (Che Ahmad et al., 2013, p. 374), made (by far) the largest contribution, accounting for 43.5% of the variance. Five other variables (furniture and equipment, space, lighting, technology, and open-ended nature of tasks) were not correlated with teachers' satisfaction.

Scott and Hannafin (2000) investigated teachers' (and parents') beliefs across dimensions of the classroom learning environment. The researchers' sample of teachers (n = 132) were asked to respond to the Classroom Learning Environment (CLE) measure of teacher beliefs along a continuum from "consistent with the traditional classroom", to "consistent with the reform classroom". The researchers used multivariate analysis of variance (MANOVA) to analyse mean CLE scores for four component measures (pedagogy, knowledge, content, and student role). The results indicated that teachers reported beliefs about the classroom learning environment was noticeably different from parents in areas of content and knowledge. Teachers' beliefs were not found to relate to years of teaching experience. However, teachers' beliefs were found to relate to the year level that teachers taught, with kindergarten teachers' pedagogical beliefs more consistent with a reformed classroom and high school teachers' beliefs more consistent with more traditional views. Views became more traditional as the student year level increased (Scott & Hannafin, 2000).

Bennison and Goos (2010) used the School Technology Survey (STS; n = 89) and Teacher Technology Survey (TTS; n = 485) to investigate the professional development experiences and needs of Mathematics teachers in Queensland secondary schools. Teachers who had participated in professional development were found to be more confident in using technology and were also more convinced of its benefits in supporting students' learning of Mathematics. Experienced, specialist Mathematics teachers in large metropolitan schools were more likely than others to have attended technology-related professional development. Teachers expressed lack of time and limited access to resources as hindrances to attending and a clear preference for professional development that helped them to integrate technology into lessons (Bennison & Goos, 2010).

Chen (2008) investigated technology integration into constructivist practices of teaching—a space where teachers designed learning activities to engage students in active problem solving and genuine inquiry. Drawing on data from observations, documents and interviews, the researcher found that teachers' beliefs played a significant role in technology integration within a pedagogical space. High stakes examination, which emphasise "competition over collaboration" play a big role in encouraging "passive learning" and teachers reverting to "old methods" that are lecture-based, teacher-centred instruction (Chen, 2008, p. 72).

Situated within a computer-mediated learning environment, Lim and Chai (2008) observed and interviewed six teachers from two primary schools in Singapore. Aligned to Chen's (2008) findings, they found that inconsistency between teachers' pedagogical beliefs and teacher-centric practices were due to assessment regimes that prevented teachers from engaging in more constructivist teaching practices. Lim and Chai (2008) suggested the need for "cognitive restructuring" (p. 826) through opportunities for teachers to contrast constructivist experiences with traditional teaching and learning activities. This may lead to teachers adopting new practices that were consistent with their pedagogical beliefs.

For Fitzgerald et al. (2013), teachers' beliefs as well as the contextual factors in the learning environment were key to why teachers taught Science the way they did. The researchers' case study of teachers in Western Australian primary school (n = 4) drew attention to the environmental aspects that helped create stimulating space for students. The authors utilised the status and quality of teaching and learning Science in Australian schools (Goodrum, Hackling & Rennie, 2001) to classify ways of enhancing Science teaching, which included "the teaching-learning environment is characterised by enjoyment, fulfilment, ownership of and engagement in learning and mutual respect between the teacher and students", and "excellent facilities, equipment and resources support teaching and learning" (Fitzgerald, et al., 2013, p. 985). Using classroom observations and semi-structured interviews, the researchers found six key themes that impacted on primary school Science teachers' effective teaching practice. These themes included classroom learning environment, conceptual knowledge and procedural skills, teaching strategies and approaches, student-specific considerations, teacher-specific considerations, and context-specific considerations (Fitzgerald et al., 2013).

Using a mixed-methods design, Zhang and Liu (2014) set out to investigate the beliefs of English language junior high school teachers in regards to their their teaching and learning within a pedagogical environment that could be considered traditional or constructivist. Drawing on data from surveys and interviews, the researchers found that while teachers favoured a constructivism-oriented pedagogy, they still held on to traditional pedagogies focusing on drill and practice, rote memorisation and teacher authority. A variety of contextual factors were found to exert a strong influence on teacher beliefs such as the Confucian culture, curriculum reform and school environment. Like Chen (2008) and Lim and Chai (2008), high stake achievement tests had a significant influence on beliefs of teachers (Zhang & Liu, 2014).

Studies with a 'repositioning' focus

Four studies utilized longitudinal approaches to ascertain change over time (Haney et al., 2007; Liu, 2007; Miranda & Damico, 2015; Peters, 2010). Of these, only one (Haney et al., 2007) reported effect sizes. Liu (2007) and Peters (2010) used qualitative methods to assess teacher beliefs at three points in time.

Haney et al. (2007) described a study of teacher beliefs and classroom practices in the context of Environmental Health Science. The study measured changes across a two-year period surrounding the intervention of a professional learning program (Project EXCITE), reporting effect sizes that ranged from d= -0.16 to d= -0.83 across four instruments (CBATS, STEBI, CLES and BPS). Results showed that teacher levels of self-efficacy and level of reform-based practices, including interdisciplinary, inquiry-based, hands-on, cooperative, problem-based, teaching for depth of student understanding, assessing performance-based tasks, and contextualized learning, increased during the professional learning (Haney et al., 2007). The study was assessed as being of moderate quality, with excellent internal consistency and reliability, and good history, instrumentation, maturation and selection.

Miranda and Damico (2015) examined how engaging 14 (highly-qualified) Science teachers in a summer Research Experiences for Teachers (RET) program, followed by a year-long Professional Learning Community (PLC) looking at inquiry-based pedagogies, supported change in beliefs and practice regarding inquiry-based and student-centred approaches in the classroom. The study focused on initial and changing beliefs about inquiry-based instruction, as well as accompanying changes in classroom practice. Miranda and Damico (2015) used qualitative methods alongside the Reformed Teaching Observation Protocol (RTOP) instrument (Sawada et al., 2002) pre- and post-participation to collect data about teachers' use of inquiry-based methods, as well as to document change. Although the researchers found that there was a considerable shift in some items on the RTOP instrument after a year, in particular increasing levels of active participation and becoming better listeners, only half of the teachers (7 out of 14) shifted in their beliefs about their instructional practices from a teacher-centred approach to a more structured-inquiry or guided-inquiry approach. Furthermore, despite the RET-PLC program being sustained over a year, for the most part, classroom practice did not shift from teacher-centred to more student-centred reform-oriented practice (Miranda & Damico, 2015). This was evident in the higher-level Science courses that are heavily reliant on Mathematics.

Liu (2007) investigated teacher beliefs, classroom routines and mobile and wireless technology infrastructure as factors in enhancing student-centred learning. Liu (2007) drew attention to studies that highlight inconsistencies between teachers' beliefs and their practice (instructional routines). A case study was conducted in a Mathematics class of sixth-grade students in Taiwan taught by an experienced teacher with basic IT skills who considered IT would be useful in education. Qualitative data was collected through classroom observation, interviews with the teacher, instructional documents, student interviews and student journals recording their views on the learning activities and their mood. Data was collected in three phases: before wireless technology was introduced (8-week period), a 4-week implementation phase during which training was undertaken by the teacher and students on the use of the wireless applications and after the wireless technologies were incorporated. In particular, researchers observed expert teacher demonstrations on the functionality, implementation of collaborative learning activities and design of instructional materials for collaborative activities. The results from the Liu (2007) case study showed a mismatch between the teacher's instructional beliefs regarding student-centred learning and his classroom practice both before and after the wireless technology was introduced. Student attitudes were initially positive, but a lack of change in instructional routines resulted in disappointment and a negative change in behaviour. This reciprocal effect, in turn, affected the teacher and his instructional behaviour negatively. Liu (2007) concluded that teachers need to be guided to implement student-centred approaches gradually to avoid teachers becoming stressed and retreating to their traditional practices.

Peters (2010) collected data on one teacher's beliefs and perceptions. The case study teacher (in her second year of practice) was acknowledged as having an interest in innovative approaches to learning, which prompted her move to the new school. The study presented data on the teacher's capacity to scaffold students, adapt her practice, and provide appropriate levels of challenge in her lessons. Among the findings were examples of her increased cognisance of the classroom as a place where error-making was considered an opportunity, one that allowed students to be meta-cognitively engaged in learning, and to have some choices available to them. Peters (2010) concluded that the design of the environment may have been the most important factor in the success of student-centred classrooms. Over time, changes to the teacher's pedagogical approach had reflected her predisposition and beliefs about teaching and learning, although these changes could not be attributed directly to school or classroom factors.

Studies that identified antecedents for desired change

Antecedental factors broadly illuminate a range of diverse 'drivers' behind the perceived need for change in teacher thinking when related to learning environments. Some of these could be determined to be push factors, (often) experienced externally (and hierarchically) by teachers. Others were pull factors, where teachers were drawn towards reform through aspects of their practice. In these studies, both these factors—identified at national, local, as well as individual levels—were considered as triggers for the need to understand the impact of learning environments on teacher mind frames.

The requirement for teachers to play a pivotal role in large-scale policy implementation formed a central theme to many of the antecedents, particularly when addressing digital initiatives. The Educational Reform Action Program by the Taiwan Ministry set the context for Chen's (2008) study. The researcher discussed the Information Education Infrastructure and the Blueprint of Information Education in Elementary and Junior High Schools (Taiwan Ministry of Education, 2011) as the driving force for building technology literacy of all its citizens. Bennison and Goos (2010) discussed the implementation of the Mathematics curriculum policy in the various states and territories of Australia that permit, encourage, or in some cases, require the use of digital technologies in secondary school Mathematics curriculum. Additionally, the English Curriculum Standards implemented in China provide the impetus for the shift of emphasis from a teacher-centred to a student-centred approach to curriculum and pedagogy, from knowledge transmission to knowledge construction (Zhang & Liu, 2014). Likewise, Scott and Hannafin (2000) deliberated on the educational reforms in the United States that have been met with resistance by teachers and other stakeholders.

The idea of theoretical agreement contrasting with practice on the ground becomes a familiar theme as an antecedent to research. In the context of foreign language teaching in China, Zhang and Liu (2014) reported a reform agenda that constituted a significant departure from the traditional teacher-centred and behaviourism-oriented approach. The idea that teachers were to act as 'agents of change' meant that they needed to "incorporate reform ideas into their belief systems before they can make changes in their teaching practice" (Zhang & Liu, 2014, p. 188). Their analysis suggested that teachers found themselves on a difficult middle-ground but with a 'multi-dimensional belief system' that allowed them to integrate the two ideas. As Zhang and Liu (2014) concluded:

> *"Teachers are sensible, practical and flexible beings: they adopt a selective strategy and seek a middle ground that fits best the local context and their own comfort zone." (p. 200)*

Studies were often prompted by the introduction of new affordances to the learning environment such as ICT (Bennison & Goos, 2010; Besnoy et al., 2012; Chen, 2008; Lim & Chai, 2008; Liu, 2007), the operationalisation of a new curriculum element (Zhang & Liu, 2014), or adoption of an alternative pedagogical approach (Haney et al., 2007; Miranda & Damico, 2015; Peters, 2010). Additionally, some of these represented initiatives being introduced to schools (Besnoy et al., 2012), or teachers shifting to a school where the practice was embedded (Peters, 2010). Moreover, these initiatives were being undertaken on a variety of scales—in some cases, identified as shifts in national educational policy, while in others, interventions were at a local- or teacher-level.

The review sought to identify quality empirical evidence that helped to explain how teacher mind frames might be influenced by the types and use of learning environments within which teachers taught. In summary, the following trends emerged.

It was possible, through inference, to identify the existence of some overlaps between the 'materiality' of teachers' work spaces and teaching 'satisfaction', but in these studies this was rare, tangential, and did not inform a valid research phenomenon. Teachers mind frames did not correlate to space, but this was predominately due to the fact the learning environment was rarely cited as a variable being investigated.

Perhaps the most consistent message concerned the perceived gap between so-called traditional versus constructivist learning/teaching approaches. The studies highlighted that teachers supported a constructivist approach (and this could be read as the pursuit of deep learning) but found that this conflicted (perceived or otherwise) with the priority of senior-level assessment scores, and disjuncture with established school assessment regimes.

Consequently, one of the factors that were commonly associated with teachers altering their mind frames included overcoming limits of assessment regimes. Others included appropriate professional development, the power of established views of quality teaching and their relevance to personal values and time, resources and opportunity to consider and challenge established thinking through new ideas and approaches. Another factor was the power of positive experiences. With these came empowerment, a sense of fulfillment, enjoyment in teaching, and mutual respect.

Longer-term (re-positional studies) aligned with the points made above, with the following additions. Professional learning over time positively affected changes in teacher beliefs about quality teaching. One effect was wider acceptance of the usefulness of student-centred learning, and the importance of deep learning characteristics, but this wider acceptance did not necessarily transfer to changes in their actual practices. There was a subject-discipline trend in such findings – for example more 'linear' subjects (such as Mathematics) resisted moves towards more student-centred teaching/learning approaches.

In short, factors that impacted teachers to 'reposition' themselves in terms of recognising the need for a change in beliefs were varied, but items such as professional development, time to consider change, and support during that process was consistent amongst the studies. Changes in beliefs did not always transfer to changes in practices. There was very limited evidence that the design/usefulness of the learning

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Conclusion

The aims of the review were two-fold. First, to delineate the definitions of the innovative learning environments and teacher mind frames as provided by the studies. The second was to identify what empirical evidence exists that assess the impact of innovative learning environments on teacher mind frames. In terms of a broader analysis of the studies selected within this review, the following trends were identified.

There was a disappointingly low volume of quality studies. What the review considered to be quality research concerning the connection between teacher mind frames and learning environments was limited to 12 papers published since 1960, of which seven reported a statistical effect. Of these, four utilised longitudinal measures to evaluate change over time, with only one (Haney et al., 2007) reporting effect sizes. Studies were prompted by the introduction of new learning affordances, such as ICT. These push and pull factors provide a trigger for a change in teacher mind frames—the conscious adoption of new curriculum, or review and re-imagining of professional beliefs about their teaching roles, the content and pedagogical elements—in sum, connected by broad or local scale reform agendas seeking a shift towards student-centric practices.

The studies that met the review's search criteria included qualitative, quantitative and mixed methods research, and ranged in scale from a single person study to large-scale randomised designs. The samples ranged considerably (from 1 to 800) across primary and secondary schools, and selected teachers according to the year level they instructed, the subject they taught, or based on their specialist roles. The smaller studies tended to present a deeper understanding of the interaction of contextual and individual factors with teacher pedagogies in a specific setting (i.e. experienced teachers, a focused professional development program or schools with moderate to high technology resources). The latter examined the relationship between contextual (i.e. access to resources, digital and physical infrastructure, leadership and school climate) and individual factors (i.e. beliefs, experience, perceptions, professional development experiences and subject-discipline) on teacher pedagogies and utilisation of technologies. Of the 12 studies, the review identified eight described as utilising survey instruments to collect data on teacher positioning, specifically measuring teacher mind frames at one point in time. These studies tended to locate predictors, and highlight hindrances impacting on teachers' practices and beliefs. In contrast, four of the studies were described as relating to teacher repositioning in that they documented changes in belief and practice over time. Variations were measured using pre- and post-intervention data. They focused particularly on the transition to more 'student-centric' models of teaching and learning, and evaluated change caused through professional learning programs, professional inquiry or enhanced access to technology. The review determined repositioning focused studies highlighting change in teacher beliefs, did not necessarily translate to change in practice.

There were poor links established between teachers' thinking, quality learning, and the environment within which this occurred. Cognitive characteristics of teachers, the way they make decisions, behave, and practice, has been shown to have significant bearing on student learning (Clark & Yinger, 1977; Hattie, 2012), yet the evidentiary relationship between this, and the environment in which it takes place, remains elusive. This constitutes a significant parallel to the dominant discourse, which has sought to establish connections between learning environments and outcomes for students (Byers et al., 2018). As such, it presents a critical dimension demanding fuller understanding, especially given the premise that the development of innovative learning environments in isolation, without parallel attention given to practice, is unlikely to lead to meaningful and sustainable change (Byers, 2014).

There was high variability in definitions. A significant challenge for reviewers was terminological disentanglement surrounding the range and variability in definitions used to describe both learning environments and teacher mind frames. In terms of learning environments, the breadth of interpretations meant that research frequently focused on one, or a combination of, physical, pedagogical, psychosocial and digital aspects. Within these areas, studies focused on how a particular environmental feature was perceived to extend or create opportunities (for example, quality of environment, adoption of problem-solving, inquiry, or constructivist approaches, and cooperative learning), or afford changing parameters (particularly through the use of ICT) in which to learn and teach. Significantly, only one of the studies (Che Ahmad et al. 2013), explicitly investigated the physical features of learning environments; the majority focused on psychosocial, digital or pedagogical aspects, and only tangentially referred to physical space. Furthermore, where changes to learning environments were demonstrated (for example Peters, 2010), they were done within the confines of a traditional classroom. None of the reviewed studies referenced the idea of more significant changes, such as those indicated through the notion of an innovative learning environment (OECD, 2013) and flexible learning spaces (New Zealand Ministry of Education, 2011). The review found that the term 'learning environment' was multifarious, inconsistent, and conditional on the aspect in focus.

Where *teacher mind frames* were concerned, the general focus was on beliefs, although also often connected with attitudes, values, judgements, perceptions, mindsets and satisfaction. Certainly, this was an issue for the reviewers, requiring significant discussion about the inclusion and exclusion criteria - consistent with Pajares' (1992) view of teacher beliefs as a 'messy construct'. Many of the beliefs examined were consistent with Hattie's (2012) teacher mind frames concept that they were "evaluators, change agents, adaptive learning experts, seekers of feedback about our impact, engaged in dialogues and challenge, and developers of trust" (p. 159). In the case of Peters (2010), this was indeed the situation—with the focus on a teacher with an acknowledged interest in innovation, and a desire for her students to be more comfortable in error-making and more meta-cognitive, and for herself to be more comfortable to provide appropriate challenge and scaffolding them. In other studies, however, it is clear that the driver was more extrinsic, pushed by broader policy initiative. There are clearly tensions between reform policy and more traditionally valued educational outcomes, as highlighted in Chen (2008) and Zhang and Liu (2014).

Change was hard to sustain. The studies illustrated increases in teacher efficacy and reform-based practices following long-term professional learning programs. However, initial changes in beliefs were not sustained, and other schooling factors diluted changes in beliefs. In other words, while teachers believed in change, they did not act on it. Gradation and duration of intervention is an important consideration in order to minimise negative experience and retreat to default practice.

The review set out with one overall objective—to establish what empirical evidence exists that assesses the impact of innovative learning environments on teacher mind frames. The paucity of studies investigating aspects of the way that teachers consider their work and the physical learning environment they conduct it in was strongly evident. Methodologically, the review found a lack of longitudinal or repeated measures studies. Few studies made the relationship between beliefs and practices – often just focusing on the beliefs. These absences indicate significant gaps in the literature and a massive opportunity for future inquiry.

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