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Curriculum Alignment After Reforms: A Systematic Review with Considerations for Queensland Pre- and In-service Teachers

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Abstract: This systematic review synthesises research on curriculum alignment to suggest considerations for the implementation of the Senior secondary curriculum reform in Queensland, Australia. It focuses on the coherence of cognitive skills in the prescribed and enacted curriculum as these are typically the least aligned curriculum components. Search methods, which followed the PRISMA model, resulted in 108 relevant articles for qualitative synthesis. Results show that alignment after curriculum reforms is typically low. The use of educational taxonomies can support curriculum alignment. Marzano and Kendall's (2007) New Taxonomy of Educational Objectives underpins the new Queensland Senior secondary syllabi which, in line with other Australian policy, encourage the explicit teaching of cognitive skills. Research is needed on the enacted cognitive skills curriculum in Queensland and its alignment with the reformed prescribed curriculum. To promote the successful implementation of the new Queensland Senior system, pre- and in-service teachers could engage with the New Taxonomy and best practice for teaching cognitive skills.

Introduction and Context

A major curriculum reform has taken place in Australia, namely the introduction of Queensland's new Certificate of Education (QCE) (QCAA, 2017a). Since 2019, Queensland's secondary teachers are implementing new syllabi for Senior secondary subjects and are preparing students for external assessments in subjects leading to tertiary study pathways (QCAA, 2018b). The goal of the new QCE is to advance Queensland's current Senior secondary assessment and tertiary entry procedures (QCAA, 2018b).

The implementation of the new syllabi means that teachers need to be expert at understanding and ensuring that curriculum alignment takes place in their classrooms. Curriculum alignment is the coherence between all components of an educational system, particularly between (1) learning objectives, (2) assessment and (3) teaching (Anderson, 2005). These three curriculum components are inconsistently referred to in the body of literature. Thus for the purpose of this review, learning objectives written by an educational authority for use in schools are defined as the 'prescribed curriculum', knowledge and skills in summative assessment tasks as the 'assessed curriculum', and teachers' classroom instructions as the 'enacted curriculum'.

Curriculum alignment can affect student outcomes. High alignment between the prescribed, assessed and enacted curriculum provides students with appropriate and sufficient opportunities to achieve learning objectives, it improves the validity of assessment tasks and

increases educational accountability (Anderson, 2005; FitzPatrick, Hawboldt, Doyle, & Genge, 2015; Ziebell & Clarke, 2018). Students have a clear idea of the direction of their learning when learning goals, instructions and assessment items are consistent (Blumberg, 2009). Hence it is not surprising that a positive relationship has been reported between curriculum alignment and student achievement (Kurz, Elliott, Wehby, & Smithson, 2010). When content or skills of certain learning objectives are omitted in assessment or classroom teaching, a course is misaligned. An imbalance of emphasis given to particular objectives in classroom instructions or the assessment also leads to misalignment (Porter, 2004). Failure to identify poor alignment could lead to low student performance when classroom instructions do not match the assessment, or to invalid results when the assessment does not align with learning objectives (Anderson & Krathwohl, 2001). Teacher effectiveness may also be decreased or misjudged if classroom instructions are poorly aligned with national standards or external assessment (Anderson, 2005).

Studies examining alignment have been conducted extensively in the USA after the implementation of the No Child Left Behind Act in 2001 and its standard based accountability system (Ziebell & Clarke, 2018). During this time, various methods of measuring the degree of curriculum alignment have been developed, most notably Webb's Alignment Method (1999, 2002), the Achieve Method (Resnick, Rothman, Slattery, & Vranek, 2004) and Porter's Survey of Enacted Curriculum (2002). The first two methods focus exclusively on alignment between the prescribed and assessed curriculum, whereas the third method can be used to measure alignment of teacher instructions.[1]

To assess or measure curriculum alignment, information in the prescribed, assessed and enacted curriculum needs to be coded into a common language to allow for comparisons (Ziebell & Clarke, 2018). Commonly, this is done on two dimensions, knowledge types and cognitive skills, which are then categorised using educational taxonomies (Anderson, 2002; Blumberg, 2009). There is a long list of currently used educational taxonomies, each with its own theoretical framework for cognitive skills (see Moseley, Elliott, Gregson & Higgins, 2005 and DeKock, Sleegers & Voeten, 2004). Anderson and Krathwohl (2001), the authors of the widely used Revised Bloom's Taxonomy, recommend that, ideally, each discipline should have its own taxonomy of objectives in its own language.

Studying alignment is particularly important during the transition to a new curriculum to evaluate the success of reform efforts (Edwards, 2010). After policy and syllabus changes, there may be large gaps between the new prescribed, assessed and the enacted curriculum (Akar, 2014; Fenwick, 2018). The effective alignment of curriculum, assessment and pedagogy is worthy of exploration for both practicing and pre-service teachers as it can inform teaching practice by improving teachers' understanding of assessment processes and the intentions of curriculum documents (La Marca, Redfield, & Winter, 2000; Shalem, Sapire, & Huntley, 2013). In short, understanding curriculum alignment can support teachers in making improvements to their planning, teaching and assessment (Martone & Sireci, 2009).

A Stronger Focus on Cognitive Skills

Queensland's curriculum reform shifts curricular priorities toward the development of students' cognitive skills. The Queensland Curriculum and Assessment Authority (QCAA), a

[1] For a comprehensive review and evaluation of these measures please refer to Martone and Sireci (2009) as well as Cizek, Kosh, and Toutkoushian (2018).

statuary body of the Queensland Government, has chosen Marzano and Kendall's (2007) New Taxonomy of Educational Objectives as the framework for their new Senior secondary syllabi. Each new syllabus adopted the taxonomy's terminology and classification of cognitive skills required to teach and understand the content. Furthermore, each learning objective in the new syllabi begins with a cognitive verb describing the depth at which students will be required to demonstrate their knowledge during assessment (QCAA, 2018a). Using the same taxonomy for all subject areas ensures consistency of language about cognitive skills and assists in teaching of specific cognitive skills. This is important because, as Schnotz (2016) notes, students who are familiar with the language of the cognitive skills can more accurately judge the difficulty level or mental effort required to learn content and make appropriate decisions about how to study.

The New Taxonomy builds on Bloom's (1956) Taxonomy, one of the most-widely used educational taxonomies. Bloom's Taxonomy was developed by a committee of American college and university examiners and describes six levels of cognitive skills: knowledge, comprehension, application, analysis, synthesis and evaluation. These levels are hierarchical with difficulty of cognitive skills increasing as skills are developed from lower to higher levels (Bloom et al., 1956). As understanding of the development of cognitive skills and student-centred approaches to learning increased in popularity, a group of cognitive psychologists, curriculum theorists, instructional researchers and assessment experts developed the Revised Bloom's Taxonomy (Anderson & Krathwohl, 2001). The structure of the Revised Bloom's Taxonomy is two dimensional with six types of cognitive skills on one dimension acting on four types of knowledge on the other dimension. The purpose of Bloom's Taxonomy stems from the construction of test items in tertiary education, whereas the Revised Bloom's Taxonomy is designed to improve the alignment of curriculum, instruction and assessment at all grade levels (Anderson & Krathwohl, 2001). Thus, the focus has shifted from student performance to student learning.

Research and discussion about the ideal classification of cognitive skills and knowledge continued and in 2007, Marzano and Kendall published the New Taxonomy of Educational Objectives. Like the Revised Bloom's Taxonomy, the New Taxonomy separates knowledge (the objects) from cognitive skills (the process). It describes three types of knowledge:

1. information, such as details, terms, facts, principles, or generalisations;
2. mental procedures, such as processes like writing and reading, following rules, tactics, or solving algorithms;
3. psychomotor procedures, such as physical procedures like movement, manual dexterity, speed or strength.

Cognitive skills used to learn all three forms of knowledge are organised into four levels, which together comprise the cognitive system:

1. retrieval: activation of knowledge by recognising and recalling information;
2. comprehension: storing knowledge in permanent memory by integrating and symbolising information;
3. analysis: reasoned extension of knowledge by matching, classifying, analysing errors, generalising or specifying;
4. knowledge utilisation: accomplishing a task by decision making, problem-solving, experimenting or investigating.

Higher cognitive levels are said to require greater intentionality of thinking than lower levels (Toledo & Dubas, 2015). Decision making, for instance, requires more conscious thought and awareness than recalling information, which is often executed automatically (Marzano & Kendall, 2007). Notably, "problem solving" has been added to the New

Taxonomy. Considering that problem solving has been shown to substantially increase student achievement (Hattie, 2008), this seems to be a valuable addition.

Marzano and Kendall (2007) argue that learning is a function of more than cognitive skills and knowledge. They recognise the influence of a student's 'self' intentionally choosing to learn and to control the learning process. Thus, in the New Taxonomy, the cognitive system is influenced by two further systems, the self-system and the metacognitive system. The self-system describes students' beliefs and emotions about the importance of knowledge and their own efficacy. It includes students' decision to engage in learning. The metacognitive system describes students' learning goals and students' strategies to monitor and accomplish those goals (Marzano & Kendall, 2007). Table 1 conceptualises the new model.

Levels of Processing	**Domains of Knowledge**		
	Information	Mental Procedures	Psychomotor Procedures
Level 6: Self-system			
Level 5: Metacognitive System			
Level 4: Cognitive System – Knowledge Utilisation			
Level 3: Cognitive System - Analysis			
Level 2: Cognitive System - Comprehension			
Level 1: Cognitive System - Retrieval			

Table 1: Levels of processing and knowledge domains of the New Taxonomy
Adapted from *The new taxonomy of educational objectives* (2nd ed.), by R. J. Marzano and J. S. Kendall, 2007, Thousand Oaks, CA: Corwin Press.

The use of the New Taxonomy as framework for the reformed QLD syllabi suggests a stronger emphasis on pedagogy which equips students with a wide range of cognitive skills. Each syllabus explicitly states in the Teaching and Learning Section that "Students are required to use a range of cognitive processes in order to demonstrate and meet the syllabus objectives" (QCAA, 2018d, p. 5). The explicit choice of a cognitive skills framework is a response to a report identifying a list of "shortcomings" (p.59) in Queensland's previous system (Matters & Masters, 2014). The authors recommended to include an increased focus on twenty-first century skills, such as problem solving and creativity, in the Senior secondary curriculum.

Aims

This paper reviews literature on curriculum alignment after educational reforms with the aim to apply findings to the Senior secondary curriculum reform in Queensland, Australia and to propose considerations for practice and pertinent future research. Prior findings of alignment studies repeatedly indicate that cognitive skills are the weakest aligned curriculum component and that only a limited range of cognitive skills outlined in learning objectives are usually taught and assessed (Blumberg, 2009; Boesen et al., 2014; Contino, 2013; El Hassan & Baassiri, 2019; Liu & Fulmer, 2008; Resnick et al., 2004; Webb, 1999; Ziebell & Clarke, 2018). Such findings suggest that reform efforts aiming at a significant change in pedagogical practices related to cognitive skills, such as Queensland's new QCE, may be problematic. Therefore, this systematic literature review on curriculum alignment after educational reforms also discusses literature on effective teaching of cognitive skills outlined in the prescribed curriculum to increase alignment. The following research questions guided the review:

1. How do reform efforts affect curriculum alignment?
2. How can cognitive skills be taught effectively in the enacted curriculum?

Systematic Literature Search

Search methods employed to identify and evaluate relevant literature were based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) model (Moher et al., 2009). Figure 1 illustrates the steps of the search methods and the number of articles included in the review. The online database SCOPUS was used to identify literature as it is the largest multidisciplinary database of peer reviewed literature in terms of coverage (Bosman, Mourik, Rasch, Sieverts, & Verhoeff, 2006) and journal range (Falagas, Pitsouni, Malietzis, & Pappas, 2008). The following search words were used in various combinations: curriculum, alignment, reform, enacted, intended, prescribed, cognit*, objective, taxonomy, pedagogy, "high school", secondary, "thinking skill", and "cognitive verb". Searches were limited to peer-reviewed literature published in the past 20 years, considering fast-changing educational paradigms and policies, and to studies published in English. Additional articles were identified via reference lists of literature located through the SCOPUS search and websites of government or educational organisations.

A total of 651 articles were located. Their title and abstract were screened for relevance to the aims of the review. To narrow the search, studies were excluded if they did not discuss mainstream P-12 education in face-to-face classroom settings. Screening resulted in 116 studies to be read in full and to be assessed for eligibility. Articles read in full were excluded from the review if they (a) did not report or review empirical data, (b) focused on teacher training, or (c) investigated a very narrow pedagogical technique to promote cognitive skills, such as visuals in PowerPoint presentations. This process resulted in 108 articles being included in the qualitative synthesis of the literature. Conclusions of this review are situated in the context of included articles and perhaps limited by publication bias. It is possible that studies identifying low curriculum alignment are more likely to be published because such studies are indicating a problem that needs attention from teacher educators or policy writers.

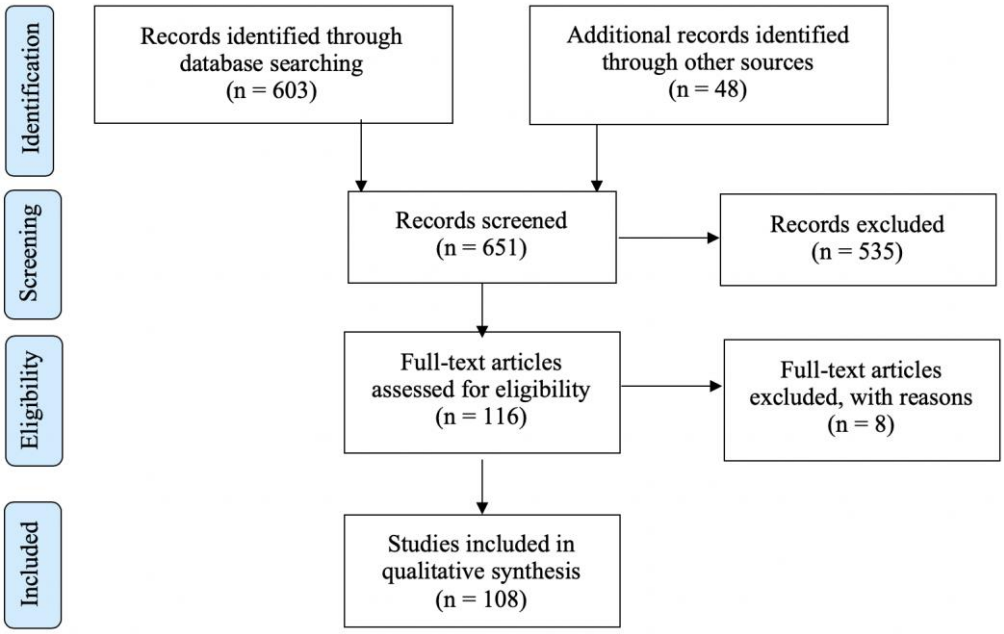

Figure 1: Steps of the literature search

Findings

Findings are organised thematically and applied to Queensland's context. First, research on curriculum alignment after reform efforts and factors impacting on curriculum alignment are discussed. Second, trends in explicitly teaching cognitive skills in the enacted curriculum are outlined, including effective pedagogies for well-aligned cognitive skills curricula.

How do Reform Efforts Affect Curriculum Alignment?

Low Alignment After Curriculum Reforms

There is a strong emphasis in the literature on measuring the alignment between the prescribed and assessed curriculum (Çil, 2015; Contino, 2013; Edwards, 2010; El Hassan & Baassiri, 2019; Kara & Cepni, 2011; Liang & Yuan, 2008; Liu & Fulmer, 2008), as opposed to examining the alignment of the enacted curriculum. After educational reforms, the prescribed and assessed curriculum tend to be poorly aligned (Kuiper, Folmer, & Ottevanger, 2013). It appears that curriculum reforms frequently entail changes to the prescribed curriculum by releasing new policies or curriculum documents, while assessment practices remain the same, leading to inconsistent messages about which knowledge and skills are important. For example, Cullinane and Liston (2016) reported that the range and emphasis on different cognitive skills in Irish biology examinations remained the same as prior to the implemented syllabus reform; the examinations predominantly assessed the first three cognitive levels of Bloom's Taxonomy. In the Netherlands, it was found that external examinations were poorly aligned with newly implemented curriculum documents that emphasise a contextualised approach to science and mathematics education (Kuiper et al., 2013). Ensuring reliability and comparability of those external examinations prevented a comprehensive assessment of all curriculum aims, including the assessment of concepts in new contexts. A similar picture emerges in China; assessment for certain subjects did not include the same range of cognitive or general skills as mandated, for example by the reformed biology (Lu & Liu, 2012) or mathematics standards (Leung, Leung, & Zuo, 2014).

In Queensland's reformed QCE, new summative assessment types, including external assessments, are being implemented which embed the same cognitive skills from the New Taxonomy in their criteria and task descriptions as syllabus learning objectives. Year 12 school internal assessment has to be submitted to and endorsed by the QCAA to ensure, amongst other quality criteria, alignment with relevant syllabus objectives. The external assessment is written by the QCAA with the aim to assess learning objectives of the final two syllabus units (QCAA, 2020). For those reasons, alignment between the prescribed and assessed curriculum may be higher than in the studies reviewed here. Where well-aligned assessment is found, it has the potential to lever curriculum change (Kuiper et al., 2013) and result in new teaching methods that align with the reformed prescribed curriculum (Holme et al., 2010). This means that there is a possibility of significant curriculum alignment in the new Queensland Senior system.

However, even when there is potential for improvement through alignment, studies in schools show poor alignment between the enacted and prescribed curriculum after educational reforms. For example, as planned in Queensland, the Swedish mathematics reform included the administration of well aligned external examinations, yet classroom observations of almost 200 teachers showed that the enacted curriculum often deviated from cognitive skills in the prescribed curriculum (Boesen et al., 2014). This may be because teachers construct their own meaning of curriculum documents, interpret and then filter the

prescribed curriculum to bring it alive in the classroom (Kim-Eng Lee & Mun Ling, 2013). In Western Australia, teacher interviews suggested that diversity in curriculum interpretation after the latest Senior secondary curriculum reform was high, even though teachers aimed for high curriculum alignment to prepare students for external exit examinations (Kruger, Won, & Treagust, 2013). Furthermore, the introduction of the new English, history and mathematics syllabi in New South Wales led to the inclusion of new content, but to no significant reform of teaching practices initially as teachers felt they were too time-poor to deeply engage with the new conceptual frameworks suggested by the syllabi (O'Sullivan, Carroll, & Cavanagh, 2008).

This shows that it is important to investigate alignment of prescribed and enacted curricula, independent of their alignment with the assessed curriculum. Table 2 lists relevant findings of all reviewed studies that explicitly researched the alignment of the enacted curriculum with a reformed prescribed curriculum. It is evident that such alignment was low across those studies without exception. In particular, Fenwick's (2018) analysis of planned lesson activities in Australia, Nargund-Joshi and colleagues' (2011) lesson observations in India, as well as Orafi and colleagues' (2009) lesson observations in Libya showed considerable differences between the prescribed and enacted curriculum. Furthermore, several studies confirmed the previously mentioned trend that cognitive skills contribute more to low alignment than knowledge (Albadi, Harkins, & O'Toole, 2019; Boesen et al., 2014; Dolma, Nutchey, Watters, & Chandra, 2018; Fenwick, 2018).

Country	Reform aim	Methods	Curriculum alignment
Australia	Improve student outcomes through the inclusion of metacognition in literacy	document analysis (n=4 teachers)	Learning opportunities for metacognition mandated by the new prescribed curriculum were not created in the enacted curriculum (Fenwick, 2018).*
Australia	"Critical Inquiry Approach" in Physical Education	interviews, lesson observations, field notes (n=3 teachers)	Inconclusive; however, the authors conclude that "*(…) curriculum and policy are volatile and rarely mobilised as the creator/s intended*" (Alfrey, O'Connor, & Jeanes, 2017, p. 117).
Bhutan	Authentic and constructivist approach to mathematics learning	qualitative survey (n=72 teachers)	Weak alignment of prescribed and enacted curriculum, particularly cognitive levels (Dolma et al., 2018).*
India	New national curriculum with a constructivist teaching approach in all subjects	interviews, lesson observations, artefacts (n=2 teachers)	Classroom practices were not aligned with the goals of the curriculum reform (Nargund-Joshi, Rogers, & Akerson, 2011).
Libya	New English language curriculum to include functional language use	lesson observations, interviews (n=3 teachers)	Misalignment: "*The analysis highlights considerable differences between the intentions of the curriculum and instructions observed"* (Orafi, Mohammed, Senussi & Borg, 2009, p. 243).
Saudi Arabia	Student-centred learning in physics (increased emphasis on practical skills and collaboration)	interviews (n=6 teachers) survey (n=360 students)	Low alignment as most teachers were using the 'old style' of teaching (Albadi et al., 2019).
Sweden	National reform of Mathematics education to include a range of competency goals	interviews, lesson observations, online surveys (n=197 teachers)	Only 18% of teachers had functional knowledge of the new competency goals in the reformed curriculum. The authors conclude that *"if a curriculum includes content goals, such as arithmetic, then arithmetic is indeed taught, but if the curriculum includes competency goals, such as problem solving ability, then the effect on teaching may vary significantly"* (Boesen et al., 2014, p. 73).
Turkey	Greater emphasis on science process skills and student-centred learning in biology	survey (n=128)	Lack of coherence between the new prescribed curriculum and assessment practices, availability of resources and teacher development (Akar, 2014).
Turkey	Student-centred, constructivist approach to primary science education	lesson observations, interviews, document analysis survey (n=1)	Enacted classroom assessment activities were misaligned with prescribed curriculum (Serin, 2015).

* Analysis of planned, but not yet implemented, lesson activities such as teachers' lesson plans

Table 2: Empirical findings on the alignment of the prescribed and enacted curriculum after reform efforts

Alfrey and colleagues (2017) conclude after analysing the implementation of a new pedagogical approach to health and physical education in Queensland that "curriculum and policy are volatile and rarely mobilised as the creator/s intended" (p.117). This may indicate that research examining the alignment of the enacted Queensland Senior secondary

curriculum would be instructive, ideally using longitudinal studies which could demonstrate how alignment changes with time after the implementation of the reform. Such research could be more informative if it began soon after the reform as teachers make important decisions about the implementation of change early (Byrne & Prendergast, 2019). Moreover, studies could be designed in a manner that gives teachers implementing reformed curricula a voice because alignment has been shown to be low if teachers are not involved in the change process and if their concerns are not heard (Akar, 2014). Participation in alignment research itself could increase curriculum alignment because it improves teachers' understanding of what is intended by the prescribed curriculum (Shalem, Sapire, & Huntley, 2013).

Factors Affecting Curriculum Alignment After Reforms

Data in Table 2 raise a question about common reasons behind low curriculum alignment after reform efforts. Even if new curriculum materials are developed concurrently with reform implementation by updating textbooks and developing teaching resources, changes in teaching practice may not occur (Albadi et al., 2019; Leat & Lin, 2003). This could be because teachers desire different changes to practice than curriculum developers (Byrne & Prendergast, 2019) or because teachers' opinions of what it means to be 'capable' in a subject do not align with the new syllabus objectives (Doyle, Seery, Canty & Buckley, 2019). This may support the idea that teachers' prior experience and values play an important role in their interpretation of a new prescribed curriculum (Dai, Gerbino, & Daley, 2011; Kuiper et al., 2013; Penuel, Fishman, Gallagher, Korbak & Lopez-Prado, 2009). In addition to these factors, teachers' capabilities and self-efficacy (Orafi, Mohammed, Senussi & Borg, 2009; Serin, 2015), as well as the amount and quality of professional development teachers are receiving on the reformed pedagogy or content (Akar, 2014; Boesen et al., 2014) may be significant influences on the degree of curriculum alignment. Support by school leadership and colleagues to implement the change has also been reported to be a noteworthy factor (Alfrey et al., 2017; Orafi, Mohammed, Senussi & Borg, 2009). Finally, factors which are independent of the direction or philosophy of the reform can lower curriculum alignment, such as perceived time constraints due to overcrowded curricula (Akar, 2014; Boesen et al., 2014), pressure to teach to high stakes assessment (Doyle et al., 2019; Nargund-Joshi et al., 2011), student resistance (Orafi, Mohammed, Senussi & Borg, 2009) and, in the case of India and Saudi Arabia, class size (Albadi et al., 2019; Nargund-Joshi et al., 2011). Table 3 summarises these obstacles to high alignment after curriculum reforms.

Factor	Evidence
Teachers' prior experience, beliefs, values or concerns	Alfrey et al., 2017; Byrne & Prendergast, 2019; Dai et al., 2011; Doyle et al., 2019; Kruger, Won, & Treagust, 2013; Kuiper et al., 2013; Orafi, Mohammed, Senussi & Borg, 2009; Penuel et al., 2009; Wallace & Priestley, 2017
Assessment requirements, particularly requirements of high stakes examinations	Akar, 2014; Dai et al., 2011; Doyle et al., 2019; Kruger, Won, & Treagust, 2013; Nargund-Joshi et al., 2011; Orafi, Mohammed, Senussi & Borg, 2009
Time constraints due to quantity of content to be covered	Akar, 2014; Albadi et al., 2019; Boesen et al., 2014; Dai et al., 2011; Nargund-Joshi et al., 2011; Serin, 2015
Teachers' capabilities, familiarity with pedagogies and self-efficacy	Akar, 2014; Shirly Avargil, Herscovitz, & Dori, 2012; Dai et al., 2011; Orafi, Mohammed, Senussi & Borg, 2009; Serin, 2015
Lack of teaching resources	Akar, 2014; Albadi et al., 2019; Boesen et al., 2014; Penuel et al., 2009
Lack of or insufficient professional development	Akar, 2014; Albadi et al., 2019; Boesen et al., 2014; Serin, 2015
School culture, i.e. insufficient support by leadership, insufficient time given to plan and prepare, peer pressure by colleagues	Alfrey et al., 2017; Lidar, Lundqvist, Ryder, & Östman, 2020; Orafi, Mohammed, Senussi & Borg, 2009; Penuel et al., 2009
Students' learning habits and/or student resistance	Dai et al., 2011; Orafi, Mohammed, Senussi & Borg, 2009
Class size	Albadi et al., 2019; Nargund-Joshi et al., 2011

Table 3: Factors affecting alignment of the prescribed and enacted curriculum

Only two reviewed studies propose factors that can increase curriculum alignment. Firstly, Avargil and colleagues (2012) emphasise the importance of continuous teacher support in the context of a new chemistry curriculum in Israel, particularly professional development on pedagogical content knowledge. Secondly, Hume and Coll (2010) examined the alignment of the enacted curriculum 20 years after a curriculum reform in New Zealand and suggest that collective decision making about classroom practices communicated by departmental guidelines can result in high alignment between the prescribed and enacted curriculum. However, this means that teachers are left with less individual agency over their teaching and it may lead to too homogenous of an approach to curriculum delivery, such as the distribution of pre-written lesson plans and resources, which carries its own disadvantages (Barton, Garvis, & Ryan, 2014).

A third factor that has the potential to increase alignment of the enacted curriculum is the use of educational taxonomies which provide a classification framework for objectives, instruction and assessment (Anderson, 2005; Bümen, 2007; Edwards, 2010). Blumberg (2009), while commenting on the tertiary education context as opposed to that of the Senior secondary school context discussed herein, notes that cognitive skills found in the objectives of university courses are often set at a higher level than the cognitive skills required of students during learning activities or assessment tasks. She, therefore, suggests the use of cognitive levels in educational taxonomies to assess alignment in university courses and, by

way of doing so, improve course design. In Australia, the Australian Qualifications Framework (AQF) has established regulations for learning objectives at different course levels to make the cognitive skills required for each level explicit (Australian Qualifications Framework Council, 2013). Similarly, taxonomies can scaffold the analysis of the scope of an existing course (Mathumbu, Rauscher, & Braun, 2014) or the scope of an assessment (Motlhabane, 2017), support teachers in their interpretation of course objectives (Bümen, 2007) or even in differentiating teaching techniques (Dettmer, 2005). In light of building new capacities in pre-service and graduate teachers, it may be interesting to explore the effect of embedding a stronger focus on curriculum alignment through the use of educational taxonomies in pre-service teacher degrees.

Pre-service teachers can play a key role in the implementation of a highly aligned reformed curriculum because they are less likely to have values, beliefs or ideologies, which may form an emotional barrier to curriculum reform (Dinan-Thompson, 2001). In Queensland, both preservice and in-service teachers would benefit from engaging with the structure and uses of the New Taxonomy of Educational Objectives. If the language used by syllabus documents is not clear to teachers, they are likely to misinterpret the prescribed curriculum, leading to low curriculum alignment (Boesen et al., 2014). Teacher and pre-service teacher professional learning could focus on how to use the New Taxonomy to plan lessons with the intention to teach cognitive skills outlined in syllabus learning objects explicitly. In fact, the QCAA (2018c) calls upon teachers to make cognitive skills outlined in the New Taxonomy part of their enacted curriculum and to use cognitive verbs when constructing assessment tasks. This leads to questions about how to implement such a goal effectively.

How can Cognitive Skills be Taught Effectively in the Enacted Curriculum?

Trends in Teaching Cognitive Skills

In many Western countries, educational reforms and policies of the last two decades have emphasised the development of students' cognitive skills, e.g. Ireland (McGuiness, 1999), Israel (Zohar & Cohen, 2016), England, the USA, Canada and Australia (Firn, 2016). Tan's (2007) literature review of pedagogical imperatives concludes that since the 1990s, effective teaching has started to be characterised by the modelling of learning and thinking skills while communicating content knowledge.

Several well-researched cognitive skills programs have been implemented worldwide. Some of these are stand-alone programs such as Feuerstein's Instrumental Enrichment in Ireland; others are subject-specific interventions such as Cognitive Acceleration through Science Education and Cognitive Acceleration through Mathematics Education in England and Australia; yet others are infused programs with a cognitive skills curriculum embedded across several subjects such as Philosophy for Children in the USA or Activating Children's Thinking Skills in Ireland. On other occasions, the implementation of a cognitive skills intervention has originated from a government initiative, as shown in the 'Thinking Schools, Learning Nation' vision launched by Singapore's Ministry of Education in 1997. Three distinct approaches for teaching cognitive skills are apparent in these programs: (1) teaching content knowledge and developing students' cognitive skills as a by-product, (2) teaching cognitive skills and developing students' content knowledge as a by-product, or (3) teaching cognitive skills with the emphasis to transfer cognitive skills to new content (Ulmer, 2005).

In Australia, support for a curricular focus on students' cognitive skills is high. The Melbourne Declaration on Educational Goals for Young Australians acknowledges that successful learners "are able to think deeply and logically, and obtain and evaluate evidence

in a disciplined way" (MCEETYA, 2008 p. 8). More recently, Gonski and colleagues (2018) argue in their *Review to Achieve Educational Excellence in Australian Schools* that the Australian Curriculum's general capabilities, i.e. critical and creative thinking, need to be at the core of the curriculum and teaching practice for students to succeed in the twenty-first century. In Queensland, most Senior secondary syllabi explicitly list critical thinking as a skill to be developed throughout the course (QCAA, 2018d) and the QCAA's (2018a) Cognitive Verb Toolkit states that "students explicitly taught the skills and processes of the cognitive verbs are better equipped to meet syllabus objectives and demonstrate their learning through assessment" (p.1).

Sustainable change in teaching practices towards an explicit cognitive skills curriculum has many barriers, including an overcrowded curriculum, limited professional development for teachers, or resistance from students as teaching cognitive skills contradicts their conditioned expectations (Zoller, 1999). Active implementation of cognitive skills curricula is also likely dependent on the familiarity of the teacher with the curriculum (Abdullah, 2017). A study of Israeli physics teachers showed that teachers are frequently uncertain about teaching cognitive skills or do not consider cognitive skills to be an important objective of their lessons (Barak & Dori, 2009). Even though there are studies reporting on excellent practice, in reality the majority of teachers in Australia likely rarely teach cognitive skills (Venville & Oliver, 2015). The OECD's (2018) Teaching and Learning International Survey sampled 3573 Australian secondary teachers and concluded that <50% use "practices involving student cognitive activation" (p.2), i.e. evaluate, apply or problem-solve. The prevalence of enacted cognitive skills curricula in Queensland Senior secondary lessons is not known and could be researched to evaluate the success of recent reform efforts.

Effective Teaching of Cognitive Skills

There is consensus in the literature that cognitive skills and their procedural steps can be taught (Beyer, 2008). Actively teaching skills such as retrieving, analysing or investigating knowledge has been shown to result in faster and more effective execution of these skills (Marzano & Kendall, 2007). Mastery of cognitive skills does not, however, come naturally as a student matures or coincidentally as more complex subject content is taught. It needs to be developed through systematic teaching (Beyer, 2008; Sandi-Urena, Cooper, & Stevens, 2011; Simon & Richardson, 2009) and continuous practice (De Acedo Lizarraga, De Acedo Baquedano, & Rufo, 2010).

Innovations in teaching of cognitive skills are predominantly informed by cognitive psychology and dominated by social constructivist principles (Adey, 2005; Marušić & Sliško, 2012; McGuiness, 1999; Oliver & Venville, 2017; Tornero, 2017; Venville & Oliver, 2015; Wilson, 2016). Cognitive psychology introduced the concept of working memory to education and states that learning is strategically regulated by the brain. Its influence on cognitive frameworks in education is so strong that more than half of the frameworks analysed in a systematic literature review of 35 taxonomies for learning have been devised by psychologists rather than educators (Moseley et al., 2005). Constructivist pedagogies acknowledge that students can arrive at an answer using different routes and thus encourage an inductive teaching approach in which learners have an active role and are provided with carefully scaffolded assistance at an appropriate level of difficulty (McInerney & McInerney, 2010). Teachers should act as facilitators and individualise learning based on students' learning preferences and interests (Juhary, 2013). In other words, teaching should be student-centred. However, Beyer's (2008) review of studies on the teaching of cognitive skills reported that both constructivist as well as didactic teaching strategies can be effective in the

development of cognitive skills. This is relevant for Queensland as the introduction of certain assessment types, such as the external assessment in the sciences and mathematics which constitutes 50% of students' final mark, can result in teachers adopting teacher-centred didactic pedagogies (Kruger, Won, & Treagust, 2013).

Effective pedagogies for teaching cognitive skills likely differ from pedagogies to teach declarative knowledge. Moreover, different cognitive learning objectives require different instructional strategies and resources (Anderson, 2005; Bietenbeck, 2014). Researchers have attempted to specify pedagogies that produce particular cognitive learning outcomes (Anderson & Krathwohl, 2001), but have not succeeded in providing a universal answer. Nevertheless, evaluation of cognitive skills intervention programs in secondary schools has pointed to a list of pedagogies that seem to be effective at improving students' cognitive skills long-term and frequently across subject disciplines (Tab. 4).

These pedagogies include a range of explicit scaffolding strategies, such as modelling (Simon & Richardson, 2009) or using visual diagrams (Burke & Williams, 2008), applications of skills to real world contexts (McGuiness, 1999), and more self-directed group or collaborative learning (McGregor & Gunter, 2006). Beyer's (2008) review of pedagogical interventions for cognitive skills and De Corte's (1990) review of pedagogies to teach problem-solving both confirm that frameworks comprised of (a) modelling the skill, (b) guided student practice of the skill with teacher feedback, (c) independent transfer of the skill to new context, and (d) metacognitive reflection on thinking procedures are particularly useful for effective cognitive skills curricula. Minimally guided approaches to teaching of cognitive skills have been criticised as less efficient because of the prerequisite knowledge required by learners to effectively discover new knowledge and solve problems in unfamiliar contexts (Hattie, 2008; QCAA, 2016). Empirical evidence also suggests that teaching cognitive skills should not be divorced from teaching content knowledge but integrated with subject content as learning will be more effective if students perceive an authentic need to use a new cognitive skill (Beyer, 2008; DeCorte, 1990; Rickey & Stacy, 2000).

Pedagogy	**Evidence**
Metacognition: making cognitive skills explicit by talking about and reflecting on mental processes	Beyer, 2008; De Acedo Lizarraga et al., 2010; McGregor & Gunter, 2006; McGuiness, 1999
Modelling cognitive skills or thinking aloud	Beyer, 2008; Fairbrother, 2000; McGuiness, 1999; Simon & Richardson, 2009
Using diagrams that visualise the steps of each cognitive skill	Burke & Williams, 2008
Transferring cognitive skills between subject domains and to authentic contexts outside of school	De Acedo Lizarraga et al., 2010; McGregor & Gunter, 2006; McGuiness, 1999; Miri, David, & Uri, 2007
Using feedback until students find a solution themselves or develop own ideas	Adey & Shayer, 1990; De Acedo Lizarraga et al., 2010
Open ended questions	De Acedo Lizarraga et al., 2010; McGregor & Gunter, 2006
Collaborative and cooperative learning	Coll, France, & Taylor, 2005; McGregor & Gunter, 2006
Group discussions	Coll et al., 2005; McGregor & Gunter, 2006; Miri et al., 2007; Simon & Richardson, 2009

Table 4: Pedagogies shown to be effective at improving secondary school students' cognitive skills

Notably, teaching strategies that incorporate social interactions tend to be beneficial to cognitive skills education. For example, Ikuenobe (2002) argues that certain cognitive

skills, especially critical evaluation, cannot be learned fully without interaction between students. A quasi-experimental study in Scotland also affirms that cognitive skills intervention programs have the greatest effect on students' performance in collaborative learning conditions, but even the individually working group of students engaging with the intervention program made greater gains on the post-test than the control group without any cognitive skills intervention (Burke & Williams, 2008).

Introducing students to the language of thinking is another factor conducive to effective teaching of cognitive skills (Burke & Williams, 2008; Zohar & Barzilai, 2013). Negretti (2018) argues that the first step in teaching cognitive skills is to make knowledge processing visible by verbalising it, so students can associate cognitive verbs with the relative cognitive skill. Students who know about and can verbalise cognitive skills are more likely to use them when confronted with different learning tasks (Pintrich, 2018) because a consistent language describing cognitive skills provides students with a cue for recognising, retrieving and applying learnt procedures (Beyer, 2008; Fairbrother, 2000).

In Queensland, the QCAA (2018a) provides guidance for teachers on the use of cognitive verbs in developing cognitive skills. Info-sheets and posters outlining the definitions, cognitive processes and examples of use for the most common cognitive verbs across Senior syllabi have been released, followed by the publication of separate resources on cognitive verbs in the Australian Curriculum for Prep to Year 10 teachers. However, thus far there is limited explicit guidance on the skills teachers should be teaching to foster metacognition and self-system thinking, the two levels influencing the cognitive system in the New Taxonomy. The self-system provides students with the necessary motivation to engage with cognitive skills and the metacognitive systems allows students to regulate their learning (Marzano & Kendall, 2007). Professional learning on such classroom practice would support the alignment of the enacted curriculum with the aims of the curriculum reform (Fenwick, 2018; Massell & Perrault, 2014). Furthermore, core pedagogy, curriculum and assessment units of study in teacher education could build knowledge of cognitive verbs. Pre- and in-service teachers would also benefit from applicable examples of best practice associated with teaching each cognitive skill and the 'language of thinking'.

Conclusion and Recommendations

This systematic literature review highlights that curriculum alignment tends to be low after educational reforms. Obstacles to high curriculum alignment after reform efforts range from factors specific to the change the reform aims to achieve, based on teachers' or students' opposing beliefs, unfamiliarity with the new philosophy and school culture, to more general factors, including time constraints, assessment requirements and lack of teaching resources or professional development. The alignment of cognitive skills in the prescribed and the enacted curriculum seems to be particularly problematic. The prescribed curriculum embeds cognitive skills in learning objectives using cognitive verbs such as analyse, justify, etc. Those learning objectives can be classified into distinct cognitive levels using educational taxonomies, which aids in interpreting the prescribed curriculum and supports intentional efforts to increase curriculum alignment. Building on Bloom's (1956) Taxonomy and the Revised Bloom's Taxonomy (Anderson & Krathwohl, 2001), Marzano and Kendall's (2007) New Taxonomy of Educational Objectives has been chosen to underpin all new Senior secondary syllabi in Queensland. It can be used by educators to analyse syllabus content matter, develop valid assessment, plan relevant lessons or teach cognitive skills explicitly. There is also evidence that Australia's educational policies strongly support such teaching of cognitive skills in the enacted curriculum (Gonski et al., 2018; MCEETYA, 2008;

QCAA, 2018a). Finally, research has identified effective pedagogies to teach cognitive skills, including but not limited to modelling, guided practice, metacognitive reflection and collaborative learning. Looking at these components, it is possible to suggest that there may be opportunity to instil effective curriculum alignment in the Queensland context.

However, compared to the USA and many Asian countries, Australia lacks comprehensive research on the alignment of its enacted and prescribed curricula, as well as research on the influence of graduate teachers in implementing a new prescribed curriculum. Specifically, there seems to be a need to examine the alignment of the enacted Queensland Senior secondary curriculum with the reformed prescribed curriculum as well as the concerns teachers may have with the implementation of the new Senior system. It seems prudent that such alignment studies use the New Taxonomy as classification framework for cognitive skills because it is considered to support the advancement of curriculum and assessment in Queensland.

Analysing curriculum alignment carries inherent benefits as it improves educators' ability to interpret learning objectives and assessment questions (Martone & Sireci, 2009; Ziebell & Clarke, 2018). Thus, it may be a valuable exercise to include in teacher education courses. The explicit teaching of this complex problem during pre-service teacher education may assist in influencing new beliefs and practices that are aligned to the reformed prescribed curriculum. In addition, pre- and in-service teachers could benefit from learning about the structure and uses of the New Taxonomy to interpret syllabus documents as intended by the curriculum reform. Cognitive verbs in syllabus documents may be interpreted differently by different teachers if there is no shared understanding of the words' meaning. Professional learning could also include sharing of best practice for teaching cognitive skills, metacognition and self-system thinking.

Finally, it is currently not clear which cognitive skills are modelled and emphasised in Queensland's classrooms and which pedagogies are used to teach them. As the systematic literature search has also not identified any empirical research on classroom discourse on cognitive skills in Australia, such as the use of cognitive verbs, this is a significant area for further research. Lack of such research undermines current educational imperatives which emphasise the development of students' cognitive abilities and twenty-first century skills.

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