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Reimagining a Framework for Teachers' Continuous Professional Development During Curriculum Reform

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Reimagining a Framework for Teachers' Continuous Professional Development During Curriculum Reform

Effective continued professional development (CPD) is critical in preparing teachers for implementing curricular changes. Utilising the professional design framework (Loucks-Horsley et al., 2009) and document analysis, this article presents a developed framework which identifies school culture, time, choice, and connection to practice as factors influencing CPD's success during curriculum reform. The aptly named STiCC framework aims to help structure CPD to aid teachers in effectively delivering a new curriculum. Employing Kennedy's spectrum of CPD models (2014) in parallel with the STiCC framework, we offer approaches to CPD which may be helpful during periods of change. The discussion points to the application of the STiCC framework worldwide as the necessity for reimagining CPD during curriculum reform exists globally.

Keywords: continued professional development; curricular change; primary mathematics education

Introduction

Education research has significantly transformed how mathematics is taught within the last twenty years. Rather than relying on rote memorisation and solving tasks using rigid, prescribed procedures, research recommends that students develop innovative solutions to real-world problems using critical thinking skills (National Council of Teachers of Mathematics, 2014). As a result, countries worldwide are examining and revising their mathematics curriculums to keep up with current best practices to impact students' achievement positively (Australian Curriculum Assessment and Reporting Authority, 2022; Ministry of Education, 2020; Sarakar, 2008). Ireland is no exception, as in the last ten years, the National Council for Curriculum and Assessment (NCCA) has been developing a Draft Primary Mathematics Curriculum (DPMC) that will be fully implemented in schools by 2024 (O'Connor, 2023). As the DPMC edges closer to being utilised, teachers must receive adequate support to help enact the curriculum as intended.

Continued professional development (CPD) can allow teachers to obtain the necessary knowledge and skills to implement a new curriculum successfully. Although CPD is often identified as a component of any successful education system (Borko, 2004), it is imperative during curriculum reform (Broadhead, 2001; Du Plessis, 2013). However, expecting teachers to learn and teach a new curriculum while undertaking CPD comes with challenges. If adequate CPD is not offered during curriculum reform, the enacted and intended curriculums may look quite different (Prendergast & Treacy, 2018). As a result, CPD offered during curriculum reform may look different from traditional professional learning experiences. Understanding which components of CPD are essential to focus on when a new curriculum is adopted is a critical first step.

This paper proposes a CPD framework to use during curriculum reform. The framework aims to aid in creating a foundation for structuring CPD that supports teachers to shift their pedagogical approaches, learn new content knowledge, and understand theories underpinning the changes to teaching and learning, all while implementing a new curriculum. Our framework pinpoints characteristics of effective CPD essential to prioritise during curriculum reform. We present our framework in the context of the change occurring in Ireland's Primary Mathematics Curriculum. However, the proposed framework is built around what is known about effective CPD while examining it through the lens of curriculum reform. Therefore, our suggested framework may apply to subject areas other than mathematics experiencing periods of change. In addition, the framework has the potential to be useful outside Ireland, as many countries are finding it necessary to reform curriculums to prepare students for the 21st century.

Background

Due to the advancements in mathematics education research and identified concerns with

Ireland's 1999 Primary Mathematics Curriculum (PMC) (Burke, 2014; Dooley et al., 2014; National Council of Curriculum and Assessment, 2016; NCCA, 2005; Perkins, 2020), the NCCA recognised the urgency of redeveloping the curriculum to adequately prepare students for life in the rapidly developing 21st century (National Council of Curriculum and Assessment, 2016). Although the mathematics content taught to students is relatively unchanged, how it is taught and assessed vastly differs between the PMC and the DPMC (National Council of Curriculum and Assessment, 2022). Understanding how enormous these changes are is significant as it signals the need for effective CPD during periods of curriculum reform.

Curriculum Aims and Goals

Although the mathematical skills and concepts remain relatively unchanged in the DPMC, how mathematics is taught, and students learn are quite different. While the PMC curriculum encourages students to develop problem-solving skills, use mathematical language, and develop an appreciation for mathematics, it emphasises learning procedures and memorising facts and formulas (NCCA, 1999). The DPMC instead focuses on a deeper understanding of mathematics and on mathematical proficiency, which aims to develop students holistically as mathematicians (National Council of Curriculum and Assessment, 2022). The DPMC identifies procedural fluency as necessary while emphasising higher-order thinking skills such as strategic competence, adaptive reasoning, productive disposition, and conceptual understanding (National Council of Curriculum and Assessment, 2022). The critical difference between the two curriculums is the DPMC's priority on these higher-order thinking skills, which are invaluable for students to learn.

The DPMC also prioritises students as individual learners, requiring teachers to adapt instruction to meet the needs of each student. While the PMC has specific goals for students

at each grade level (NCCA, 1999), the DPMC takes a different approach. Instead, teachers are encouraged to recognise that each student will be on a distinct learning path and are provided with 2-year learning outcomes as a guide for instruction (National Council of Curriculum and Assessment, 2022). The learning outcomes focus on the big ideas in teaching mathematics rather than particular learning targets, as seen in the 1999 curriculum.

The aims of the DPMC were developed in reaction to education research (National Council of Curriculum and Assessment, 2016). Therefore, Ireland is not alone in their endeavour, as countries worldwide are also enhancing their curriculums. In the United Kingdom, the mathematics curriculum, updated in 2021, focuses on students being able to solve complex problems by reasoning mathematically through developed higher-order thinking skills and being adaptable in how problems are solved (Department for Education, 2021). The Australian Curriculum, to be taught from 2023, aims for students to grow into mathematicians who can confidently persevere through real-world scenarios and communicate findings to others in all subjects (Australian Curriculum Assessment and Reporting Authority, 2022). As curriculums evolve their aims and goals, it is inevitable that how the content is taught also transforms, and teachers must have the skills to do so effectively.

Pedagogical Shifts

As a curriculum's aims evolve, the pedagogical approaches recommended for teachers to employ also change. Ireland's 1999 PMC encourages a constructivist approach to teaching mathematics, emphasising guided discussion and hands-on approaches to learning mathematics (NCCA, 1999). Unfortunately, the constructivist approach to teaching was poorly implemented for reasons such as a dependency on textbooks and undeveloped skillsets in teachers (National Council of Curriculum and Assessment, 2016; O'Shea & Leavy, 2013).

The DPMC still posits that constructivist teaching approaches should be the focus but expands upon how this should look in a classroom. The DPMC sets forth five critical pedagogical practices essential to enacting the curriculum: using cognitively challenging tasks, using formative assessment, emphasising mathematical modelling, fostering productive disposition, and promoting maths talk (National Council of Curriculum and Assessment, 2022). These pedagogical practices are complex skills that the DPMC states should be integrated into everyday mathematics lessons. Teachers will most likely need to adjust their approach to teaching and change their expectations of what students will know and be able to do when learning. Table 1 provides an overview of the pedagogical approaches the DPMC asserts are critical to teaching mathematics effectively, along with examples of what these look like in practice.

Table 1. Draft Primary Mathematics Curriculum’s Five Core Pedagogical Practices

Pedagogical Practice	Aim	Student Goals	Teacher Goals
Fostering productive disposition	Increasing positive attitudes toward learning and doing mathematics	Persevere through challenging tasks, value mistakes, and develop an enthusiasm for mathematics.	Facilitate collaboration in mixed-ability groups, praise effort, and provide time for deep thinking
Emphasising Mathematical Modeling	Placing importance on conceptual understanding, flexible approaches to solving, and innovation rather than just on correct solutions.	Solve tasks using chosen methods, apply learning to new scenarios, and compare and contrast methods	Use questioning to promote deeper thinking, incorporate technology, and allow time for revisiting ideas
Using Cognitively Challenging Tasks	Provide all students, no matter their ability level, the opportunity to engage with rich mathematics tasks to develop higher-order thinking skills.	Value productive struggle as part of doing mathematics, engage in real-world tasks, use a range of models to communicate thinking	Develop or modify tasks, allow time for students to explore methods for solving, provide opportunities for collaboration
Promoting Maths Talk	Students deepen their understanding of mathematics by communicating with peers and teachers.	Clearly explain their thinking to others, learn from the thinking of others, and link prior knowledge to new concepts	Develop a classroom culture where all students feel safe sharing and discussing ideas, select appropriate tasks for fostering

Using Formative Assessment	Students and teachers know an individual's progress in learning mathematics and how to adjust learning to meet each child's needs.	Students become experts in their learning progress, self and peer-assess, take increased responsibility for learning	conversations, facilitate discussions Use a variety of assessment approaches rather than only summative types in daily lessons, include students in the assessment process, teach students methods to monitor progress
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Note: Developed based on Chapter 6 in the DPMC, which explains five critical pedagogical practices and guidance for teachers. From *Draft Primary Mathematics Curriculum* (p. 25-37), by National Council for Curriculum and Assessment, 2022.

As many of these practices are not the focus of the PMC, teachers may be unfamiliar with them. In Ireland, primary teachers must incorporate these pedagogies to enact the curriculum as intended. Unfortunately, short-term solutions are often chosen as teachers are advised on how to respond to changes in the curriculum rather than developing pedagogical skills that will serve them long-term (Harford, 2010). Developing teachers' pedagogical skills must be at the core of curriculum reform. Each pedagogical approach listed in the DPMC is complex and requires time and space to develop. Teachers unfamiliar with these pedagogies will need to not only master new skills but also learn the new curriculum, possibly simultaneously. Teachers will therefore require access to quality CPD to teach the curriculum as written successfully.

Teacher Agency

A significant shift from the 1999 PMC to the DPMC is the abundance of agency primary teachers will have in teaching mathematics. The 'Preparation for Teaching and Learning' document (DES, 2021) guides teachers in navigating this increased agency. An explanation of what it means to prepare for teaching and learning, along with a renewed responsibility of teachers to be knowledgeable in pedagogy, partly achieved from their participation in CPD, is presented. In alignment with this guidance, an earlier Department of Education document

titled 'Looking at Our School' recognises teachers as committed, skilled, and agentic professionals (Department of Education, 2016). These documents aim to support teachers in realising the role agency and autonomy play in learning appropriate pedagogies in preparation for the new curriculum, a tremendous shift for some teachers. A significant amount of responsibility will be placed upon teachers to direct their professional development journey as the DPMC is integrated.

Teachers will also see increased agency and autonomy due to the shift to using learning outcomes to teach mathematics. In the National Literacy and Numeracy Strategy (Department of Education, 2017), a decision was made at the system level that all primary and post-primary curricula would become outcomes-based. According to the European Centre for the Development of Vocational Training, learning outcomes are beneficial because they provide flexibility to the teacher in how the content is presented based on the student's needs (2008). This format affords teachers greater autonomy in the classroom. "By making professional decisions based on a sound knowledge of pedagogy, of content and taking account of the interests, curiosities and prior learning of the children, teachers exercise their agency and efficacy" (Department of Education, 2021, p. 9). The call for teachers to guide instruction based on the needs of students will require changes in teacher practice, such as less reliance on the structured format of textbooks. Currently, teachers in Ireland state that textbooks are used daily to help with planning, save time, and guide curriculum completion (National Council of Curriculum and Assessment, 2016), despite reports that Irish textbooks fail to cover the entire curriculum (Burke, 2014). This increased autonomy may be challenging for teachers not accustomed to making extensive decisions to meticulously guide individual students' learning progression.

Teachers frequently seek autonomy, stating that it increases job satisfaction and reduces work-related stress (Pearson & Moomaw, 2005). The DPMC will grant more

autonomy to teachers but will also call for them to develop lesson plans, assessments, and learning targets based on students' needs. Irish teachers who have relied on textbooks or premade lesson plans may be unsure how to direct the learning progression while covering the entirety of the curriculum. Therefore, teachers may need support through CPD to learn how to teach mathematics while navigating this increased sense of autonomy.

Examining CPD During Curriculum Reform

Literature continually identifies teachers' CPD as a critical step to advancing education (Creemers et al., 2012; A. Hargreaves, 2014). During curriculum reform, CPD is essential as the expectations of teachers and students will most likely change. Without the skills and knowledge, teachers risk unintentionally implementing the curriculum incorrectly (LaChausse et al., 2014). As discussed in the previous section, introducing a new curriculum may require teachers to adopt new pedagogical approaches. These approaches to teaching may call into question the philosophical beliefs teachers hold about education (Roehrig & Kruse, 2005). To ensure teachers effectively make these adjustments, CPD is essential (Smith, 2015). Therefore, as a new curriculum is introduced, examining how CPD can be structured is imperative to increase its likelihood of success.

Although the definition of CPD can vary, there is an agreement that its overarching goals are to increase teachers' pedagogical skills, beliefs, attitudes, and knowledge to impact student achievement positively (A. Hargreaves, 2014). Nevertheless, while the aims of CPD are relatively similar, the pathway to reaching the intended goals can differ. This paper examines CPD within the context of curriculum reform and cites a significant change in teachers' practice as its goal. Therefore, Guskey's defined goals of CPD were identified as valuable for guiding our work. Guskey states that CPD should aim to 'change in the

classroom practices of teachers, change in their attitudes and beliefs, and change in the learning outcomes of students' (Thomas R. Guskey, 1999, p. 383).

During times of significant change, such as curriculum reform, those organising CPD should recognise the large number of adjustments to instruction some teachers may need to undertake. It is also critical for those designing and facilitating CPD to understand the characteristics of effective CPD during periods of change. This paper proposes that certain aspects of CPD should be highlighted as particularly important during curriculum reform. We have designed a framework we propose as helpful for those developing, facilitating, and analysing CPD during curriculum reform.

CPD designers need to consider how specific conditions can impact the success of teacher learning (Loucks-Horsley et al., 2009). Loucks-Horsley et al. (2009) present a framework for designing CPD in mathematics and science education, showcasing critical components of effective CPD. The framework from Loucks-Horsley et al. identifies the capacity for sustainability, making time for professional development, developing leadership, ensuring equity, building a professional learning culture, garnering public support, and scaling up as factors of effective CPD (2009). Although none of the issues within the Loucks-Horsley et al. framework should be ignored, the context in which the CPD is set can exacerbate some factors' importance (2009). Therefore, when developing our framework, it was essential to consider which components of effective CPD may be significant during a new curriculum rollout.

It should be noted that although there is agreement on the importance of CPD, what makes it effective and the CPD models which produce positive outcomes are sometimes contradictory (Thomas R Guskey, 2003; M. Kennedy, 2016). It is essential to continue researching what constitutes effective CPD and the characteristics that may cause success.

We, therefore, set out to first examine what CPD components may be of particular concern during periods of curriculum reform.

In order to identify the prominent CPD characteristics during curricular change, research and policy documents (Harford, 2010; Hertz et al., 2022; McMillan et al., 2016; Murchan et al., 2009) were examined in parallel with Loucks-Horseley et al.’s framework (2009) to identify commonalities. Based on the work of Bowen (2009), document analysis was utilised to guide this process, requiring skimming, reading, and iteratively interpreting documentation to help identify themes. As a result, we identified four themes as critical to reimagining CPD during curricular changes: choice in CPD, time for CPD, school culture, and connection between CPD and practice. These themes correlated with three critical issues identified in the professional development design framework: making time for professional development, learning culture, and scaling up, as seen in Table 2. Comparing findings from the document analysis with Loucks-Horsely et al.’s professional development framework (2009), four central themes of effective CPD during curriculum change were identified, as seen in Figure 1. School culture, time, choice, and connection to practice are the elements of the apply named STiCC framework. What follows is a brief overview of each element of the STiCC framework.

Table 2. Commonalities between document analysis and Professional Development Framework (Loucks-Horsley et al., 2009)

Document Analysis	Professional Development Framework: Critical Issues (Loucks-Horsley et al., 2009)
Choice in CPD (Hertz et al., 2022; McMillan et al., 2016; Organisation for Economic Co-Operation and Development, 2010)	Building capacity for sustainability

Time for CPD (Hertz et al., 2022; National Council of Curriculum and Assessment, 2016, 2022)

Teaching Environment (McMillan et al., 2016) Learning Culture

Relevance between CPD and practice (Harford, 2010; Murchan et al., 2009; National Council of Curriculum and Assessment, 2016) Scaling up

STiCC Framework for CPD Integration During Curriculum Reform

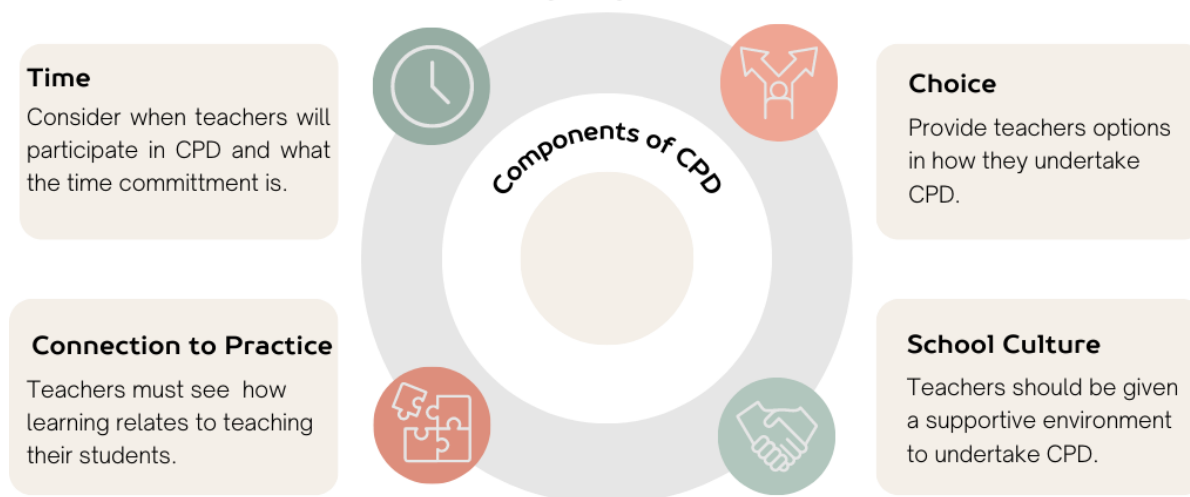


Figure 1. STiCC (School culture, time, choice, connection to practice) Framework for CPD During Curriculum Reform

Time for Continued Professional Development

Participating in sustained CPD can help impel teachers to continue learning and developing

research-based pedagogies (Darling-Hammond & McLaughlin, 2011). Unfortunately, teachers often find themselves with limited time to devote to CPD. A survey by the Organisation for Economic Co-operation and Development (OECD) indicated that 42% of secondary teachers worldwide identified scheduling conflicts as a leading reason for not participating in CPD (2010). Teachers also need time to implement, reflect, and develop the skills learned due to the CPD (Loucks-Horsley et al., 2009). Going through multiple cycles of success and failure as they implement new skills is essential to teacher learning. However, the time it takes to witness the positive effects of CPD is often lengthy (Postholm, 2018; Power & Goodnough, 2019). Educational leaders who organise and facilitate CPD should examine how to offer learning opportunities for teachers while working around the issue of time. Loucks-Horsely identifies four categories of how time can be structured to accommodate CPD: restructuring school-wide schedules, providing set times for teachers to learn together, re-examining existing free time, and purchasing additional time outside the regular schedule (Loucks-Horsley et al., 2009), which can be helpful to consider as a curriculum approaches implementation.

Time is particularly vital to examine when designing CPD that accompanies curriculum reform. Unlike traditional professional development opportunities in which teachers may be trying to upskill, CPD during curriculum reform requires teachers to learn a new curriculum and skills to implement it while simultaneously teaching the content. In addition, teachers may have new resources, assessments, and lessons to become familiar with and utilise. As a result, teachers may spend additional time planning and reflecting on lessons when first using a new curriculum (Altinyelken, 2010). Therefore, teachers' time to allocate to CPD may be limited, posing a challenge as the new knowledge and skills they must learn during curriculum reform may be considerable. Time can be a significant barrier to teachers'

CPD during curriculum reform, and careful planning is required to ensure teachers are given opportunities for professional growth.

Continued professional development should be ongoing and sustained throughout curriculum reform (Darling-Hammond & McLaughlin, 2011). Accomplishing this can be challenging during curriculum reform as time is scarce and often taken from other necessary tasks such as teaching or planning (Sugrue, 2011). Upon reviewing the DPMC, many pedagogical skills are identified that teachers will need to implement (Table 1). Depending on their current skillset, teachers may have an extensive amount to learn. Therefore, those in charge of organising CPD should collaborate with teachers to identify the essential skills to learn at the start of curriculum adoption and work with teachers' schedules to integrate learning.

Discussing the use of time for CPD would not be complete without considering how it relates to other aspects of professional learning. For example, choice in learning and connection to practice both share a relationship with time. Teachers may feel their time is ill-spent if they are forced to devote time to CPD not connected to their classrooms or given a choice in how they will spend their time. Therefore, the interconnectedness of all aspects of effective CPD must be considered.

Choice in Continued Professional Development

Professional growth goals are unique and can vary between teachers; therefore, offering a choice in CPD is central to ensuring training corresponds to teachers' goals. In the United States, teachers indicate they desire content-specific CPD tailored to their individual needs (Appova & Arbaugh, 2018). Unfortunately, catering to the broad learning needs of teachers is a challenge experienced globally. Eradicating choices from CPD pathways can be detrimental to teachers' life-long learning. An OECD survey of teachers in 30 countries reports the lack

of suitable CPD options as the number one reason for unmet professional development needs (2010). Alternatively, in Ireland, teachers reported that having a choice of CPD based on topic interest, career development, and learning that will improve teaching motivated them to participate (OECD, 2010). CPD detached from teachers' goals or needs is incredibly demotivating as it can negatively impact their desire to learn and embed the content into the classroom (McMillan et al., 2016). CPD, not meeting teachers' needs, can become nearly unproductive, often failing to enact changes in the classroom, leaving student achievement unchanged. Although meeting the diverse CPD needs of teachers can be difficult, it is necessary to identify approaches to overcoming this barrier to ensure CPD results in changes in practice.

Implementing a new curriculum, such as the DPMC, may require teachers to learn numerous new skills. Teachers must play a role in determining which skills they feel it necessary to learn first and devote their time to. Building autonomy into CPD can improve the teacher's chances of developing buy-in and applying the newly learned skills (E. Hargreaves et al., 2013). At a time in which teachers are potentially being asked to adjust their approach to teaching, giving them freedom as to how they choose to work toward full implementation may increase can help for a smoother transition. Realistically, it may be impossible for educational leaders to offer CPD for every teacher in each skill at the start. Therefore, teachers must be a part of the conversation on how CPD courses will be structured to increase the likelihood of each teacher's learning needs being met.

Connection to Practice

Continued professional development must ensure teachers find value in the learning by connecting the CPD directly to real-world situations. In the United States, teachers report that CPD should provide learning relevant to their classrooms in order for them to transfer

knowledge effectively (Appova & Arbaugh, 2018). Without this connection, teachers may fail to engage with the content or resist new learning altogether. All students must learn from teachers apprised of the best learning and teaching strategies to ensure equity and access to rigorous instruction (National Council of Teachers of Mathematics, 2014). Therefore, teaching and learning strategies taught in CPD must be connected to the teachers' practice and show how the learning is realistic to implement (Loucks-Horsley et al., 2009). Teachers who fail to see this connection may consequently dismiss learning.

In examining the DPMC, there are numerous changes in what students and teachers will be expected to do. To buy into the changes and implement them in the classroom, teachers must see the connection to the students they teach (Garet et al., 2001). Therefore, it is necessary for those designing and facilitating CPD during curriculum reform to make these connections explicit. Solidifying these connections can be complex as each student, classroom, and teacher is different; therefore, the relationships between CPD and real-world practice can differ. Teachers should be encouraged to share information about their students and themselves early in the professional learning process so CPD coordinators can ensure that the learning is relevant to each teacher (Hunzicker, 2011). In Ireland, progress is occurring in mathematics education at the primary level (Gilleece et al., 2020). Because of those successes, teachers may feel they do not need to learn and implement new skills. However, students in Ireland still struggle with developing the complex higher-level thinking skills necessary to become proficient in mathematics (Perkins, 2020). CPD offerings should ensure teachers understand why changes in instruction and curriculum are being introduced. In addition, teachers must have the opportunity to discuss their students' struggles and successes to ensure learning relates to their experiences in the classroom (Hunzicker, 2011). As before, connection to practice is closely related to time and choice. Teachers who have a

choice in the CPD they undertake may be more likely to see the connections between the learning and classroom environment.

School Culture

School culture can profoundly affect teachers' motivation to engage in CPD and implement learning. A study in Irish schools determined that positive interpersonal relations and school policy led to a culture that motivated teachers to undertake CPD (McMillan et al., 2016).

Without a supportive culture, teacher learning will likely have a short-lived impact on implementing the new knowledge and skills into their practice (Loucks-Horsley et al., 2009). A lack of a supportive culture within a school can do more than impede growth but can inflict negative experiences on teachers. Teachers may feel frustrated and resent schools that accept stagnation in professional growth and do little to support teachers' professional goals (Loucks-Horsley et al., 2009).

Principals and teachers must have the necessary skills to help develop positive school culture. Ensuring teachers have communication and collaboration skills, respect for one another, and the ability to have professional discourse is necessary for a supportive learning culture (Loucks-Horsley et al., 2009). Principals must be included in teachers' professional learning to provide necessary support and create a collective vision toward CPD at the school (Bredeson, 2000; Loucks-Horsley et al., 2009). Unfortunately, in Ireland, principals have not shown a high level of involvement in the professional growth of teachers. A survey of teachers in Ireland reported that 43% never received feedback from their principal (OCED, 2010). This lack of engagement may indirectly signal to teachers that continual reflection and growth in daily practice are not significant to principals. Building positive relationships with constructive feedback and praise can positively affect teachers' self-efficacy, as indicated in the Teaching and Learning International Survey (OECD, 2010). Principals should send the

message to teachers that sustained learning is necessary, motivate teachers to engage with CPD and value teachers' professional growth. Ensuring teachers are empowered to learn and grow as professionals is key to successful curriculum reform.

Approaches to CPD During Curriculum Change

The STiCC framework identifies time, choice, connection to practice, and school culture as focal points for effective CPD during curriculum change. Utilising the framework, educational leaders and facilitators of CPD can begin to use it to identify what methods of CPD could benefit the teachers they serve. Several approaches to CPD are effective, each with its pros and cons. In examining CPD options that may benefit teachers during curriculum change, a framework by Kennedy (2005, 2014) was identified as a helpful guide. Kennedy (2014) developed the spectrum of CPD models, which categorises models of CPD and the purposes they serve in the educational system. Kennedy explains that the purpose of the CPD should be identified first to choose the model that best serves teachers (2014). The transformative model of CPD is more likely to invoke lasting change in teacher practice due to increased teacher agency and autonomy (A. Kennedy, 2014). As a new curriculum is adopted, teachers may need to adjust their teaching practices and pedagogies. Therefore, CPD approaches that fall into the transformative category in Kennedy's (2014) framework may have the best chance of enacting long-lasting change in teacher practice and successfully enacting a new curriculum.

Purpose of Model	Examples of models of CPD which may fit within this category
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Transformative	Collaborative professional inquiry models
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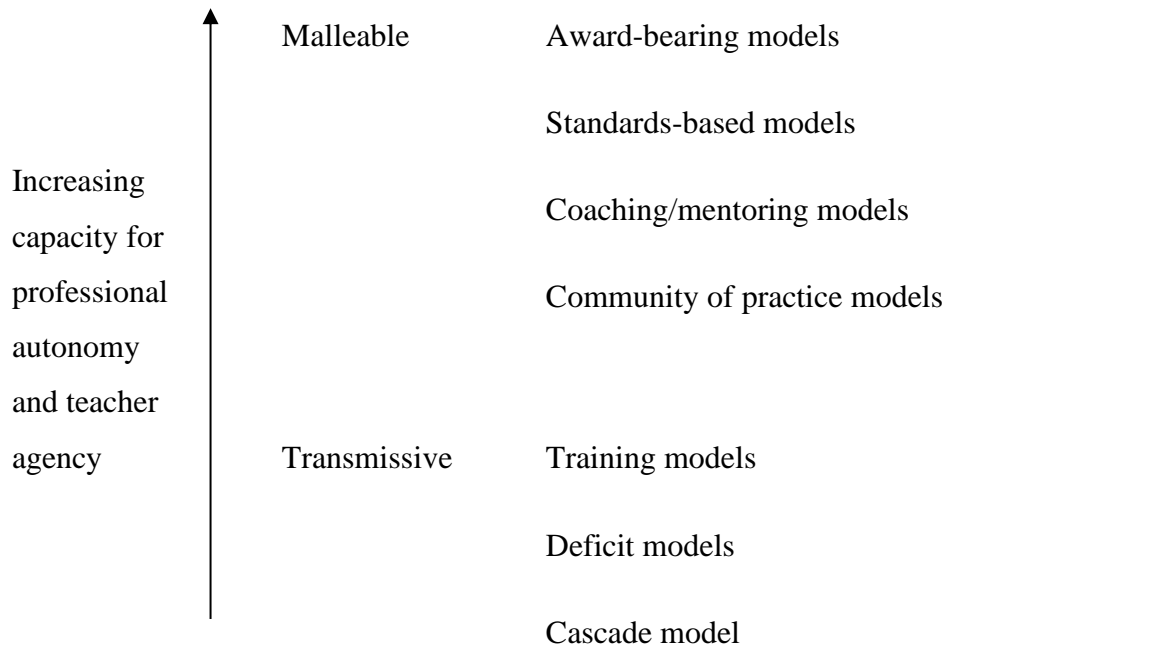


Figure 2. Spectrum of CPD Models adapted from (A. Kennedy, 2014)

After identifying the purpose of CPD during curricular change as transformative, it was necessary to understand if transformative models of CPD could address the four components identified in the STiCC framework (Figure 1). Using Kennedy’s (2014) framework, the CPD models of coaching, action research, and professional learning communities were all labelled transformative. Those CPD models were then examined using the STiCC framework. It was identified that these CPD models could address the components of time, choice, school culture, and connection to practice during curriculum adoption, as seen in Table 2. Each potential CPD model is described briefly below using the STiCC framework to consider the applicability of each during curriculum reform.

Table 3. CPD Models Potentially Useful During Curriculum Reform

Transformative CPD models (Kennedy, 2014)	Considers time	Considers choice	Considers culture	Considers connection to practice
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Instructional Coaching	X	X	X	X
Professional Learning Communities	X	X	X	X
Action Research	X	X	X	X

Instructional Coaching

As primary mathematics education continues to develop, instructional coaching should be considered a potential pathway to help teachers adapt their pedagogies. Instructional coaching centres on a partnership between a coach and a teacher, guiding professional learning through a focus on equality, choice, voice, dialogue, reflection, praxis, and reciprocity (Knight, 2012). Within instructional coaching, importance is placed on the one-to-one relationship between a teacher and the coach (A. Kennedy, 2005), resulting in many benefits that can help be successful during curriculum reform.

Due to the small group structure of instructional coaching, instructional coaches can adjust to teachers' schedules and time constraints. Teachers can also adapt the focus of the instructional coaching based on their current needs, which may change throughout the year. Due to the structure of instructional coaching, the quality of the time devoted to this form of CPD can be extraordinarily beneficial to teachers' practice (Warnock et al., 2022).

The one-on-one support teachers receive through instructional coaching helps to address choice and connection to practice. Teachers engaged in instructional coaching guide the area of focus when collaborating with the coach while choosing the intensity and depth of the learning (Desimone & Pak, 2017). Instructional coaching can be transformative, in which open dialogue can lead to challenging and progressing ideas and beliefs the teacher holds (A. Kennedy, 2005). Instructional coaching is directed by teachers' professional growth goals

and needs based on their current classroom experiences, which highlights it as a suitable model for CPD during curricular change.

Lastly, instructional coaching can potentially aid in developing a supportive school culture for CPD. Instructional coaching relationships focus on equity among ideas between the teacher and coach rather than the teacher being told what to do authoritatively (A. Kennedy, 2005). As a result of instructional coaching focusing on collaboration during learning, colleague relationships can be positively affected (Lieber et al., 2009). Teachers have reported benefits from instructional coaching, such as individualised support, focusing on their students and classroom, and participating in cycles of reflection on their practice (Teemant, 2014). Instructional coaching can offer a pathway to individualised teacher learning and assist teachers in addressing the issues they experience when learning professionally, particularly as they enact a new curriculum.

Professional Learning Communities

A Professional Learning Community (PLC) is a group of teachers or a cohort within a school that "...exists to bring about some innovation and change directly related to improving learner outcomes" (Harris & Jones, 2015, p. 15). PLCs can provide the environment for teachers to hear colleagues' experiences, insights, and ideas, creating a school culture focused on collective growth. Research out of Ireland indicates that CPD should encourage teachers to share and learn alongside one another (Harford, 2010), supporting the inclusion of PLCs at all schools. PLCs support a school culture in which the values and beliefs of teachers are shared in a trusting environment helping to develop growth in the school. Kennedy (2005) writes that this model of learning can develop "...powerful sites of transformation, where the sum total of individual knowledge and experience is enhanced significantly through collective endeavour" (p. 245). Building a school culture that emphasises the collective

professional growth of all teachers can help support curricular change and increase its likelihood of successful implementation.

Professional learning communities can also place value on choice and connection to practice. Teachers participating in PLCs take on the role of curriculum developers and should guide the discussions and lessons formed (Tam, 2015). This collaborative dialogue directed by teachers can provide a deep connection to practice. Buy-in to professional learning is more likely to occur when it addresses teachers' immediate concerns, thereby developing a school culture valuing lifelong learning (Allen, 2013).

A considerable barrier to effectively implementing PLCs within a school is time. Not only do schools need to schedule teachers to meet during a common time, but the structures necessary to implement successful PLCs may take time to build. Interpersonal relationships between teachers, students and school leaders impact the effectiveness of PLCs (A. Kennedy, 2005). Therefore, teachers must have time to meet with their colleagues regularly. Principals may need to get creative on integrating PLCs into teachers' schedules. However, it is vital to point out that PLCs should not be mandatory and must allow teachers the flexibility to attend if their schedule permits (DuFour & DuFour, 2013). The school culture must encourage and highlight the benefits of PLCs while allowing teachers the professional freedom of when and how to participate (A. Kennedy, 2005). As teachers learn to implement best-teaching practices in a new curriculum, PLCs can offer a local support system to help them grow professionally.

Action Research

Action research involves teachers participating in a structured form of reflective practice focused on research methodologies designed to bridge the gap between research and practice (McNiff & Whitehead, 2009). Teachers undergo iterative cycles to develop solutions to

problems affecting them or their students. Therefore action research encourages collaboration and discussion with colleagues, which teachers report as a positive by-product (Hardy & Rönnerman, 2011). This form of CPD positively impacts school culture by focusing on the importance of learning as a school community and as individuals.

A critical component of action research is that the teacher guides the research topic and progression in their CPD. The barrier of choice is overcome as teachers are free to select a problem area affecting their teaching and the pathway to a possible solution (A. Kennedy, 2005). The teacher will likely become invested in the research due to its connection to their practice, potentially invoking feelings of agency. Teachers claim action research can encourage them to share with colleagues, increase reflective practice, and develop pedagogical knowledge (Yigit & Bagceci, 2017). Due to the ability to guide the topic in action research, teachers increase the connection to practice. Action research has the potential for teachers to engage in reflective practice, leading to change in their classrooms (Connolly et al., 2021). Action research may not be entirely individualised, yet it emphasises the collective growth of all teachers involved and values the ideas of all group members (A. Kennedy, 2005). As a result, action research can help develop a school culture that supports a positive CPD experience for teachers and emphasises the importance of continued learning.

The iterative cycles that are the basis of action research demand that teachers devote time to reflecting on and adjusting instruction to generate a solution to their chosen problem successfully (López-Pastor et al., 2011). Despite the time commitment needed to implement action research effectively, it can be adapted to fit the teachers' capacity, needs, and constraints, such as scheduling. In addition, due to its transformative nature, after its completed, teachers can continue to benefit from the outcomes of the action research, therefore justifying the time required from teachers (Zehetmeier et al., 2015). Action research can encourage teachers to reflect and adjust learning as they enact a new primary

mathematics curriculum, thereby ensuring the issues which affect them are focused on within the learning.

Conclusion and Future Research

CPD continues to be an essential part of quality education systems. Over time, curriculums will inevitably reform as there is an increased understanding of how students learn. When this happens, teachers will be expected to adapt their teaching pedagogies and possibly their beliefs about education. During these transitions, CPD is critical to ensuring teachers understand the new curriculum, research that underpins it, and develop pedagogical skills to implement the updated curriculum effectively. CPD offerings during curriculum reform may need to look different due to the increased pressures on teachers to change their practice. It is, therefore important to understand which factors might heavily impact whether CPD is effective. The STiCC framework proposed in this paper highlights four aspects of CPD to pay particular attention to during curriculum reform. Time, choice, connection to practice, and school culture all play a significant role in ensuring teachers receive effective CPD during periods of immense change.

Before discussing the potential uses of the STiCC framework, it is important to highlight that it has not been thoroughly tested and analysed in a real-world context. The framework is being used and tested in an ongoing research project which aims to develop a method of CPD for primary teachers on utilising questioning in mathematics lessons. Therefore, while this framework may offer others insight into potential areas of CPD that may be helpful during curriculum change, it should be used cautiously. However, the four components of the framework are seen in the literature as necessary to CPD, and, therefore, we are confident it can act as a guide for those involved with or participating in CPD.

Additional research is still needed using the STiCC framework to determine its validity and useability

The STiCC framework can potentially aid in developing a CPD roadmap for teachers implementing a new curriculum. While this paper frames the discussion around mathematics education in Ireland, the commonalities between other subjects and countries are vast. Therefore, the framework could be applied to several other scenarios where curriculums are being revised. We believe the STiCC framework could aid in helping to select appropriate CPD for teachers and evaluating its progress to make improvements. Each school, teacher, and student is bound to have varying needs; therefore, those must be examined to identify the best route for professional learning. The models of action research, professional learning communities, and instructional coaching may be viable options for educational institutions to consider implementing during curriculum reform as they highlight the components of effective CPD indicated by the STiCC framework.

The success of CPD is highly dependent on a variety of factors. During curriculum reform, time, connection to practice, choice, and school culture may play an even more prominent role in determining the success of CPD programs. Teachers must receive quality CPD that meets their needs as teachers and ultimately positively affects student achievement. Students must receive instruction based on current best practices. As curriculums aim to achieve that goal and adjust, teachers will need CPD to help them enact the written curriculum to ensure students are equipped with skills pertinent to the 21st century.

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