Analysing the reasoning required by textbook tasks: how successful are tasks in translating policy into practice?

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Textbooks can be viewed as mediators between the intentions of policymakers and classroom teachers. We report here on a study in which textbook tasks and the opportunities for learning they afford were used as a lens through which the impact of the Project Maths curriculum reform in Ireland was observed. A total of 7635 tasks on the topics of *Differential Calculus* and *Patterns, Sequences and Series* in the three most widely used post-primary textbook series (pre- and post-reform) were examined using Lithner's reasoning framework. An analysis of the reasoning required to successfully solve these tasks concluded that 92% of the tasks required imitative reasoning alone, while only 8% of tasks required creative reasoning. There was, however, a statistically significant increase in the percentage of tasks requiring creative reasoning between the pre-Project Maths textbooks (4.5%) and those published post-Project Maths (11%). Nevertheless, our results indicate that learners are not being provided with sufficient opportunities to develop reasoning skills central to the reform agenda and that the textbooks examined did not successfully mediate the reform envisaged.

Keywords: creative reasoning; textbook analysis; curriculum reform

Introduction

The period from 2000 to 2010 saw a significant review of the post-primary mathematics curriculum in Ireland, culminating in the introduction of a major curricular revision in 2012; such large-scale curricular reforms are relatively rare in Ireland, occurring approximately every 20 years. The review was motivated by emerging evidence that mathematics teaching at post-primary level was highly didactic with an over-emphasis on procedures and routine exercises, and little focus on problem-solving (Conway & Sloane, 2005). There were also concerns around the performance of Irish students on both national and international assessments (National Council for Curriculum and Assessment [NCCA], 2005). The curricular revision (known as 'Project Maths'), which is still in use today, aimed to create a classroom environment where there was an increased focus on the development of student problem-solving skills and conceptual understanding (NCCA, 2012).

The curriculum developments in Ireland were not unique but formed part of a broader international movement in mathematics education reform that sought to reposition problem-solving and reasoning as central components of mathematical learning (OECD, 2024). Across many jurisdictions, curriculum designers attempted to move away from narrow, procedurally focused conceptions of mathematics towards richer views that emphasise sense-making and problem-solving. For example, Jader et al. (2020) list eight countries including Australia, Singapore and the USA as having such an ambition. Internationally, problem-solving is increasingly framed not as an endpoint of instruction, but as a primary means through which mathematical understanding is developed.

The Project Maths syllabus document defines problem-solving as ‘engaging with a task for which the solution is not immediately obvious’, and states that problem-solving is ‘integral to mathematical learning’ (NCCA, 2012, p. 10). The document also emphasises the role that tasks play in developing problem-solving skills:

> The quality of the tasks that learners engage with plays an important role in a problem-solving environment. A task must engage learners and present them with a challenge that requires exploration. Problem-solving tasks activate creative mathematical thinking processes as opposed to imitative thinking processes activated by routine tasks. Reasoning mathematically about tasks empowers learners to make connections within mathematics and to develop deep conceptual understanding (NCCA, 2012, p. 10).

The notions of creative and imitative reasoning or thinking processes mentioned here were originally introduced by Lithner (2008). Creative reasoning must be novel (for the student), plausible, and anchored in appropriate mathematical foundations, and it was this type of mathematical thinking that Project Maths sought to promote (NCCA, 2012). Conversely, imitative reasoning relies on the use of well-rehearsed methods or the memorisation of procedures. From the Project Maths syllabus document, it is clear that the policymakers wish students to develop their problem-solving skills by engaging with creative reasoning tasks, and that they see the use of tasks that require only imitative reasoning as insufficient to achieve the aims of the syllabus. It makes sense, therefore, to investigate the opportunities that are offered to students to engage in creative reasoning.

Mathematics textbooks are seen as one of the most influential factors in the teaching of mathematics and implementing reform. For instance, Usiskin (2013) reports that significant reform does not typically occur in the classroom until the key ideas of the reform have been manifested in textbooks. The latter are intended to exemplify the concrete steps that will successfully translate policy intentions into practice (Valverde et al., 2002). Tasks form a major component of mathematics textbooks and students spend a large proportion of their learning time engaging with such tasks (Jader et al., 2020). However, gaps have been identified between curriculum standards and textbooks in many countries (Foxman, 1999; OECD, 2024) which serve to undermine policy intentions, especially regarding the promotion of higher-order thinking. In Ireland, textbooks - which play a central role in mediating classroom practice - are produced commercially and without formal oversight from curriculum authorities (Foxman, 1999) affording additional potential for misalignment between the intended curriculum and enacted learning opportunities.

Thus, we report here on a study whose aim was to probe how national policy was enacted, using an examination of the textbooks tasks available both before and after the curriculum reform, and the opportunities for learning they afford, as a lens through which to observe the impact of Project Maths. A total of 7635 tasks on the topics of *Differential Calculus* and *Patterns, Sequences and Series* in the three textbook series most widely used were examined using Lithner's reasoning framework.

The research questions addressed in this paper are:

- Do the textbook tasks examined fulfil the expectations of the Project Maths reform in terms of its increased emphasis on problem-solving? Specifically, what kind of reasoning (imitative or creative) is necessary in the completion of these tasks?
- Are there differences between (a) textbook series, (b) pre- and post-reform textbooks, (c) versions of textbooks for different syllabus levels, in their proportions of tasks requiring imitative versus creative reasoning?

Conceptual Framework

Lithner (2008) distinguishes between two types of reasoning: imitative and creative. The essence of his reasoning framework is that "rote learning reasoning is imitative, while the opposite type of reasoning is creative" (Lithner, 2008, p. 256).

Reasoning is classified as imitative if it is founded on recalling a complete answer (e.g. a number fact or the memorised proof of a theorem) or recalling a solution algorithm. For the latter, all parts that are conceptually difficult are taken care of by the algorithm and the remaining reasoning required to complete the solution is deemed to be trivial. Only a careless mistake can prevent the correct answer from being reached. An imitative reasoning task can be solved either with limited understanding or with full understanding of the underlying algorithm or procedure.

On the other hand, reasoning is creative if it has the following three properties:

(1) *Novelty*: a new (to the reasoner) reasoning sequence is created, or a forgotten one is re-created.

(2) *Plausibility*: there are arguments supporting the strategy choice and/or strategy implementation motivating why the conclusions are true or plausible.

(3) *Mathematical foundation*: the arguments are anchored in intrinsic mathematical properties of the components involved in the reasoning. (Lithner, 2008, p. 266)

Some creative reasoning tasks may be solvable using an algorithm but the algorithm would need to be modified in a non-trivial manner. On the contrary, many creative reasoning tasks may not have a solution which is based on an algorithm and 'new' mathematical arguments are required throughout. In a recent article (Norqvist et al., 2025), Lithner and his colleagues emphasise the importance of the novelty property when deciding if a task is a creative reasoning task or not:

> In this study, a task that does not include a solution method and is not likely (by the researchers' experiences and earlier analyses of Swedish teaching) to be of a common type where a complete solution usually is memorized by students will be denoted CMR [creative mathematical reasoning] task (Norqvist et al., 2025, p. 412).

Thus, we will focus on the novelty of a task when classifying them, as novelty is a necessary condition for creative reasoning in this framework. Since our analysis concerns the reasoning needed to solve mathematics textbook tasks correctly (and not a particular student's work on a task), we assume that the solution must be plausible and have a mathematical foundation.

Literature Review

Reasoning and task types

Reasoning is "the line of thought adopted to produce assertions and reach conclusions"

(Boesen et al., 2010). As such it is essential for both the development and the evaluation of mathematical arguments, it enhances understanding and is intimately connected to problem-solving (Boesen et al., 2018; Jäder et al., 2020; Norqvist et al., 2025). Lithner (2017) notes that the development of reasoning, conceptual understanding and problem-solving skills can only be achieved through active engagement with challenging learning processes, such as the solving of non-routine problems and can have a profound impact on learners. Firstly, such tasks or activities for which students initially lack solution methods or templates give rise to a productive struggle through which students learn to explore and reason (Norqvist et al., 2025). Beneficial effects of productive struggle have also been seen in memory research, as the struggle that takes place during encoding facilitates memory retention.

Furthermore, Jonsson et al. (2014) have shown that students who practiced creative reasoning tasks out-perform students who only worked on imitative reasoning tasks on a test that included similar tasks to the imitative ones. In a follow-up study, Jonsson et al. (2020) showed that the same held for a test that consisted of transfer tasks where a previously seen algorithm could not be used but the main idea it encompassed could be employed. This supports Lithner's (2017) remark that "there is little or no transfer to such [reasoning, problem-solving] competencies from easier learning processes, such as imitation of given solution templates" (2017, p. 938). It seems that, when working on imitative reasoning tasks, students' failure to reflect on why given formulae, exemplars, or algorithms work makes it more difficult for them to recall and transfer the algorithms when needed for an unfamiliar context or task.

Norqvist et al. (2025) explored the impact of the repetitive practice of completing imitative reasoning versus creative reasoning tasks on student behaviour. They confirmed that students who practice solving imitative reasoning tasks tend not to internalize useful information but rather reread the given methods repeatedly from their classroom materials. On the other hand, students who practised tasks which required creative reasoning seem to commit their processes and approaches to memory. Moreover, the resulting act of repeated retrieval from memory has itself been shown to be a powerful tool when learning. Thus, there is evidence in the literature that engaging with creative reasoning tasks helps students' mathematical development.

Textbooks as mediators between policy and practice

In the context of curriculum reform, mathematics textbooks are widely regarded as instruments for the implementation of change in classrooms, providing a bridge from the 'intended curriculum' (the formally written documents outlining expectations for learning mathematics at a system level) to the 'implemented curriculum' (which operates at a classroom level through school and classroom processes as implemented by teachers) (Valverde et al., 2002). As such, they have an impact on how policy or standards are interpreted by teachers and the educational opportunities afforded to pupils. In this way they can both define and delimit such learning opportunities. Their importance is particularly evident when current or established practices must change, and teachers and pupils require sound and compelling illustrations from textbooks of ways in which new challenges can be met. Indeed, Valverde et al. (2002) argue that "textbooks are truly fulcrums whereby system-wide goals are likely to accomplish intended changes" (p. 170) and caution that the absence of solid guidance from textbooks in a reform context can prolong outdated pedagogical practice.

Glasnović Gracin and Jukic Matic (2021) also highlight the importance of the textbook during curricular reform as a "major conveyor of the curriculum" (p. 1373), not least because of its role as an authoritative *educative* resource for teachers regarding the new approaches espoused in the reform. They further suggest that monitoring the use of resources, and textbooks in particular, in the period of curricular change may improve our understanding of the processes of transformation and development in teaching and learning. Their longitudinal approach to studying a Croatian educational reform revealed the stability of the use of textbooks throughout its implementation, a finding which they report is “in line with the claim that curriculum reform is conducted through the textbook” (p. 1383).

Superfine et al. (2015) outline the importance of ‘fidelity of implementation’ research because of the critical role it plays not only in understanding how and why specific curriculum programmes work, but also how they can be enhanced. They also believe it is particularly important to examine written curriculum materials, including textbooks, because these artefacts mediate teachers’ actions and the extent of their accomplishment of curricular goals. Jäder et al. (2020) contend that the *proportion* of different kinds of tasks in a textbook, the solution methods they require and the mathematical thinking in which they enable students to engage can indicate the extent to which a particular text aligns with a competence framework.

Project Maths reform

The implementation of the Project Maths curricular reform has been studied to some extent and from a variety of perspectives. O’Keeffe and O’Donoghue (2012) studied the textbooks published in response to the initial stages of the roll-out of the Project Maths reform (ten in all), using an adaptation of the TIMSS curriculum framework (Valverde et al., 2002) through which they examined structure, content and expectations. They found that while, all of these textbooks displayed a genuine attempt to match Project Maths expectations, no one textbook met all requisite expectations, and that the treatment of problem-solving in particular was unsatisfactory across all textbooks. O’Keeffe and O’Donoghue (2012) subsequently recommended that all commercially produced textbooks be reviewed, culminating in a list of officially approved texts. O'Sullivan, Breen and O'Shea (2023) reported on another aspect of the analysis of the 7635 textbook tasks which are the subject of this paper. They described how the three textbook series examined neglected important objectives of the Project Maths curriculum such as providing opportunities for students to devise models or techniques, or to explain findings and justify conclusions in their completion of the tasks presented. In another study, Lubienski (2011) conducted classroom observations and interviews with Project Maths leaders and teachers, as well as an analysis of materials and textbooks. While she was impressed by the engagement from mathematics teachers in the reform process and the collaborative approach taken by the various groups involved in delivering the reform (NCCA, Department of Education and Skills (DES) etc.), she also raised questions about the clarity of the Project Maths' vision and the textbooks produced. In an exploratory study on the impact of Project Maths on students' learning, Jeffes et al. (2013) undertook a qualitative analysis of student work. They found that there did not appear to be a substantial change in what teachers were asking students to do as the reform was implemented, and recommended that students engage more regularly with high quality tasks which facilitate the thinking processes emphasised by the revised curriculum, namely, reasoning, problem-solving, and drawing out connections between topics. Finally, as part of an international study to better understand the support textbooks offer for the development of problem-solving skills, Jäder et al. (2020) examined 550 tasks from a single post-primary school mathematics textbook from Ireland. (This particular textbook was chosen to represent the offering in Ireland after the researchers had established that there were no major differences between the Algebra and Geometry tasks therein and those in other commonly used Irish post-Project Maths textbooks.) The results exposed a predominance of Algebra and Geometry tasks which could be solved by imitating given procedures alone, while only a small minority of the tasks on these topics required solvers to construct their own solution methods.

Contribution

Our comparative analysis of tasks from pre- and post-reform textbook tasks facilitates a unique investigation of the extent to which the policy intentions of the Irish Project Maths reform were enacted. Previous studies examining the implementation of this curriculum reform did not consider data from the pre-reform era and thus did not afford the quantification of a *change* in the learning opportunities provided to students. Furthermore, these other studies did not examine tasks per se, disregarding the importance placed on tasks by the policymakers (NCCA, 2012) and consequently overlooking an essential element of the reform.

Fan et al. (2025) report that the number of studies examining the alignment between curriculum reform and textbook content is growing and outline how the significance of mathematics textbook research is reflected in the number of international conferences and special journal issues dedicated to this topic over the past decade. Nevertheless, they call for more research to be undertaken on how the quality of textbooks can be evaluated, with the recognition that the calibre of student mathematical activities therein should be sufficiently high for a textbook to facilitate effective teaching. Our study illustrates how the quality of mathematics textbooks can be appraised in a systematic manner through the computation of the proportion of creative reasoning tasks they contain. Using Lithner's (2008) reasoning framework as an analytical lens, we explicitly investigate whether the central position of problem-solving and creative reasoning envisaged by the reform is reflected in the nature of the tasks with which students are expected to engage. In doing so, this study contributes to international discussions on curriculum enactment and the challenges involved in translating reform ambitions into classroom practice via instructional materials. This is particularly relevant considering the recent shift internationally to an emphasis on core competencies of problem-solving and reasoning, rather than content, in the evolution of curricula (OECD, 2024).

Irish Educational System/Context

In Ireland, post-primary or secondary education is divided into junior cycle (1st to 3rd year), an optional transition year (4th year), and senior cycle (5th and 6th year). Students typically start post-primary school at 12-13 years old and finish at 18-19 years old. At the end of senior cycle. the subjects studied are assessed by means of a high-stakes terminal state examination, called the Leaving Certificate (LC); entrance to university is entirely determined by students' LC results. While mathematics is not compulsory in senior cycle, the vast majority of students take this subject: in 2025, 98.8% sat the examinations in mathematics (State Examinations Commission (SEC), 2025). There are three choices of syllabi to be followed for mathematics: Foundation, Ordinary or Higher Level. Foundation Level is intended to provide students with the mathematical tools needed in their daily life; Ordinary Level goes a step further and provides techniques and knowledge necessary for the application of mathematics in a variety of future careers; whereas Higher Level is aimed at more able students who may study mathematics at the tertiary level and thus places greater emphasis on the notion of rigorous proof and the development of abstract thinking (NCCA, 2012). The majority of students tend to take the Ordinary Level examination: for instance, in 2025, 55% did so while 39% sat the Higher Level examinations, and only 6% took the Foundation Level (SEC, 2025). Foundation Level Mathematics is not accepted for entry to many university-level programmes.

Project Maths is a state-mandated national curriculum reform, developed by the NCCA and formally adopted by the Minister for Education, giving it statutory status within Irish post-primary education. The Project Maths initiative was introduced on a phased basis, beginning with pilot implementation in a small number of schools in 2008, followed by a national rollout from 2010, supported by teacher professional development. The syllabus changes were incremental, initially starting with changes to two of the five strands of the curriculum and eventually covering all strands with full implementation of the revised curriculum formally established by 2012 (Professional Development Service for Teachers [PDST], 2012).

Methodology

This study involved the examination of three textbook series for post-primary senior cycle mathematics: Active Maths (Keating et al., 2012a, 2012b; Murphy, 2001, 2002), Text & Tests (Cooke et al., 2012; Morris, 2003, 2004a, 2004b; Morris & Cooke, 2013; Morris, et al., 2012) and Concise Maths (Humphrey, 2003a, 2003b, 2004; Humphrey, et al., 2011, 2012a, 2012b). These series were chosen because they were the three most commonly used textbooks nationwide before the Project Maths reform and they have maintained their popularity since. They were also the first series to publish an updated version in response to the curriculum reform, with Text & Tests and Concise Maths retaining the authors from before the reform on their teams of post-reform authors, while the pre-reform author of Active Maths acted as an advisor to the team of authors post-reform. (In fact, before the reform, Active Maths was known as Discovering Maths but for simplicity, we will use the label Active Maths here for both pre- and post-reform versions.) We focussed on the senior cycle level because of the high- stakes state examination associated with it.

It was not feasible to examine all tasks from the chosen textbooks due to the volume involved. Instead, a total of 7635 tasks relating to the topics of *Patterns, Sequences & Series* (from the *Numbers* syllabus strand) and *Differential Calculus* (from the *Functions* strand) were investigated. These topics form part of both the Higher and Ordinary level syllabi and were present before and after the curricular reform and thus would allow for relevant comparisons to be made. As mentioned earlier, the Project Maths curriculum change was phased in over a number of years. When choosing the topics to investigate, we chose a topic from the first strand to be changed (*Numbers*), as well as one from the final strand to be altered (*Functions*). We did this in order to see if the textbook writers included more creative reasoning tasks over time.

The textbook chapters were organised in a similar manner across the series: each consisted of short subsections dealing with particular aspects of the topic. Subsections typically began with an expository section containing some motivation, definitions and worked examples, and ended with a list of "exercises". The 7635 tasks came from these exercise sections, though 16 were discarded before classification due to ambiguities in their interpretation caused by typographical or other errors. A task was seen as consisting of one question or prompt. In cases where a particular textbook exercise included a number of parts or questions, these were treated as multiple tasks and analysed individually.

The classification process used was very similar to that used in Boesen et al. (2010), Jader et al. (2015) and Mac an Bhaird et al. (2017). It involved three steps:

Step 1: The researcher formulated a solution to the task.

Step 2: The researcher searched the expository material and the worked examples preceding the task in the chapter concerned.

Step 3: The researcher classified the task as requiring 'imitative reasoning' only if a template (for instance, a formula, algorithm etc.) which could be followed to solve the task successfully was available to students. Otherwise, it was classified as requiring 'creative reasoning', similar to Norqvist et al. (2025). Note that we assume that a valid solution would be plausible and built on a mathematical foundation.

Each task was analysed independently by the first author along with at least one of the other authors to guarantee reliability and consistency. In the early stages of this project, small subsets of tasks were classified at a time and the results shared with the group at regular intervals. Differences which emerged were discussed in detail by the whole group until the application of the classification scheme was clarified and the differences resolved. Tasks which had been classified up until that point were reviewed and their classifications were revised if necessary – this ensured consistency throughout the analysis.

A unique identifier was assigned to each task and all necessary information about the task, together with the classification allocated to it, was recorded in an SPSS data file. SPSS was then used to carry out some basic descriptive statistical analysis on the data. Chi-squared tests (or Fisher exact tests when necessary) were also used to investigate whether relationships existed between particular pairs of the variables of interest.

Sample Tasks

Three sample tasks are included below to illustrate the classification process. In the textbook in question for Tasks 1 & 2, students were introduced to the notion of arithmetic sequences and given the formula for the *n*th term. Several worked examples on this topic were given before the exercise section of the chapter.

Task 1 – *Imitative Reasoning Task*: Find T_n the *n*th term of the following arithmetic sequence: 8, 13, 18, 23, …. (Cooke et al., 2006, p. 142)

Rationale for classification:

Step 1: This algorithmic task can be successfully completed using the formula $T_n = a + (n-1)\, d$, where a is the first term of the sequence and d is the common difference. Here a=8 and d=5, so T_n=8+5$(n-1)$.

Step 2: This formula was presented and explained at the beginning of the relevant chapter subsection, followed by worked examples showing how the formula would be applied.

Step 3: Since the formula and some worked examples were available in the textbook, the reasoning required to solve the task is not new to the student and so we classify the reasoning as imitative.

Task 2 – *Creative Reasoning Task*: The first eight terms of the Fibonacci sequence are given below. Describe in words how the sequence is formed and hence write out the next four terms in the sequence. 0, 1, 1, 2, 3, 5, 8, 13, 21, … . (Cooke et al., 2006, p. 138)

Rationale for classification:

Step 1: We expect that students would try to find a formula for the *n*th-term by experimentation and would eventually notice that each term is the sum of the two that precede it. This can be checked for the given terms of the sequence. This observation could then be used to find the next four terms: 34, 55, 89, 144.

Step 2: Students have not met the Fibonacci sequence earlier within the chapter, or indeed the textbook; nor have they met any sequence in which a term depends on more than one previous term.

Step 3: Thus, there was no algorithm or template available to the students to follow complete the task. To find the next four terms, students would have to check that their method for generating terms works for the examples given (thereby showing that their argument is plausible and has a solid mathematical foundation) and then apply their formula to find the new terms. Therefore, there was evidence of novelty, plausibility, and an anchoring to mathematical foundations in the reasoning required to bring the task to a successful conclusion.

In the section of the textbook from which Task 3 is taken, the expository material showed how to determine where a function is increasing or decreasing. An example showing that the derivative of a specific rational function is always positive is included before the exercise section.

<u>Task 3 - *Creative Reasoning Task*</u>: Let $f(x)=x^3+4x+2$. Explain why this function is bijective. (Humphrey et al. 2012a, p. 416.)

Rationale for classification:

Step 1: We expect that students would show that the function is always increasing on $\mathbb{R}$ (see Step 2 below) and then make a connection between monotonic functions and injections (probably using graphs and the horizontal line test). Students would then use their knowledge of the graphs of cubics to show that the range of the function is all of $\mathbb{R}$. Thus, f is injective and surjective and therefore bijective.

Step 2: This task appears in the *Differential Calculus* section of the textbook and is part (ii) of a question where the first part asked the students to show that the derivative of the given function was always positive. In a previous section of the textbook, students were introduced to the concept of bijections. They also saw examples of using the horizontal line test to decide if a function was injective.

Step 3: There was no algorithm or previous worked example available to the students to follow to complete the task. Students need to make connections between different concepts in a mathematically sound manner. Therefore, there was evidence of novelty, plausibility, and an anchoring to mathematical foundations in the reasoning required to bring the task to a successful conclusion.

Results

Considering all 7635 tasks examined, 607 (8%) were categorised as requiring creative reasoning for their solution, while 7028 (92%) could be solved using imitative reasoning alone (Table 1). Looking at the proportion of creative reasoning tasks in the textbooks published before the Project Maths reform in comparison with the textbooks published afterwards, we see that the overall proportion increased from 4.5% (162 tasks) to 11% (445 tasks).

Table 2 gives details of the proportions of creative reasoning tasks in the versions of each textbook (Active Maths, Text & Tests, Concise Maths) available for the Higher Level syllabus, and allows us to compare such proportions before and after the reform. Chi-squared tests (α=0.05) show that there was a statistically significant higher incidence of creative reasoning tasks in the post Project Maths textbook for each textbook series compared with its pre Project Maths counterpart (p<0.001 in each case). The same can be said for the Ordinary Level versions of the textbooks: there was a statistically significant increase in the proportions of creative reasoning tasks moving from pre to post reform textbooks ($p<0.001$ for Active Maths and Concise Maths series; $p=0.03$ for Text & Tests). Details are shown in Table 3.

Looking at each textbook series separately and comparing the proportion of creative reasoning tasks in the book for Higher Level with that for Ordinary Level, chi-squared tests ($\alpha=0.05$) show that there is a statistically significant difference in the proportions of creative reasoning tasks between Higher Level and Ordinary Level counterparts for the post-reform Text & Tests series only ($p=0.01$). In that case, there was a greater proportion of such tasks in the Higher Level version of the textbook. In all other cases (pre- or post-reform, any textbook series) there was no significant difference in the proportions of creative reasoning tasks in the Higher Level textbook compared with the corresponding Ordinary Level text.

Examining the breakdown of creative reasoning tasks across the topics of *Patterns, Sequences & Series* and *Differential Calculus*, reveals a different emphasis for different textbook authors. Table 4 shows details for the Higher Level textbooks in each series. For Active Maths, there is a similar proportion of creative reasoning tasks across topics (in both pre and post-reform textbooks) and the proportions of such tasks increased for both topics in the implementation of the curriculum reform. For Text & Tests, there was a statistically significant difference in the proportions of creative reasoning tasks available for each of the two topics and this difference was amplified in the implementation of the reform ($p=0.01$ for pre Project Maths text, $p<0.001$ post Project Maths on chi-squared tests with $\alpha=0.05$). For Concise Maths, there was a statistically significant higher proportion of creative reasoning tasks on *Patterns, Sequences & Series* in the pre-reform text ($p=0.01$) but this reversed as the reform was implemented with the post-reform text containing a higher proportion of creative reasoning on *Differential Calculus* ($p=0.01$).

Discussion

Textbook tasks and the reform

The results showed a startling majority of imitative reasoning tasks (92%) in the sample studied (Table 1). While there was a significant increase in the proportion of creative reasoning tasks, moving from pre-reform to post-reform textbooks, from 4.5% to 11%, the learning opportunities afforded by textbook tasks continue to be heavily dominated by imitative reasoning. In answer to our first research question, our findings seem to indicate that the textbooks published in response to the Project Maths reform failed to embody the bold new vision of post-primary mathematics in Ireland set out by the reform. We are not advocating that all tasks (or even the majority of tasks) in textbooks should require creative reasoning and we recognise that imitative reasoning tasks are also important for mathematical development, nevertheless the focus of the new curriculum led us to expect that the proportion of creative reasoning tasks in the new textbooks would be higher than 11%. Given textbooks' function as mediators between curricular intention and implementation, Conway and Sloane (2005) had argued prior to the Project Maths reform of post-primary mathematics in Ireland that a radical overhaul of the textbooks would be necessary in order to move toward the problem-solving orientation envisaged: this radical overhaul does not seem to have been realised. Furthermore, Table 4 shows the proportions of imitative and creative reasoning tasks across topics. As the *Patterns, Sequences and Series* topic was part of one of the first strands to be revised in the phased reform process, whereas *Differential Calculus* was part of the final strand to be revised, we were interested to explore whether this would affect the proportion of related creative reasoning tasks in the textbooks. Yet, it can be seen that despite the greater preparation time to revise the *Differential Calculus* tasks, the authors did not necessarily allocate a higher proportion of tasks for the promotion of creative reasoning. We also did not notice that authors modified tasks from the pre-reform textbooks. Sample Task 3 shown above illustrates how an existing pre-reform imitative reasoning task might have been modified to allow students to engage in creative reasoning, in this case through making a connection to another topic on the syllabus. However, our examination of the corpus of tasks selected did not reveal any evidence that textbook authors used such a strategy to enhance existing pre-reform tasks.

The dominance of imitative reasoning textbook tasks is supported by findings of Jäder et al. (2020) in their study of Algebra and Geometry tasks from the post Project Maths Active Maths series for Ordinary Level. They found that 86% of Algebra and 82% of Geometry tasks could be solved by imitating given procedures, a further 10% and 11% (of Algebra and Geometry tasks, respectively) could be solved with minor adjustments to the imitation of a given procedure, while only 5% of Algebra and 7% of Geometry tasks required solvers to construct solution methods. However, it should be noted that their study only examined approximately 550 tasks from a single Ordinary Level post-reform textbook from Ireland and so did not admit a comparison across textbooks, syllabus levels or pre- and post-reform. The dominance of routine imitative tasks is not peculiar to the Irish education system: findings from Jäder et al.'s (2020) study for commonly used textbooks from twelve countries (including Ireland) found that, overall, 79% of Algebra and Geometry tasks could be solved purely by imitating given procedures, with a further 13% involving minor adjustments only, and only 9% of the tasks required the construction of a solution method. Similarly, Brehmer et al.'s (2016) analysis of 5,722 Calculus tasks from three mathematics textbooks series for Swedish upper secondary schools found that only 5.45% of them were classified as 'mathematical problems' meaning that they required creative reasoning in their solution rather than imitative reasoning alone.

Creative reasoning tasks across textbooks

Regarding our second research question, the strong predominance of imitative reasoning tasks observed was true for each of the three textbook series examined. Moreover, proportions of imitative versus creative reasoning tasks were largely similar across syllabus levels (Tables 2 & 3), even though the Higher Level syllabus places more emphasis on rigour and abstraction and as a result textbooks for this syllabus may reasonably be expected to contain a higher proportion of challenging tasks. Indeed, apart from the post-reform Text & Test series, there was no statistically significant difference in the proportions of creative reasoning tasks between Higher Level and Ordinary Level editions. In fact, our results indicate that the between-series variation was more pronounced than the variation between syllabus levels. This suggests that opportunities for creative reasoning are more shaped by individual textbook authors or publishers than by official guidance regarding differentiation between levels.

O'Keeffe and O'Donoghue (2012), in their analysis of ten post-primary mathematics textbooks published in response to Project Maths (for both junior and senior cycle), concluded that all the textbooks examined fell short of the standard needed to support the Project Maths reform effectively. They uncovered disparities between the textbooks in the approaches taken to teaching for understanding and problem-solving, but they did not compare or contrast textbooks at different syllabus levels. Our findings are in broad agreement with the findings of O'Keeffe and O'Donoghue (2012), and those of other studies which also addressed the implementation of Project Maths (Lubienski, 2011; Jeffes et al., 2013), though the data collected and methodologies adopted are substantially different in each study (e.g.

teacher interviews, classroom observations, analysis of student work). These studies converged in concluding that there did not appear to be a substantial change in what students were being asked to do as the Project Maths reform was implemented and recommending that there should be greater engagement from all stakeholders with the key processes of reasoning and problem-solving as emphasised by the revised curriculum. As such, the study we report on here adds to existing research in the area by offering large-scale evidence of how the Project Maths curriculum reform was mediated through textbooks, through a study of 7635 tasks from 16 textbooks covering two syllabus levels from three different publishers.

Implications

Our results indicate that the goals of the reform syllabus were not met by the textbooks. Despite the focus of the Project Maths reform being on the development of conceptual understanding, creative reasoning and problem-solving skills, a dominance of textbook tasks based on the imitation of given solution methods prevails. Endeavouring to change the dominant task design has been described by Lithner as "one of the most persistent challenges in mathematics education" (2017, p. 937).

These findings have implications for student learning. While imitative reasoning plays a legitimate role in students' practice of skills and development of procedural fluency, previous studies have found that the pervasiveness of imitative reasoning tasks in textbooks can lead students to rely on superficial rote learning and does not afford the learning of mathematically founded reasoning, problem-solving or the development of conceptual understanding (Boesen et al., 2010; Lithner, 2017). Jonsson et al. (2020) agree and submit, on the other hand, that sufficient engagement with creative reasoning tasks leads to superior performance on both practised tasks and transfer tasks, while Norqvist et al. (2025) discuss the benefits of the 'productive struggle' evoked by engagement with creative reasoning tasks. Coming from a prevailing culture of didactic and procedural mathematics education in Ireland in the early 2000s (Conway & Sloane, 2005), the failure of the post-reform textbooks to enact a reformed vision of mathematics learning vis-à-vis reasoning is concerning. We do not argue here for a predominance of creative reasoning tasks in post-primary textbooks but rather an appropriate balance between the opportunities offered for imitative and creative reasoning - a balance which our findings indicate is not currently being achieved.

Why did the Project Maths reform not achieve the expected effects?

The production of textbooks in Ireland is a commercial enterprise and is effectively deregulated, with neither the NCCA (the statutory body charged with the development of curricula for Irish primary and post-primary schools), nor the government Department of Education commissioning, appraising or endorsing textbooks (Foxman, 1999). This can lead to a disconnect between the curriculum designers and the textbook authors, resulting in a lack of the coherence necessary, between policy and learning activities, to bring about the desired changes in student learning (Cai & Howson, 2012).

Krainer (2021) frames the implementation of curriculum reform as “a change-oriented process of endorsing an action plan” (p. 1185) made possible by the interactions of a community of ‘proponents’ (policymakers) with a community of ‘adapters’ (teachers, textbook authors). It would seem then that such interactions between proponents and adapters, and how they are mediated, are essential to ensure close alignment between the intended and the implemented curricula. The question thus arises, in the case of the Project Maths reform in Ireland, as to whether the interactions between proponents and adapters were appropriate and effective. This is particularly pertinent given the major change of focus necessary to ensure a break with traditional mathematics teaching and learning and communicate a richer view of what 'doing mathematics' means in line with the reform.

It seems that there was a failure to harness textbooks to ensure teachers (as well as pupils) were well-informed of the new approaches central to the reform and how they might be effected through learning opportunities for pupils. In fact, Lubienski (2011) went so far as to state that Project Maths leaders appeared to be "circumventing textbooks as opposed to leveraging them" (Lubienski, p. 45). It seems it would have been wise to have heeded Krainer's (2021) articulation of the process of implementation of change as having "a societal dimension, involving different stakeholders, jointly being co-responsible for a successful implementation" (p. 1180) and for greater engagement and collaboration between policymakers and textbook authors to have been facilitated and promoted in Ireland. Our results showed that textbook authors interpreted the curriculum documents differently. This is corroborated by Petersson et al.'s (2019) contention that students may be afforded very different learning opportunities in cultures in which textbooks are unregulated, typically resulting in a plethora of choice for teachers. As Usiskin (2013) remarks, textbooks convey to students a picture of what learning is expected; and textbooks which fail to adequately communicate the key curricular tenets work to disadvantage students.

In more centralised education systems in which administrative regulations and oversight mechanisms are standard, the alignment of textbooks with official guidelines is quite high (Benavot, 2011). Official curricular intentions tend not to be accurately captured in textbooks not only when textbook oversight measures are ineffective, but also in contexts where textbook production is largely commercial and there is a high expense attached to revising textbooks in the wake of new curricular reforms. Then textbook authors or editors often rely on past practices and existing materials, even when ‘new’ pedagogical principles are a main tenet of the reform (Benavot, 2011). We would urge Ireland’s NCCA to give thought to these points and how they might relate to textbook production in Ireland, and to consider establishing an oversight mechanism by which mathematics textbooks are at least approved by the NCCA, if not commissioned, before adoption in schools. However, it is important to acknowledge that a system in which textbooks are highly regulated is not necessarily a panacea (Charalambous &Philippou, 2010).

Another reason why a curricular reform may not achieve its intended results is because of difficulties that can arise in the implementation of curricular reform when the reform message is presented in a non-conspicuous way (Boesen et al., 2014), and when terms are not clearly defined and operationalized for the community of adapters. In such cases, the relevant terms may be easily filtered out or interpreted in such a way that coincides with how teaching is already performed. Merely assigning ‘problem-solving’ and ‘reasoning’ a central role in the description of a revised curriculum is clearly not enough, without furnishing a clear definition of these terms (Olivares et al., 2021). Benavot (2011) further explains that textbooks tend not to accurately capture official curricular intentions if the official guidelines lack specificity. This may explain why there was relatively little change to the type of tasks seen in textbooks in Ireland over the period of the implementation of the reform. The Project Maths curriculum documents (NCCA, 2012) referenced creative and imitative thinking processes without defining them, and although the documents made some attempts to operationalise the central tenet of ‘problem-solving’, this may not have been sufficiently conspicuous for the community of adapters and textbook authors in particular.

We recommend therefore that the goals of any new curriculum should be very clearly articulated, that the curriculum designers should cooperate with textbook writers, and that some official oversight of textbooks would be helpful in ensuring the curriculum message is delivered uniformly to all students and in the way desired.

Limitations

A limitation of our study is that the tasks examined addressed the topics of *Differential Calculus* and *Patterns, Sequences and Series* only. The study of other topics may have led to different findings. However, as mentioned earlier, our results were corroborated by those of Jäder et al. (2020).

Conclusion

The failure of textbooks to reflect curricular vision is not unique to Ireland: in fact, Valverde et al. (2002) found it to be common among the countries involved in the TIMSS study, leading them to lament that the primary relationship between system-wide policies and the achievement of children is through textbooks. Many of these TIMSS countries reported embarking upon school mathematics reform in which problem-solving and reasoning received increased emphasis. Nonetheless, we share the perspective of Boesen et al. (2014) in their discussion of a Swedish national school mathematics reform. They regarded that reform as an ongoing process rather than an event that happened right when the ideas of the reform were first introduced fifteen years prior. As such, we recognise the continued opportunities for Project Maths textbooks and teaching to evolve, supported by future productive interactions between proponents and adapters of the reform.

Additionally, we note the observation that textbook research has the potential to influence future curriculum reform (Fan et al., 2025). To that end, we hope that studies such as ours, which aim to measure whether a reform has been implemented with fidelity, will contribute to our collective understanding of how outcomes, in terms of both policy and practice, can be improved.

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	Pre Project Maths	**Post Project Maths**	**Total**
Creative Reasoning	162 (4.5%)	445 (11%)	607 (8%)
Imitative Reasoning	3422 (95.5%)	3606 (89%)	7028 (92%)
Total no. of tasks	3584	4051	7635

Table 1: Imitative and creative reasoning tasks across all textbooks published before the Project Maths reform and published after the reform

		Pre Project Maths	**Post Project Maths**
Active Maths	*Creative Reasoning*	6.6% (56)	15.2% (135)
	Imitative Reasoning	93.4% (796)	84.8% (756)
	Total no. of tasks	852	891
Text & Tests	*Creative Reasoning*	4.3% (28)	10.3% (65)
	Imitative Reasoning	95.7% (616)	89.7% (566)
	Total no. of tasks	644	631
Concise Maths	*Creative Reasoning*	3.6% (25)	10.1% (84)
	Imitative Reasoning	96.4% (660)	89.9% (747)
	Total no. of tasks	685	831

Table 2: Reasoning proportions for Higher Level textbook in each of three series examined

		Pre Project Maths	Post Project Maths
Active Maths	*Creative Reasoning*	4.3% (23)	11.7% (76)
	Imitative Reasoning	95.7% (513)	88.3% (571)
	Total no. of tasks	536	647
Text & Tests	*Creative Reasoning*	2.1% (8)	4.9% (23)
	Imitative Reasoning	97.9% (378)	95.1% (448)
	Total no. of tasks	386	471
Concise Maths	*Creative Reasoning*	4.6% (22)	10.7% (62)
	Imitative Reasoning	95.4% (459)	89.3% (518)
	Total no. of tasks	481	580

Table 3: Reasoning proportions for Ordinary Level textbook in each of three series examined

		Pre Project Maths		Post Project Maths	
		Patterns, Sequences, Series	Differential Calculus	Patterns, Sequences, Series	Differential Calculus
A M	*Creative Reasoning*	7% (22)	6.3% (34)	16% (52)	14.7% (83)
	Imitative Reasoning	93% (294)	93.7% (502)	84% (273)	85.3% (483)
	Total	316	536	325	566
T T	*Creative Reasoning*	7.5% (15)	2.9% (13)	21.6% (42)	5.3% (23)
	Imitative Reasoning	92.5% (184)	97.1% (432)	78.4% (152)	94.7% (414)
	Total	199	445	194	437
C M	*Creative Reasoning*	5.7% (17)	2.1% (8)	6.7% (24)	12.7% (60)
	Imitative Reasoning	94.3% (281)	97.9% (379)	93.3% (336)	87.3% (411)

	Total	298	387	360	471

Table 4: Reasoning proportions for Higher Level textbook in each of three series examined (AM: Active Maths, TT: Text & Tests, CM: Concise Maths), broken down by topic