The Development of the 'English Pre-Service Primary Teachers' Beliefs concerning the Integration of Children's Literature in Mathematics Learning and Teaching' (EPPTB-ICLMLT) Framework: An Exploratory Study

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Abstract

While much has been written about how children's literature can be integrated in mathematics instructions, very little has been written about perceptions on such integration as held by teachers, particularly teacher trainees. Such research gap is worrying given how it has been argued that teachers' beliefs can influence their instructional practices, and that any attempt to improve the quality of their teaching must begin with an understanding of their beliefs. As part of an international research collaboration (see www.mathsthroughstories.org), this paper reports the content analysis of open-ended survey responses concerning the integration approach, as elicited from 109 primary teacher trainees in England. The analysis yielded 9 themes and 93 sub-themes (or categories), demonstrating a wide range of teacher trainees' beliefs concerning the approach. These themes and categories subsequently formed the *English Pre-Service Primary Teachers' Beliefs concerning the Integration of Children's Literature in Mathematics Learning and Teaching* (EPPTB-ICLMLT) framework.

Keywords:

Children's literature; picture books; primary mathematics learning and teaching; teachers' beliefs; pre-service mathematics teacher education

Introduction

Improving young children's mathematical understanding and their attitude towards mathematics has been a priority for many governments around the world (e.g. Singapore's Ministry of Education, 2012; UK's Department for Education, 2013). In the context of England, such goals are particularly imperative when only 44% of Year 5 children (9-10 years old) reported that they 'like' mathematics and just 33% reported that they are confident in the subject (International Association for the Evaluation of Educational Achievement, 2012). The situation is worse for older children, with only 14% and 16% of Year 9 children (13-14 years old) reporting that they like and feel confident in the subject respectively (IEA, 2012).

Arguably, one of the more affordable teaching and learning resources that has the potential to achieve those goals is children's literature. Through story narratives, children discover that mathematics is part of their everyday life, and as such it provides a meaningful context for them to explore and investigate mathematical concepts and develop mathematical skills (Billings & Beckmann, 2005). Leading developmental psychologists, such as Donaldson (1979) and Hughes (1986), have also shown in their experiments that children perform better on mathematical tasks that are situated in contexts that are meaningful and comprehensible for them; more so than when the problems are presented in an abstract form. In addition to the potential cognitive gain, children's literature can also arguably foster a more positive attitude towards and confidence in the subject as story plots are usually presented in an engaging manner and hence make mathematics learning seems less daunting.

Despite the potential pedagogical benefits of integrating children's literature in mathematics instruction as outlined above, whether or not this approach will be adopted largely depends on several key factors - one of which is the willingness of teachers to actually implement the approach as it is not a statutory requirement to teach mathematics using such resource in England. Thus, knowledge and understanding of teachers' beliefs and perceptions on this approach is arguably vital. This study will go further and argue for benefits in examining the beliefs as espoused by teachers during their training. Consequently, pre-service teachers' beliefs on the integration approach will form the focus of this paper.

Theoretical perspectives

It is hard to define social-psychological constructs, such as *belief* as they are not directly observable and thus they have to be inferred (Leder & Forgasz, 2002). Drawing from the works of Furinghetti and Pehkonen (2002), Goldin (2002) and Op't Eynde, de Corte and Verschaffel (2002), Trakulphadetkrai (2012) attempts to define belief by contrasting it with *knowledge*. He argues that the former differ from the latter in three key areas, namely *consensuality, disputability* and *stability*. Instead of viewing belief and knowledge as either possessing or not possessing these characteristics, Trakulphadetkrai (2012) posits that they should be viewed in terms of magnitude. More specifically, knowledge is, to a large extent, more consensually, more undisputedly and more strongly held, while belief is largely personal and subjective and as such it is more likely to be held much less consensually, much less undisputedly and much less strongly.

Beliefs, together with knowledge, concerning subject matter, and its teaching and learning form part of *teacher identity* (Collopy, 2003), which can be "shaped and reshaped in interaction with others in a professional context" (Beauchamp & Thomas, 2009, p. 178). Such malleability is crucial as it highlights the role of teacher education and how training can shape teacher trainees' identity and hence beliefs. Added to that, an investigation into teachers' beliefs about teaching and learning is crucial for Thompson (1984) argues that "any attempt to improve the quality of […] teaching must begin with an understanding of the conceptions held by the teachers" (p. 106), for "the beliefs teachers hold influence their perceptions and judgements, which, in turn, affect their behaviour in the classroom" (Pajares, 1992, p. 307). Examination of such beliefs is arguably particularly crucial in the context of teacher education for "there is considerable evidence that the entering beliefs of teacher candidates strongly affect what and how they learn [to be a teacher], and eventually how they approach teaching in the classroom" (Richardson, 2000, p. 9). In the context of teacher development, such beliefs in teaching and learning can also be referred to as *pedagogical content knowledge* (PCK), a term coined by Shulman (1986, 1987), who argues that it is not enough for teachers to possess just content knowledge and general pedagogical knowledge. For him, PCK bridges this gap as it is "the blending of content and pedagogy into an understanding of how particular [subject] topics,

problems, or issues are organised, represented, and adapted to the diverse interests and abilities of learners, and presented for instruction" (Shulman, 1987, p. 8).

In the relation to this study, while much has been written about how children's literature can be integrated into mathematics instructions (e.g. Bintz, Moore, Wright, & Dempsey, 2011; Borden & Geskus, 2001; Moyer, 2001; Usnick, McCarthy, & Alexander, 2001), very little has been written about teachers' beliefs on such integration (Cotti & Schiro, 2004).

The current study thus believes that an examination of pre-service teachers' beliefs, particularly in relation to the integration of children's literature in mathematics instruction, can bring to bear and address misconceptions or gaps, if any, in trainees' knowledge of the approach much early on in their teaching career.

Literature review

Over the past decades, research into children's literature in mathematics teaching and learning can be categorised into two broad areas, namely *potential cognitive and affective gains* and *selection criteria*.

Research concerning potential cognitive and affective gains

A small number of empirical studies over the past decades have attempted to investigate potential cognitive and affective benefits of integrating children's literature in mathematics instructions. For example, Jennings, Jennings, Richey and Dixon-Krauss's (1992) study of 61 kindergarten children in Arkansas, USA concluded that those in the intervention group whose teachers incorporated children's literature into their mathematics instructions for five months demonstrated a statistically significant improvement in their mathematics test scores, interest in the subject and the frequency in which they used mathematical vocabulary when compared to their peers in the comparison class whose teachers relied on traditional instructional method and resources e.g. workbooks and counting objects to teach mathematics.

Similarly, Hong's (1996) intervention study of 57 kindergarteners in South Korea showed that more children in the intervention group who received mathematics related storybook reading and discussion time preferred the mathematics corner and more likely to choose mathematics tasks. Further, these children were also found to do significantly better than their peers in the comparison group in the classification,

number combination, and shape tasks. Hong (1996) attributed this to how children's literature can motivate children to pursue mathematics activities related to the story independently and that such motivation is positively related to cognitive engagement and hence cognitive development.

In Young-Loveridge's (2004) study of 106 children in their first year of school in New Zealand, it was found that children in the intervention group who were withdrawn in pairs to work with a specialist teacher using number books (and games) produced statistically significant gains in their mathematics performance in a range of areas (e.g. counting, pattern recognition, numeral recognition, addition and subtraction, among others), when compared to their peers in the comparison group.

Additionally, both van den Heuvel-Panhuizen and van den Boogaard's (2008) and Elia, van den Heuvel-Panhuizen and Georgiou's (2010) studies of four 5-year old children in the Netherlands and Cyprus respectively, who were individually read a mathematics-related picture book to without prompting, showed that the pictures in the book could greatly elicit children's mathematical thinking, particularly those that are concerned with spatial-awareness, numbers, and to a less extent measurement. More recently, van den Heuvel-Panhuizen, Elia and Robitzsch's (2016) study of 384 pre-school children across 18 schools in the Netherlands also found that the picture book reading programme had a positive effect on the children's mathematics performance on number, measurement and geometry.

While the goal is not strictly on exploring the effectiveness of children's literature in mathematics learning, English's (2012) 3-year longitudinal study of over seventy 6-7 years old children in Australia illustrates how children's literature can be used to provide a meaningful context for the children to develop their knowledge and understanding of data modelling.

To a large extent, it can be argued that the pedagogical benefits observed in the above studies can be explained by a number of factors. For example, children's literature can provide a meaningful and relevant context to embed mathematics learning and teaching in (Billings & Beckmann, 2005). It might also be useful to note that by meaningful and relevant context, it is not exclusively limited to *real-world* contexts for Wiest (2001) argues that fantasy contexts can also be just as good, if not more engaging and more effective in fostering children's creativity and imagination.

The visualization of mathematical concepts, through illustrations, is a key component of effective mathematics teaching and learning (Haylock & Cockburn, 2013) as it helps mathematics learners translate mathematical notations and symbols to a form that they can access more easily. This is highlighted in England's primary mathematics curriculum: "Mathematics is an interconnected subject in which pupils need to be able to move fluently between representations of mathematical ideas" (DfE, p. 3). *How big is a million?* (Milbourne, 2007) is an example of a book that places an emphasis on learning mathematical concepts visually. The story is about a penguin who wants to know how big a million is. In his quest to find the answer to that question, he comes across 10 fish, 100 penguins, 1,000 snowflakes and finally 1,000,000 stars that are colourfully illustrated and printed on a big folded-out foster at the end of the book.

Courtade, Lingo, Karp and Whitney (2013) argued that children's books can be used to address common mathematical misconceptions and highlighted as an example that teachers too often display an image of an equilateral triangle in a traditional format when teaching two-dimensional (2D) shapes. Arguably, children in these teachers' classes could then potentially develop a misconception that an equilateral triangle is the only form of 2D triangle. Courtade et al. (2013) suggested that children's books, such as *The Greedy Triangle* (Burns, 1994) can be used to address this potential misconception as the book illustrates a variety of triangles in the everyday context e.g. a sandwich (right-angled triangle) and a boat sail (scalene triangle), among others.

Another factor is children's literature ability to make cross-curricular links with other subjects. Such cross-curricular integration is endorsed by England's recently revised primary mathematics curriculum, which stipulates that children "should also apply their mathematical knowledge to science and other subjects" (DfE, 2013, p. 3). Teachers can, for example, link mathematics with writing by reading *Measuring Penny* (Leedy, 2000) to children and ask them to write their own short story about some of the issues their characters experience when using non-standard units to measure objects. *If the World were a Village* (Smith, 2004) can also be used to link mathematics (ratio) with geography and global citizenship (world population in different continents and countries), while *Grandfather Tang's Story: A Tale Told with Tangrams* (Tompert, 1998) can be used to teach children that tangram is essentially a set of seven 2D shapes that can be arranged to create a wide range of

different interesting compound shapes before encouraging them to create their own creative artworks based on their chosen tangrams.

Finally, Lake (2009) also suggests that mathematics-related children's literature provide opportunities for teachers and their pupils to discuss about mathematics, and in effect, to use mathematical language. Such view resonates that of Janes and Strong (2014) who argue that children's books have the potential to "engage children in meaningful and reflective conversations, discussions, and investigations in productive mathematics discourse" (p. 140).

Research concerning selection criteria

Another strand of research that focus on the use of children's literature in mathematics teaching and learning is centred around the development of selection criteria of children's literature. It is not my intention here to present a full summary of the history of this research strand as Flevares and Schiff (2014) have already done so recently. Instead, the focus of this section is to present a brief discussion on some of the recurring themes as found across the different frameworks.

A number of selection criteria frameworks have been proposed over the past decades to help teachers select and hence assess the quality of children's literature for their mathematics instruction. These frameworks vary in *length* (from just a few to over 20 criteria) and *focus* (some focus on the mathematical aspects of the books only, while other also focus on the literary aspects). For the purpose of brevity, the discussion here will focus on six recurring criteria which can be found in some, if not all, of the following frameworks: *Hellwig, Monroe and Jacobs's (2000)* 5-criteria framework; *Hunsader's (2014)* 12-crietria framework as adapted and reduced from the original Schiro's (1997) 22-criteria framework; *Marston's (2010)* 7-criteria framework; and *van den Heuvel-Panhuizen and Elia's (2012)* 4-criteria framework.

These common criteria are concerned with the extent to which the book's mathematical content is intellectually and developmentally appropriate for its audience (Hellwig et al., 2000; van den Heuvel-Panhuizen & Elia, 2012) as well as the extent to which the mathematical content in the book is presented accurately and visually (Hellwig et al., 2000; Hunsader, 2014; Marston, 2010). That the mathematical content should be represented visually will, however, depend largely on the literary format in question for it would not be sensible to suggest that a

mathematics story book is of poor quality for its lack of illustrations when compared to what are available in picture books.

Additionally, children's books for mathematics instruction should be chosen based on the extent to which it promotes meaningful connections between the different mathematical strands; between mathematics and other curricular subjects; and between classroom mathematics and children's everyday mathematical experiences (Hellwig, Monroe & Jacobs, 2000; Marston, 2010; van den Heuvel-Panhuizen & Elia, 2012), as well as the extent to which it promotes mathematical processes, such as problem solving and posing, and engage children and foster positive attitudes towards the subject (Marston, 2010; van den Heuvel-Panhuizen & Elia, 2012).

Finally, whilst not specific to mathematical contents or processes, it has also been proposed that children's books for mathematics instruction should also be assessed on the extent to which the story in the book promotes inclusiveness, be it gender equity or cultural and socio-economic diversity (Hunsader, 2004; Lake, 2009; Marston, 2010).

It is important to reiterate that the above criteria represent those that are common across the frameworks only, and are, by no means, the only criteria. Other criteria, as proposed by some of the aforementioneded frameworks, do also exist, but can only be found in only a particular framework e.g. A book should present an appropriate view of mathematics, as found in Schiro's (1997) and no other frameworks.

Previous studies on teachers' beliefs about the integration of children's literature in mathematic learning and teaching

To the best of the researcher' knowledge, there have only been three empirical studies that examine teachers' beliefs and perceptions concerning the integration of children's literature in mathematics learning and teaching, namely studies of Alazzi (2006), Cotti and Schiro (2004), and Wilburne and Napoli (2008), all were conducted in the US.

Alazzi's (2006) study explored the aforementioned integration perceptions of 85 pre-service primary teachers who enrolled at a Midwestern university. Three children's picture books with geometric content ('Grandfather Tang's Story', 'A Cloak for a Dreamer' and 'The Greedy Triangle') were read aloud to the participants

by the researcher. They were subsequently asked to write a reflection on these books from both their personal standpoint and their perspective as a pre-service teacher. The analysis of their written responses yielded six different recurring themes: 1) *'making personal connections with the literature'* – relating how the stories in the books resonate with certain aspects of their personal life; 2) *'reading for children'* – predicting how children would react to the stories; 3) *'being a teacher'* – reflecting on the values they as a teacher place in these books; 4) *'looking for the math'* – identifying mathematical contents in the books; 5) *'finding instructional ideas'* – identifying methods in which the book contents can be embedded as part of their teaching, and 6) *'focusing on morals'* – identifying opportunities to teach moral points in the stories.

Wilburne and Napoli's (2008) study examined the aforementioned beliefs of 8 pre-service teachers at a Northeastern university who were asked to design an upper primary-aged lesson based on the storyline of a young adult novel, titled 'Chasing Vermeer' (Balliet, 2004) with a focus on mathematical topics relating to pentominoes, such as transformations, lines of symmetry, area and perimeter. Qualitative data from a wide range of sources (e.g. unstructured interviews, reader response journals as they read the book, and their lesson plans among others) were analysed through the process of coding. Three common themes emerged, namely *1) the use of literature helps motivate students to want to learn mathematics; 2) designing mathematics lessons around literature helps make the mathematics more meaningful;* and *3) teachers need to make mathematical connections with literature*.

Cotti and Schiro's study (2004) was conducted at two Northeastern universities with 109 pre-service undergraduate-level teachers and 18 experienced teachers enrolled on a graduate level course. The participants completed the Mathematics and Children's Literature Belief (MCLB) Inventory, which was adapted from the researchers' more general Curriculum Belief Inventory that had been originally constructed in 1975. The MCLB Inventory has six sections: *instructional purposes, teaching, learning, knowledge, childhood* and *evaluation*, and each section contains four different statements reflecting four ideological stances that the participants were asked to rank according to their preference.

One key distinction between Alazzi's (2006) and Wilburne and Napoli's (2008) studies on the one hand and Cotti and Schiro's (2004) on the other is their approach to elicit teachers' perceptions. Whilst the former two studies let the different

beliefs emerged from the teachers' interview responses and their written reflections, the latter adopted the top-down approach using a fully structured survey instrument, which had originally been designed with something else in mind. Such approach prevented any beliefs which were not part of the researchers' analysis framework from emerging. This methodological shortfall was acknowledged by the researchers themselves for Cotti and Schiro (2004) pointed out that "simplification of the more complex portrayal of teacher ideology is one limitation of this research" (p. 352).

Research Question

Drawing from the research gaps as highlighted above, this study thus sets out to examine the following research question: 'What are trainee teachers' beliefs concerning the integration of children's literature in primary mathematics learning and teaching?' In the context of this study, children's literature will be taken to refer to *imaginative stories that are written predominantly with, but not exclusively to, children of various sub-groups in mind, varying in lengths, writing styles, formats and genres and can be either for children's entertainment or education or both*.

Methods

Research Design

In order to explore developing teachers' beliefs concerning the place and role and of literature in the teaching and learning of mathematics, a cross-sectional survey was carried out. The reason for choosing a survey was that it allowed for a large amount of data to be collected. As the research was concerned with what trainee teachers' beliefs were and not why, this research design was considered the most appropriate.

Data Collection

An open-ended electronic survey instrument was constructed to elicit the pre-service teachers' beliefs, and was piloted with a small group of 10 teacher trainees in September 2014. The data for this paper were collected in the Spring 2015 and explores responses to one of the survey items that asked the participants to list the first five thoughts that come to their mind when they think of the integration of children's literature in primary mathematics teaching and learning. They were given a table with three columns: the first column simply listing: '1st Thought'; '2nd Thought', and so on. The participants were then invited to write their thoughts in the second

column, with description and clarification in the third column. For example, a trainee wrote "Relation to real life" in the *Thought* column (the second column) and adding "A story can show the children how the skill they have learnt can be needed in real life" in the *Description* column (the third column). However, in the pilot study, a few participants commented that this was quite difficult as they were not sure of the distinction between *thought* and *description*. Thus, in order to demonstrate to the survey participants in the post-pilot stage how this table ought to be completed and in what depth, an example on a different topic was offered. The example was based on the first three thoughts that came to mind when the researcher thought of 'Thailand'. 'Warmth', 'Tasty food', 'White sand beach' were listed in the *Thought* column. In the *Description* column for 'Warmth', the following statement was given: "It's so warm and sunny there. It's so cold here in my office, and this makes me want to visit Thailand". The given example was different to the focus of the research in order not to influence the participants' thoughts on the topic.

Whilst it may appear simplistic in nature, this method of data collection is deeply rooted in the Jungian notion of *complex*, or a "core or pattern of emotions, memories, perceptions, and wishes in the personal unconscious organized around a common theme" (Shultz & Shultz, 2009, p. 95). To elicit his participants' complex, Jung made use of the word association test where a list of words was read out to each participant, who was then asked to say, as quickly as possible, the first thing that came to their mind in relation to each of those words, with the time taken recorded for further analysis (Jung, 1910). To an extent, such approach is one of the many so-called *projective techniques,* in which ambiguous stimuli are given to participants in an attempt to elicit their unconscious mind through the association they make with those stimuli (Cooper & Schindler, 2006). The use of the word association test is evident in empirical studies in a wide range of disciplines, including but not limited to *business management* (e.g. Goliath, Farrington & Saunders, 2014; Roininen, Arvola, & Lahteenmaki, 2006), *cultural studies* (e.g. Szalay, Strohl, Fu & Lao, 1994) as well as *education* (e.g. Kostova & Radoynovska, 2008), among other disciplines. Similar to the original approach as employed by Jung (1910), the word association test in these studies was presented as continued and time-limited, meaning that participants are asked to think of as many words as possible relating to the given stimuli within a specific duration e.g. 1 minute. Arguably, one of the fundamental flaws of this design is that it fails to allow the participants to elaborate on meanings of their associated

words, forcing most of the interpretation to be done solely by researchers. Subsequently and as described previously, the word association test has been adapted for the current study by allowing participants to elaborate their thoughts in the 'Description' column and without any time limit. It is thus hoped that such adaptation will introduce an alternative way of administering the word association test for studies that set out to explore their participants' beliefs and perceptions.

Sample

The survey was distributed electronically via email to 236 Years 1 – 4 students enrolled on the BA Ed in Primary Education programme at a teacher training university faculty in the South East of England in late 2014 and early 2015. From these, 109 students responded, representing a 46% response rate. The sample consists of 10 male and 99 female trainees. 33 students in this sample were in their first year of the programme; 23 in the second year; 27 in the third year and 26 in the final year. The majority of the participants were British. This exploratory study adopted convenience sampling, and thus the generalizability of the study's findings is limited.

Data analysis

As each teacher was asked to identify the first five thoughts that come to their mind when they think of the research topic (i.e. the integration of children's literature in primary mathematics teaching and learning), and given that 109 participants completed the survey, there should have been 545 thoughts in total (109 participants x 5 thoughts). However, some participant gave fewer than five thoughts, resulting in only 492 thoughts in total. Eighteen of those thoughts were disregarded as the meaning or the relevance was not sufficiently clear. For example, 'Literature directly helps teachers and children' or 'Has an educational point'. The final total number of thoughts was thus 474 from 109 students.

In order to better understand the range of the pre-service teachers' beliefs about the integration of children's literature in primary mathematics teaching and learning, content analysis was performed on the 474 thoughts. In its basic form, content analysis can be defined as "an analysis of the frequency and patterns of use of terms or phrases" (Savin-Baden & Major, 2013, p. 438) with the implication that "the greater the frequency of occurrence of content (a word or phrase) the more important was that element of the message to the communicator" (Newby, 2014, p. 489).

However, Cohen, Manion and Morrison (2011) caution against such a view by arguing that "[f]requency does not equal importance, and not saying something (withholding comment) may be as important as saying something" and go on to emphasise that content analysis "only analyses what is present rather what is missing or unsaid" (p. 568). With this in mind, the approach to the analysis involved not just counting the frequency of the types of words, but also including a thematic analysis that considered the themes that were present.

Other key characteristics of content analysis are widely debated. For example, while Bryman (2012) states that content analysis is conducted deductively by seeking to "quantify content in terms of predetermined categories" (p. 289), Cohen et al. (2011) again argue that the approach can be also carried out inductively, making use of both "pre-existing categories and emergent themes" (p. 564).

In the context of this paper, the key purpose of performing content analysis was conducted *inductively* entirely without subjecting any pre-determined categories onto the data. Constant comparative analysis, an iterative and inductive process of data reduction (Glaser & Strauss, 1967) through the use of open coding, axial coding, and selective coding, was used as an analytic procedure for this part of content analysis to identify emergent categories and themes. This procedure is closely associated with grounded theory (Lichtman, 2013), which lets data emerge organically from the participants instead of imposing an existing theoretical framework on them (Charmaz, 2014; Glaser & Strauss, 1967). Finally, whilst I agree with Krippendrop (2004) in thinking that multiple meanings are possible, I also agree with Bryman (2012) when he argues that researchers' personal biases and subjectivity ought to be minimised. Subsequently, I adopted the approach employed in Sam and Ernest's (2008) study by having parts of the current study's data and the initial coding framework validated by 5 participants at a conference of the British Society for Research into Leaning Mathematics (BSRLM) in November 2014. The participants, aged from around 30 to 50 years old, were researchers in the field of mathematics education. Three were British, whilst the two others were from Sweden and Uganda. They were given thought responses of 20 trainees and were asked to code these thoughts either using existing codes in the coding framework that I had developed or by creating new ones. No new codes were proposed as the participants found that the existing codes could be applied to the given data. However, a suggestion was raised to collapse two original themes ('Learning Benefits' and 'Teaching Benefits') into one

('Pedagogical Benefits'), as it was argued that it was difficult to separate learning from teaching. This is in line with Bryman (2012) when he advises that categories and themes ('dimensions') should be discrete as mutually exclusive, and that "there should be no conceptual or empirical overlap between them" (p. 303). This suggestion was adopted and reflected in the framework reported in this paper.

Within each of the 474 thoughts, more than one code could be applied if deemed relevant in order to maintain the richness of the data (Hammersley & Atkinson, 1983). For example, both Code 8.1 ('*Poems, rhymes and songs*') and Code 3.3 ('*Ability to identify mathematics learning and teaching opportunities in children's literature books that do not contain explicit mathematical contents'*) were applied to the following thought: "I am sure there is a way to find maths in almost any children's books and more excitingly – poems!" The result was 670 *coding occurrences* in total with 93 different codes or categories that can be classified into one of the following 9 different broad themes as shown in Table 1. These themes and categories subsequently formed the English Pre-Service Primary Teachers' Beliefs concerning the Integration of Children's Literature in Mathematics Learning and Teaching (EPPTB-ICLMLT) framework, and they will be discussed in more detail in the following section.

[Insert Table 1 here]

Ethical considerations

This study received the permission from the Ethics Committee of the researcher's university department to conduct his study with its undergraduate teacher trainees. Information sheets and consent forms were distributed electronically to 236 Years 1 – 4 students enrolled on the BA Ed in Primary Education programme. They were informed that their participation would be voluntary and that they could withdraw from the study at any time without any repercussion to them. Pseudonyms were used to report their views in order to protect their identity.

Results and Discussion

In this section, the nine emerging themes, forming the English Pre-Service Primary Teachers' Beliefs concerning the Integration of Children's Literature in Mathematics Learning and Teaching (EPPTB-ICLMLT) framework, will be presented and

discussed. For the purpose of brevity, examples of trainees' quotes highlighting emerging themes can be found in Appendices A-I.

Theme 1: Pedagogical Benefits

This theme represents the highest proportion (37.01%) of all the coding occurrences (248 out of 670). It is consisted of 19 categories that are concerned with pedagogical benefits *(see Appendix A)*.

Collectively, the trainees appear to be aware of a wide range of potential pedagogical benefits of the integration approach, though the majority of those coding occurrences relating to this theme appear to be skewed towards just one benefit, namely *increasing children's engagement and enjoyment in mathematics learning*, which was mentioned by 63 trainees 86 times (or 12.84% of the total coding occurrences). Arguably, this suggests that the majority of trainees are not as fully aware of other potential benefits as they are with the benefit relating to increasing students' engagement. Subsequently, mathematics teacher educators should ensure that their trainees are made aware of other benefits, particularly cognitive benefits, for example, to provide children opportunities to address specific mathematical misconceptions in the story or to introduce mathematical language – both of which were only mentioned twice each.

Other beliefs under this theme do resonate with the literature in the field. For example, the notion that the use of children's literature could: provide a meaningful context for mathematics learning (Billings & Beckmann, 2005); introduce or reinforce mathematical language and vocabulary (Janes & Strong, 2014; Jennings et al., 1992; Lake, 2009); and address potential misconceptions (Courtade et al., 2013).

Interestingly, a number of trainees highlighted the potential benefit of the integration approach in making mathematics teaching and learning more inclusive and accessible to different types of learners, particularly those who normally either like reading, but not mathematics, or the other way around.

Theme 2: Ways of Integration

This theme represents 7.01% of all the coding occurrences (47 out of 670). It is consisted of 12 categories that are concerned with ways in which children's literature can be integrated in mathematics teaching and learning *(see Appendix B)*.

Similarly, the trainees – as a whole – appear to be aware of a wide range of ways to integrate children's literature in mathematics instruction, with the majority of coding occurrences relating to this theme are associated with integrating children's literature to generate mathematical problems and context for mathematical problem solving (12 out of 47). This belief is supported by the works of Welchman-Tischler (1992) and Whitin and Wilde (1992).

Other beliefs also resonate with the literature in the field. For example, the notion of using children's books to introduce manipulatives (Lake, 2009); the notion of using children's literature to introduce new mathematical concepts and consolidate children's mathematical understanding (Heuvel-Panhuizen & Ella, 2012) as well as the notion of using the integration approach as a way to formatively assess children's mathematical understanding (Courtade et al., 2013).

Other ways of integration which do not get mentioned as frequently, but are equally interesting, include using children's literature to integrate mathematics indoor and outdoor learning; to encourage children to write their own mathematics-related story; and to use in collaboration with posters and class displays to extend mathematics learning found in the story - all of which were only mentioned once. Interestingly, these suggested methods of integration are not found in the literature.

Theme 3: Enabling Factors

This theme represents 11.49% of all the coding occurrences (77 out of 670). It is consisted of 7 categories that are concerned with a range of enabling factors that arguably make it possible for teachers to subscribe to the integration of children's literature in mathematics learning *(see Appendix C)*.

The majority of coding occurrences (32 out of 77) relating to this theme are associated with teacher trainees' positive attitudes towards the integration approach, which can arguably be perceived as one of the key enabling factors to teachers trying out the approach. This is closely followed by teacher trainees' willingness to further explore how the approach works and to hopefully try it out in their own lessons.

Another key enabling factor is associated with teacher trainees' ability to identify mathematics learning and teaching opportunities in children's books that do not contain explicit mathematical contents or what Wilburne, Keat and Napoli (2011) describe as having a mathematical lens or as Schiro (1997) describes as going on a mathematical treasure hunt.

Whilst they were not mentioned as frequently as the above three factors, other enabling factors include the roles of lecture on raising the trainees' awareness of the approach as well as trainees' knowledge in the range of children's books and an awareness of where to look for them. Finally, one trainee also highlights that their own enthusiasm in children's literature in general likely encourages her to try out the approach.

Theme 4: Key Barriers

This theme represents 18.36% of all the coding occurrences (123 out of 670). It is consisted of 15 categories that are concerned with a range of key barriers that likely prevent teachers from integrating children's literature in mathematics teaching and learning *(see Appendix D)*.

The majority of the coding occurrences relating to this theme (25 out of 123) attribute trainees' limited or lack of awareness of children's books that have explicit mathematical elements as a key barrier to the integration approach. As argued by Schiro (1997) and Wilburne et al. (2011), any children's book could be turned into a mathematics teaching and learning resource as long as the teachers put on their *mathematical lens*. Mathematics teacher educators will thus find it beneficial to ensure that their training sessions also provide a focus on how to get trainees to identify mathematics teaching and learning opportunities from any children's book, in addition to exposing them to the wide range of mathematics-specific children's books.

Another common key barrier to the approach is teacher trainees' perceived incompatibility between children's literature and mathematics teaching and learning. However, as Moyer (2000) previously argued, such separation of literacy or language and mathematics instruction is very unnatural for children and that such boundaries between subjects are largely and artificially created by adults. Teacher trainees should thus be given ample opportunities to learn how a wide range of children's books can be used to cover a wide variety of mathematical topics and skills.

A misconception concerning how the use of children's literature is only appropriate for younger children is also another key barrier to this integration approach. As previously discussed, there are several children's books that set out to cover more advanced mathematical topics, such as algebra (e.g. Adler's (2012) *Mystery math: A first book of algebra)* and factorial (e.g. Masaichiro's (1999) *Anno's*

Mysterious Multiplying Jar). Such trainees need to be made aware that such books exist and encourage them to try to incorporate them as part of their teaching practice.

Interestingly, curriculum pressure or restriction was also attributed as a key barrier. This resonates well with what Wilburne et al. (2011) have previously highlighted. As part of their training, teacher trainees should thus be shown how even within a restrictive mathematics curriculum, children's literature can still be incorporated as part of mathematics instruction.

Closely related to curriculum pressure is the perception that both lesson preparation and lesson time are too limited to accommodate such integration approach. To a large extent, this issue could be addressed by, for example, a creative use of Literacy lesson time. More specifically, children could go over a chosen book as part of their Literacy lesson with a focus on reading comprehension before focusing on the mathematical aspect of the book in their subsequent mathematics lessons. With this approach, teachers will find such integration does not have to be a time consuming process.

Finally, some of the trainees also highlighted their low level of confidence in mathematics teaching and, more concerningly, their limited or lack of interests in both mathematics as a subject and children's literature as an instructional resource. These factors can be a key barrier preventing children's literature from being incorporated in mathematics lessons. Mathematics teacher educators should be aware of their trainees' confidence level in and attitudes towards mathematics teaching, particularly those of non-mathematics specialist trainees, and design their mathematics training sessions in a way that foster positive dispositions towards the subject.

Theme 5: Cautions

This theme represents 3.28% of all the coding occurrences (22 out of 670). It is consisted of 8 categories that are concerned with a range of cautions as put forward by the teacher trainees in the study *(see Appendix E)*.

The majority of the coding occurrences relating to this theme (6 out of 22) are concerned with how such integration approach might not be suitable for all types of learners, followed by a caution against over-using the approach in mathematics lessons and how children could get distracted by the literary aspect of the approach over their mathematics learning. Concerning this last point, it is interesting to see that the trainees' concern is the exact opposite of those raised by the literature as

Welchman-Tischler (1992) and Hunsader (2004) warn against distorting the literary quality and enjoyment of the book by placing too much emphasis on mathematical aspects and against interrupting the story to ask too many mathematical questions.

Theme 6: Selection Criteria

This theme represents 3.13% of all the coding occurrences (21 out of 670). It is consisted of 12 categories that are concerned with a range of criteria for selecting children's literature for mathematics teaching and learning *(see Appendix F)*.

None of the twelve selection criteria particularly stood out, as they were either mentioned once or twice. In brief, these criteria include choosing stories and literary genres/formats that match children's interests as well as ensuring that the books are appropriate to their age as well as their reading and mathematical abilities. These latter selection criteria resonate with those proposed by Hellwig et al. (2000) and van den Heuvel-Panhuizen and Elia (2012). The visual appeal of the books was also mentioned and is also reflected in the view of Hellwig et al. (2000) and van den Heuvel-Panhuizen and Elia (2012). However, it is important to bear in mind that this selection criteria is not applicable for every literary format, as storybooks for older children are generally text-heavy with very few illustrations, if at all.

Concerning mathematics-specific criteria, choosing children's books that can prompt children to ask mathematical questions and those that provide children opportunities for mathematical investigations are also considered by the trainees.

Practical considerations, such as affordability of children's books and choosing books that are not too long, were also mentioned and interestingly such selection criteria are not evident in any literature reviewed. However, none of the trainees' criteria is concerned with the extent to which the story in the book promotes inclusiveness, be it gender equity or cultural and socio-economic diversity as proposed by some of the literature (e.g. Hunsader, 2004; Lake, 2009; Marston, 2010). Additionally, none of the trainees considered to what extent the books promote meaningful connections, either in terms of between the different mathematical strands; between mathematics and other curricular subjects; and between classroom mathematics and children's everyday mathematical experiences, as proposed by Hellwig et al. (2000), Marston (2010) and van den Heuvel-Panhuizen and Elia (2012), as well as the extent to which it promotes mathematical processes, such as problem solving and posing, and engage children and foster positive attitudes towards the

subject, as proposed by Marston (2010) and van den Heuvel-Panhuizen and Elia (2012).

Theme 7: Associated Mathematical Topics and Skills

This theme represents 10% of all the coding occurrences (67 out of 670). It is consisted of 11 categories that are concerned with a range of mathematical topics and skills that the teacher trainees in this study associated with the integration of children's literature in mathematics teaching and learning *(see Appendix G)*.

The majority of all the coding occurrences relating to this theme appear to be concerned with using children's literature to teach children counting skills (3.43%), possibly suggesting that the trainees still largely perceive the use of children's literature for mathematics instruction as a pedagogical approach for very young children only. However, overall, the trainees appear to be aware of the different children's books that can be used to teach a wide range of mathematical concepts and skills. From the frequency of coding occurrences of these different concepts and skills, mathematics teacher educators will benefit from exposing their trainees to a wide range of children's books that can be used to cover underrepresented concepts and skills, such as estimation, fraction, time and patterns. Similarly, one area of the primary mathematics curriculum that is noticeably absent in the trainees' response is algebra. As previously mentioned, *Mystery math: A first book of algebra* (Adler, 2012) is one of several examples of books that can be used to introduce children to the concept of algebra.

Theme 8: Associated Literary Genres

This theme represents 5.07% of all the coding occurrences (34 out of 670). It is consisted of 3 categories that are concerned with a range of literary genre that the teacher trainees in this study associated with children's literature that can be integrated in mathematics teaching and learning *(see Appendix H)*.

While traditional literary genres, such as fiction and non-fiction were mentioned, it is also interesting to observe that the majority of coding occurrences (14 out of 34) relating to this theme are concerned with the use of poems, rhymes and songs for mathematics instruction. This is particularly revealing in terms of exploring teacher trainees' perceptions of what they think children's literature is and what it encompasses. Additionally, when the teacher trainees' examples of poems, rhymes

and songs were examined in more detail, it soon became apparent that these are poems, rhymes and songs that were aimed at very young children, reinforcing the findings in the previous section that too often the integration of children's literature in mathematics instruction is still largely perceived as a pedagogical approach that is found mostly in early years classes.

Theme 9: Associated Literary Formats

This theme represents 4.63% of all the coding occurrences (31 out of 670). It is consisted of 6 categories that are concerned with a range of literary formats that the teacher trainees in this study associated with children's literature that can be integrated in mathematics teaching and learning *(see Appendix I)*.

The majority of the trainees either explicitly or implicitly refer to traditional literary formats, such as picture books (15 out of 31) and story books (8 out of 31). Interestingly, references to graphical novels or comic books are noticeably absent, despite the existence of mathematics-specific comic book series, such as Thielbar's (2010a) *The Lost Key: A Mystery with Whole Numbers,* (2010b) *The Secret Ghost: A Mystery with Distance and Measurement,* and (2010c) *The Hundred-Dollar Robber: A Mystery with Money*, among others. Subsequently, time should be invested as part of their training early on to address any misconceptions or lack of awareness regarding the resource and the approach.

Apart from the two aforementioned traditional literary formats, it is interesting to note that some trainees think of children's literature simply in terms of mathematics textbooks and worksheets, possibly suggesting their lack of experience and exposure to the integration of actual children's literature in mathematics instruction. Similarly, some trainees also associate 'children's literature' with textbooks for mathematics teacher trainees. Interestingly, some also associate the integration of children's literature in mathematics instruction with mathematics-related classroom posters and with blog writing. This is important for teacher educators to be aware that not every trainee perceive children's literature in a convention sense – arguably due to their lack of exposure to the resource in the context of mathematics instruction.

Conclusions

Key findings and implications

The study set out to explore the beliefs concerning the integration of children's literature in primary mathematics teaching and learning. The analysis yielded a 9-theme and 93-category belief framework that demonstrates teacher trainees' wide range of views and perceptions concerning the integration.

Across the nine themes, beliefs concerning pedagogical benefits represented the largest proportion of all coding occurrences, and this theme encompassed 19 different potential pedagogical benefits. To an extent, this is particularly encouraging to observe as it demonstrates that the teacher trainees in this study are *collectively* aware of the wide range of benefits that children's literature can bring to mathematics teaching and learning. However, the *'Increases children's engagement and enjoyment in mathematics learning'* category *(12.84%)* appears to eclipse other potential benefits, arguably highlighting that the majority of the trainees are only fixated on the emotive benefits, and less so on some of the potential cognitive benefits, such as using children's literature to 'introduce or reinforce mathematical language' *(0.30%)* or to 'help children become familiar with solving word problems' *(0.15%)*. Through teacher training, mathematics teacher educators should strive to emphasise these potential cognitive benefits to their trainees as well.

The second most recurring theme is concerned with trainees' views on a range of key barriers that could prevent them from successfully integrating children's literature in their mathematics teaching. This theme encompasses 15 different key barriers, with the *'limited or lack of awareness of children's literature books that have explicit mathematical elements in them'* category *(3.73%)* being the most cited one. While this concern is largely valid, it also highlights how trainees, at this stage of their career, feel the necessity to rely on children's literature books that contain explicit mathematical focus only. The validity of this view can be questioned particularly in light of a large number of children's literature books that do not have explicit mathematical focus and yet can still serve as an ideal mathematical instruction resource, as we have seen from the given example of Burningham's (1994) 'Would You Rather?'. Mathematics teacher educators should encourage their trainees to wear *mathematical lens* when exploring non-mathematics specific children's literature books to search for mathematics teaching and learning opportunities in them.

The next key finding is relating to the Associated Mathematical Topics and Skills theme. Given nearly a third of all codings relating to mathematical topics is

concerned with counting, and less so on topics that are more associated with the upper end of the primary school, such as algebra and statistics: mathematics teacher educators should incorporate children's literature that cover these latter topics as part of their teaching these topics too.

While Theme 9 ('Associated Literary Formats') demonstrates a range of literary genres that the pre-service teachers in this study associated with mathematics learning and teaching, none mentioned graphic novels or *manga*. Thus, they are missing out on a literary genre that has been increasingly used to either introduce or reinforce mathematical concepts, such as the *Manga Maths Mysteries*. The inclusion of such graphic novel collection as part of teacher training will help broaden teacher trainees' awareness of other type of available resources.

Limitations

The reliability of the EPPTB-ICLMLT framework can, to an extent, be questioned due to the small sample size and the relatively homogenous characteristics of the participants (i.e. largely British Caucasian) from one single geographical region of England. The framework will benefit by being further developed using data from teachers in other socio-cultural contexts.

Additionally, the quality of the analysis is also arguably limited as it was carried out by the researcher alone, and hence his own personal worldviews and experiences could arguably shape the interpretation in a certain way.

Future research directions

Since research have shown that teachers' beliefs about mathematics learning and teaching vary according to teachers' age (Chai, Teo, & Lee, 2009) and teaching experience (Perry, Howard, & Tracey, 1999), it would be beneficial to replicate the study with in-service teachers as well to explore if the existing belief framework can also be used to capture their beliefs concerning the integration of children's literature in mathematics teaching and learning, or whether there are other beliefs that did not emerge from the pre-service teacher dataset.

Similarly, since beliefs are arguably shaped by socio-cultural forces, it would be interesting to see the extent to which the EPPTB-ICLMLT framework reflects non-English pre-service teachers' beliefs on this integration approach as well. International research collaboration on this research topic is therefore needed.

Finally, it would be interesting to investigate this emerging concept of 'mathematical lens' further to ascertain, for example, what factors influence one's mathematical lens and what can be done to help teachers to develop their personal mathematical lens.

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Appendix A
Theme 1: The nineteen categories of the Pedagogical Benefits theme

Categories	Examples of quotes	Frequency of coding occurrences (Number of pre-service teachers whom the category is linked to)	Percentage frequency (in relation to all the coding occurrences)
1.1 Increases children's engagement and enjoyment in mathematics learning	"Often by providing the children with a synopsis for their learning, they are eager to fill the task, or help out the character in the book, becoming fully engaged in the task"	86(63)	12.84%
1.2 Promotes cross-curricular links	"This is a great idea which promotes cross curricular learning which is vital within a classroom. It allows them to create systematic links"	39(38)	5.82%
1.3 Provides a meaningful and relevant context and application	"Sharing a book that uses mathematical concepts in everyday life will put the lesson in context for the children and they will be able to see why they are doing it"	37(33)	5.52%
1.4 Makes mathematics learning more accessible and inclusive	"Within my previous class, there were girls who lacked confidence in numeracy, because the class was extremely boy heavy. Mathematics was delivered in a way that arguably did not adhere to their needs. Using literature could have potentially increased the girl's motivation and confidence in the subject"	16(15)	2.39%
1.5 Encourages children who do not normally enjoy one of the two subjects to become more enthusiastic about it	"Perhaps children who enjoy one subject may bring this enthusiasm to other subjects"	16(13)	2.39%
1.6 Represents abstract mathematical concepts visually	"Visual. If children can see 5 objects on the page, and count along with the story then it can consolidate learning"	13(12)	1.94%
1.7 Caters to different learning styles	"Using a range of teaching approaches in a maths lesson with the support of children's literature can help make the lesson accessible to a range of learning styles. For example, a visual learner may appreciate the use of a picture book whilst an auditory learner may develop a greater understanding in a mathematical concept if they can sing a song that explains the process of a concept"	7(7)	1.04%
1.8 Helps children remember mathematical facts and problem solving	"Sometimes stories involve a repetition element that can be converted into a calculation at the end working on the times tables"	6(6)	0.90%

methods through repetitive structure			
1.9 Combats the rigid structure of mathematics lessons	"Using literature can combat the rigid structure that is generally applied to mathematics lessons (introducing the topic on the carpet, trying out a few examples, children going back to their tables to work independently), making the lesson more interesting for the children and therefore helping them to learn better"	6(6)	0.90%
1.10 Helps children develop their conceptual understanding	"As a stimulus for learning, children's literature can kickstart the connections in our understanding of a particular mathematical concept […]"	4(4)	0.60%
1.11 Broadens children's knowledge of children's books	"Using literature that children are unfamiliar will increase their breadth of knowledge"	3(3)	0.45%
1.12 Makes teaching more enjoyable for teachers	"Enjoyable for teacher. In the past I have enjoyed delivering stories to children, especially reception aged, because they are easily engaged with the story and enjoy it"	3(3)	0.45%
1.13 Raises children's awareness of the importance of and enjoyment in reading	"I think that literature is a key part to children's education in general, not just in literacy and that this needs to be recognised. Reading is a skill that can help children in many areas and something that they can do for pleasure […]"	2(2)	0.30%
1.14 Encourages collaborative learning	"Using books can form a base from which you can plan more creative lessons; for example, you can encourage children to work in teams to come up with a solution to a problem in a book"	2(2)	0.30%
1.15 Encourages independent learning	"If the adult pretends to be 'unsure' about a concept or an answer and asks the child for 'help', I feel as though this allows a child to develop their independent thinking skills and confidence in their abilities most effectively"	2(2)	0.30%
1.16 Introduces or reinforces mathematical language	"While children are learning a particular skill in Mathematics, by using Literature they are also learning the specific language, for example addition or subtraction, which develops their vocabulary."	2(2)	0.30%
1.17 Provides children opportunities to address specific mathematical misconceptions, if any, in the story	"Good way of dealing with misconceptions. They can be dealt with in a way that does not expose the child or children with the misconception as a character takes on this misconception for them"	2(2)	0.30%
1.18 Helps children become familiar with solving word problems	"Moving on from sums to word problem can often be challenging for children, if they have been used to using text and words within maths lessons they will hopefully find the transition easier"	1(1)	0.15%
1.19 Improves the pace of the lesson	"A great learning hook to engage children, and improve the pace of the lesson in that I perceived the use of children's literature to be	1(1)	0.15%

	useful for starters in a lesson, and therefore a short activity which may engage the children, instead of becoming bored. With more activities in a lesson, I automatically assumed that the pace will have to be faster in order to finish the lesson on time"		
	Total	**248**	**37.01%**

Appendix B
Theme 2: The twelve categories of the Ways of Integration theme

Categories	Examples of quotes	Frequency of coding occurrences (Number of pre-service teachers whom the category is linked to)	Percentage frequency (in relation to all the coding occurrences)
2.1 Used to generate mathematical problems and context for mathematical problem solving	"You can encourage children to work in teams to come up with a solution to a problem in a book i.e. Spaghetti and Meatballs for All!"	12(11)	1.79%
2.2 Used for introducing new mathematical topics and skills	"Would be good to introduce a new topic of mathematics in the form of a story"	7(7)	1.04%
2.3 Used to generate discussions about mathematics	"Within a piece of literature, we can explore different ideas and children can discuss these with their peers. So they then discover and co-construct their understanding"	6(6)	0.90%
2.4 Used in collaboration with role play and games	"Games should be incorporated, children ideally learn through play"	4(4)	0.60%
2.5 Used in collaboration with hands-on investigative activities	"Interactive. The children can use the books to explore the subjects that the books are based on"	4(4)	0.60%
2.6 Used for assessment	"By using literature in mathematics lessons the children often review and recap previously taught skills without them being fully aware. This allows them to increase their progress on this specific skill and provides the teacher with information on their progress."	3(3)	0.45%
2.7 Used for reviewing / recapping mathematical topics and skills	"By using literature in mathematics lessons, the children often review and recap previously taught skills without them being fully aware"	3(3)	0.45%
2.8 Used to consolidate knowledge at the end of the	"The use of a book in a plenary can secure any knowledge around the topic"	3(3)	0.45%

lesson			
2.9 Used in collaboration with manipulatives	"Create more opportunities for interaction between pupils […] and equipment"	2(2)	0.30%
2.10 Used to integrate mathematics indoor and outdoor learning	"Chances to take learning outdoors through the book"	1(1)	0.15%
2.11 Used to encourage children to write their own mathematics-related story	"Children writing during a Maths lesson. Could children write their own story based on a Maths topic?"	1(1)	0.15%
2.12 Used in collaboration with posters and class displays to extend mathematics learning found in the story	"Posters and displays. Children will take a greater interest of a particular story if they have made a certain item that can be displayed in the classroom, making the process of learning and reading a particular book more fun for example"	1(1)	0.15%
	Total	**47**	**7.01%**

Appendix C
Theme 3: The seven categories of the Enabling Factors theme

Categories	Examples of quotes	Frequency of coding occurrences (Number of pre-service teachers whom the category is linked to)	Percentage frequency (in relation to all the coding occurrences)
3.1 Teachers' positive attitude towards the integration approach	"A new and creative way of teaching maths – children find it different"	32(28)	4.78%
3.2 Further exploration intended by the teachers	"I haven't had the opportunity to learn about the relationship between children's literature and mathematics but this would be an area I would be keen to learn more about, as it is not necessarily an obvious link."	17(15)	2.54%
3.3 Ability to identify mathematics learning and teaching opportunities in children's literature books that do not contain explicit mathematical contents	"I am sure there is a way to find maths in almost any children's books and more excitingly – poems! Surprisingly, the literature would often not have to be specific to maths in order to be relevant to a maths lesson"	17(15)	2.54%
3.4 Role of	"I haven't read this whole book [The Number	6(6)	0.90%

lectures	Devil], but remember covering it in a lecture, it was the first book that came to mind"		
3.5 Knowledge of the range of children's literature on offer and the integration approach	"The teacher needs to be confident in their knowledge of the children's literature and mathematics. They need to find a balance between the two and know how to link or use the children's literature in teaching mathematics"	3(3)	0.45%
3.6 Awareness of where to search for children's literature	"I can't think of any more books, so would resort to Amazon or the library to find some"	1(1)	0.15%
3.7 Teachers' general enthusiasm in children's literature	"As a huge fan of children's literature I would relish the opportunity to use literature within mathematics teaching and learning"	1(1)	0.15%
	Total	**77**	**11.49%**

Appendix D
Theme 4: The fifteen categories of the Key Barriers theme

Categories	Examples of quotes	Frequency of coding occurrences (Number of pre-service teachers whom the category is linked to)	Percentage frequency (in relation to all the coding occurrences)
4.1 Limited or lack of awareness of children's literature books that have explicit mathematical elements in them	"The book you choose has to be very specific and so may be hard to find a piece of literature that covers the topic"	25(22)	3.73%
4.2 Perceived incompatibility between children's literature and mathematics teaching and learning	"I feel that the possible learning links between children's literature and mathematics teaching are limited. Whilst books can make engaging starting points for lessons, I can think of no further links"	22(19)	3.28%
4.3 Perceived difficulty in implementing the integration	"Not straightforward - The very traditional method of teaching maths only really required the teacher to stand, talk and use the blackboard. This is more complex".	20(20)	2.99
4.4 Limited or lack of exposure children's literature being used in mathematics	"In the school I was working in, I never once observed a maths lesson that used children's literature"	12(11)	1.79%

lessons			
4.5 Age of children	"I would feel more comfortable using children's literature with my previous Year 3 and Year 2 class than my Year 6 class. This is not down to confidence in teaching the level of upper Key Stage 2, but more so that it may be more difficult to find an engaging and appropriate piece of literature that the children can use and relate to"	12(10)	1.79%
4.6 Limited or lack of time for planning	"Planning lessons around literature can be time-consuming as sometimes using books make it more difficult to make sure it is at a suitable level for both the children's English and mathematics knowledge"	9(8)	1.34%
4.7 Limited or lack of training	"How could this be achieved? Can I receive more training to better my ability to teach the two alongside each other?"	5(5)	0.75%
4.8 Teachers' low confidence level	**"**Confidence both in your own ability and in the material you have decided to use"	5(5)	0.75%
4.9 Teachers questioning the effectiveness of the approach	"Will it be very effective? [...] the very nature of the subjects seem so different that it makes me wonder if it would really work or not"	5(5)	0.75%
4.10 Limited or lack of experience in the integration	"As I have never known where to source children's literature that relates to mathematics (or if there are even many pieces exist), I have not used any in my own lessons"	3(3)	0.45%
4.11 Curriculum pressure	"I hadn't much thought about this idea of linking literature with maths, as it is hard to find and link age appropriate content literature with content in the National Curriculum. As there is a lot to cover in the maths National Curriculum, it is easier to follow maths schemes than link every topic with literature."	1(1)	0.15%
4.12 Children's short concentration span	"For children in Reception, their lessons are only 15-20 mins long. Therefore, they would struggle to have the concentration time to listen to a book and then have the concept/method taught and then practice it"	1(1)	0.15%
4.13 Limited lesson time	"My training has taught me that numeracy sessions should be pacey; including a story within the lesson could reduce the amount of time being spent on using and applying number"	1(1)	0.15%
4.14 Misconception about the role of children's literature in mathematics teaching	"Reward. At the end of a lesson the child who has worked hardest gets to choose the story time book"	1(1)	0.15%
4.15 Limited or lack of interests in both mathematics as a subject and children's literature as an instructional resource	"Uninspiring – I am personally unenthused by both mathematics and education and children's literature and find it a chore to prepare and teach maths lessons in particular"	1(1)	0.15%

Total	**123**	**18.36%**

Appendix E
Theme 5: The eight categories of the Cautions theme

Categories	Examples of quotes	Frequency of coding occurrences (Number of pre-service teachers whom the category is linked to)	Percentage frequency (in relation to all the coding occurrences)
5.1 Not suitable for all children	"[U]sing books makes it more difficult to make sure it is at a suitable level for both the children's English and mathematics knowledge"	6(4)	0.90%
5.2 Avoid overuse	"I believe that over reliance upon books would serve to dictate learning and inhibit progress (without a sufficient range available) due to their static nature"	4(4)	0.60%
5.3 Potential distraction	"Although literature can be used to engage children, they may get distracted and focus too much on the literature rather than the actual mathematics they are learning"	3(3)	0.45%
5.4 Avoid forcing links between literature and mathematics	"Shouldn't force links between literature and mathematics. Only use literature if it is appropriate to do so, only if it will aid and enhance learning"	3(3)	0.45%
5.5 Could result in children being confused by the integration	"Children may be confused with the concept of literature being used within a mathematics lesson"	2(2)	0.30%
5.6 Not suitable for all mathematical topics	"Although children's literature can be incorporated in maths lessons, not every subject in maths could be taught through literature. Some topics are best taught through demonstrations and going through lots of questions"	2(2)	0.30%
5.7 Teachers' personal preferences in particular literary genre can lead to children's imbalanced literary experience	"As a teacher we should be aware that our personal preferences will influence the literature that we use, which could give children imbalanced experiences"	1(1)	0.15%
5.8 Could lead to a repetitive lesson structure	"It's hard to find a new way to incorporate a book into a lesson without the lessons beginning to follow the same, repetitive structure of reading a book, introducing a problem and asking children to come up with a solution"	1(1)	0.15%
	Total	**22**	**3.28%**

Appendix F
Theme 6: The twelve categories of the Selection Criteria theme

Categories	Examples of quotes	Frequency of coding occurrences (Number of pre-service teachers whom the category is linked to)	Percentage frequency (in relation to all the coding occurrences)
6.1 Choose specific children's literature genre to match the interest of individual children	"Targeting specific literature to children for one-to-one reading and such will not only help you learn more about the child but engage them in the genre of text which interests them"	3(3)	0.45%
6.2 Choose children's literature books that provide children opportunities for mathematical investigations	"It is crucial to make sure the text […] is open to exploration […]"	2(2)	0.30%
6.3 Choose children's literature books that are appropriate for the age of the children	"Must be tailored for all ages"	2(2)	0.30%
6.4 Choose children's literature books that are visually attractive	"Children will respond best to bright and colourful books that offer a range of different shades of colour"	2(2)	0.30%
6.5 Choose children's literature books that are accessible to children of different reading abilities	"Not too many words. So they are accessible to all reading abilities"	2(2)	0.30%
6.6 Choose children's literature books that are relevant to the topic in question	"Relevant literature has to be used. The book has to be relevant to the topic [...]"	2(2)	0.30%
6.7 Choose children's literature books with a story that children find interesting	"To use narratives that interest the child, to plan using the class's interests"	2(2)	0.30%
6.8 Choose children's	"Counting books in the EYFS setting usually only went up to 10 and for children who are	2(2)	0.30%

literature books that match children's mathematical abilities	confident in counting these books were very easy. More books need to be available that can extend their learning"		
6.9 Choose children's literature books that are not too long or children could lose interest	"Short or the children can lose interest"	1(1)	0.15%
6.10 Choose children's literature books that have explicit mathematical elements in the story	"It is crucial to make sure the text has a relative, strong link to mathematics."	1(1)	0.15%
6.11 Choose children's literature books that prompt children to ask mathematical questions	"It is crucial to make sure the text […] is open to […] questioning by the child."	1(1)	0.15%
6.12 Choose children's literature books that are affordable to the school	"Affordable. So the school will be compelled to buy them."	1(1)	0.15%
	Total	**21**	**3.13%**

Appendix G
Theme 7: The eleven categories of the Associated Topics and Skills theme

Categories	Examples of quotes	Frequency of coding occurrences (Number of pre-service teachers whom the category is linked to)	Percentage frequency (in relation to all the coding occurrences)
7.1 Counting	"Books that incorporate counting"	23(20)	3.43%
7.2 Numbers and Number Operations	"The children were reading 'The Faraway Tree' as a class and did some addition work using one of the lands as inspiration"	14(12)	2.09%
7.3 Measurement	"Actual Size by Steve Jenkins – […] I was teaching a sequence of lessons on […] measuring lengths. The children were struggling to understand the concept of certain lengths so I used this book to allow the children to discover the actual sizes of objects, such as butterfly, or the length of a crocodile"	6(5)	0.90%
7.4 Shapes and Geometry	"Shapes in picture books can be explored in greater depth"	6(6)	0.90%
7.5 Money	"Millions by Frank Cottrell Boyce. This is a	5(5)	0.75%

	fantastic book that could be read as the class book. Themes and ideas could then be taken into maths lessons, and work could be set out to do with the book e.g. money, conversions, budgeting"		
7.6 Place Value	"[C]hildren's literature could be useful when demonstrating more abstract concepts related to place value that children within my class struggle to understand"	3(3)	0.45%
7.7 Data Handling	"Using methods such as story telling can make mathematics learning interesting and different. For example, I used a Dr Seuss book to teach data handling"	3(3)	0.45%
7.8 Fractions	"A poem was read to the class which discussed the fractions within a cake"	3(3)	0.45%
7.9 Estimation	"Actual Size by Steve Jenkins. This was a book I used whilst on my last placement with a low ability year 3 class. I was teaching a sequence of lessons on estimations [...]"	2(2)	0.30%
7.10 Time	"Using literature to help with children's mathematic skills. Teaching about time, days of the week [...]"	1(1)	0.15%
7.11 Patterns	"Patterns. Illustrated children's books have great examples"	1(1)	0.15%
	Total	**67**	**10.00%**

Appendix H
Theme 8: The three categories of the Associated Literary Genres theme

Categories	Examples of quotes	Frequency of coding occurrences (Number of pre-service teachers whom the category is linked to)	Percentage frequency (in relation to all the coding occurrences)
8.1 Poems, rhymes and songs	"Poems. Another form of literature that can be used within mathematics. Or children could write their own maths poems."	14(13)	2.09%
8.2 Fiction	"Fictional stories for children with a mathematical theme e.g. 'Mathemagical' – Colin Davies"	14(11)	2.09%
8.3 Non-fiction	"I feel that non-fiction maths books frequent more in the classroom than fiction"	6(6)	0.90%
	Total	**34**	**5.07%**

Appendix I
Theme 9: The six categories of the Associated Literary Formats theme

Categories	Examples of quotes	Frequency of coding occurrences (Number of pre-service teachers whom the category is linked to)	Percentage frequency (in relation to all the coding occurrences)

9.1 Picture books	"Given that the books are read aloud by an adult, picture books can be particularly beneficial to engage and interest children to read and slowly start to recognise words"	15(15)	2.24%
9.2 Story books	"Millions by Frank Cottrell Boyce. This is a fantastic book that could be read as the class book. Themes and ideas could then be taken into maths lessons, and work could be set out to do with the book e.g. money, conversions, budgeting"	8(6)	1.19%
9.3 Mathematics textbooks / worksheets	"Workbooks. The only mathematical literature I have encountered in recent years is textbooks e.g. CGP books [a series of commercially available UK-based mathematics exercise books], aimed at teenagers"	3(3)	0.45%
9.4 Textbooks to help teacher trainees teach mathematics	"Books like 'Mathematics explained for primary teachers' – by Haylock, that help trainee teachers teach mathematics to children"	2(2)	0.30%
9.5 Mathematics-related classroom posters	"Posters dotted around the classroom that include mathematical concepts that use text to explain"	2(2)	0.30%
9.6 Blogs	"Teaching using blogs, or getting children to write blogs explaining their learning to other children"	1(1)	0.15%
	Total	**31**	**4.63%**