

To Engage or Not Engage: How is the question!  
An Examination of Student Engagement in Elementary Mathematics

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Some years ago, I was teaching a unit on place value to my Grade 4 and 5 class. Towards the end of a unit, I asked the students to write a letter to anyone they wished, describing what place value is and why it is important. I encouraged them to use their imaginations in choosing a recipient, but I gave no other specific instructions. This activity replaced the more usual end-of-unit test.

In the response, shown in Figure 1.1, Lorna (a pseudonym) was able to explain to Harry Potter the importance of the different positions represented in the place value of numbers with regard to money and sports. Lorna's submission was more creative than her previous mathematics exercises and oral discussions. Her response included three examples of creatively expressing her understanding of place value, as represented by money, the place value of a certain digit in large numbers, and the variation of scores in sports events, as well as a sense of honest ironical humour ("you'd be happy, but that's not you're score is it?"). The self-drawn cheque suggested her strong connection with the activity. When given the opportunity to express her ideas in a more imaginative way than is traditionally expected in a mathematics lesson, Lorna responded with an enthusiasm I had not previously observed.

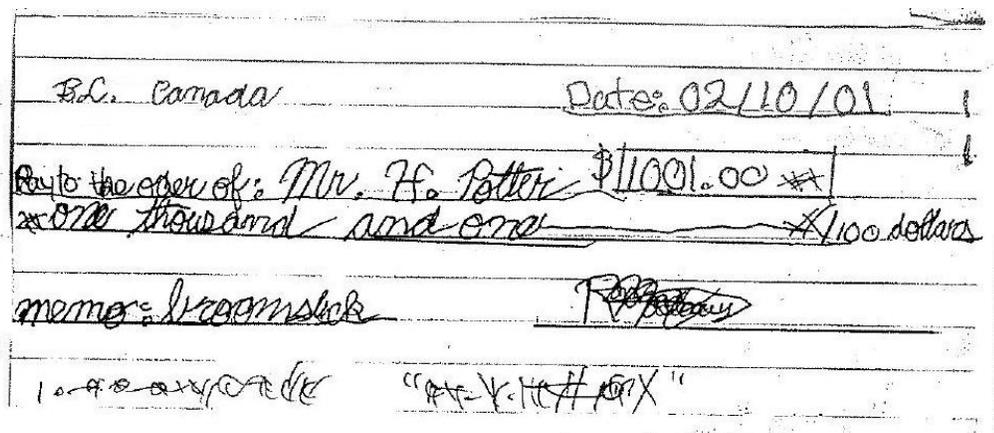
Dear Mr. Potter

My name is Lorna S. and I believe in magic and have been doing calculations and discovered that 1 galleon is equal to \$3.50 Canadian, so I'm sending \$1001.00 or 286 galleons. I hope that will be enough for a broom.

Well while I am here why don't I talk about Place Value. Place value is the sequence of numbers that go into a bigger number. It's the fact that the 3 in 7356 is equal to 300, stuff like that.

Money is a big example for using place value. Like you use it to figure out that four ninety nine is four dollars ninety nine and not four hundred ninety nine dollars. You use place value to make sure you get paid the right amount on your pay cheque. It's important to know place value because if you were to play Quidditch and you scored 725 but the scorekeeper made it 72.5 or 527, or  $7.25 \times$  then you wouldn't be to [sic] happy. But if they gave you 7250, you'd be happy but that's not you're score is it?

yours sincerely Lorna Summerfield



**Figure 1** Lorna's letter explaining place value.

Lorna was not an isolated example in this regard. Over a period of approximately 3 years during which I was becoming familiar with and using aspects of imaginative education ([IE]; Egan 1997, 2005) in my teaching of mathematics, other students also responded in multifaceted ways to the invitation to use their imaginations. I gradually moved from trying out this theory in isolated opportunities to planning groups of lessons using the theory's recommended imaginative lesson planning frameworks (ILPFs).

Based on my almost 20 years of teaching practice, it appeared that when I taught mathematics from an IE perspective, the subject became more appealing and engaging for students. The more I used this theory, the more my students' reactions seemed to contradict popular opinion that most students do not like mathematics very much and that it is often a challenge to get them engaged with the subject. This raised some puzzling and deep questions for me. What was really going on when I used aspects of IE theory in my mathematics lessons? How could there be such a wide difference between what I was seeing in my students' work and the widely held beliefs about difficulties in trying to engage students with mathematics?

### **The importance of mathematics**

The significance of mathematics to our society and its citizens is echoed time and time again in the literature (see, for example, du Sautoy, 2010; National Council of Teachers of Mathematics, 2000). The National Research Council (2002), in a report on recommendations to improve mathematical proficiency of students in the elementary and middle grades, states the following:

Mathematics is one of humanity's great achievements. By enhancing the capabilities of the human mind, mathematics has facilitated the development of science, technology, engineering, business, and government. Mathematics is also an intellectual achievement of great sophistication and beauty that epitomizes the power of deductive reasoning. For people to participate fully in society, they must know basic mathematics. Citizens who cannot reason mathematically are cut off from whole realms of human endeavor. Innumeracy deprives them not only of opportunity but also of competence in everyday tasks. (Kilpatrick, et al 2002, p. 1)

Thus, being numerate is very important in the 21<sup>st</sup> century. However, engaging students in the learning of mathematics is generally considered to be a challenge (Bruce, 2007; Clarke, 2007). Bruce (2007) and Clarke (2007) both suggest that pedagogical issues dominate this challenge. In particular, Bruce (2007) discusses the challenges teachers face in teaching in a manner different than that used in their own school learning. Similarly, Clarke (2007) concludes that the lack of mathematical content knowledge and pedagogical content knowledge underpin the problem of student engagement in mathematics education.

A dichotomy therefore exists between the recognition of how important mathematics is on the one hand and our ability to engage students in mathematics and to foster numeracy skills on the other. It is thus vital to examine the role pedagogy plays in student engagement in mathematics and to look for teaching methods that enhance engagement.

### **Engagement in learning**

When considering this dichotomy in the specific context of mathematics, it is important to consider engagement in more general terms. Over the last 30 years, numerous studies have presented a variety of interpretations of just what student engagement means, whether psychological (Appleton, Christenson, Kim, & Reschly, 2006; Marks, 2000; Newmann, Wehlage & Lamborn, 1992) or behavioural (Finn & Cox, 1992; Finn & Voekl, 1993). Nevertheless, most educators and researchers accept that student engagement is an important part of learning (Furlong & Christenson, 2008; Parsons & Taylor, 2011). In reviewing the literature on student engagement, Parsons and Taylor (2011) reinforce the importance of engaging students in learning when they state that "student engagement has become one of *the* key concerns and key strategies for educational and social reform particularly in middle and high schools" (p. 7). Given this view, it seems reasonable to infer that learners who are engaged in the learning process are more likely to absorb and understand the content of a lesson (Brophy, 2010). This applies to any subject, including mathematics.

## **Disengagement in mathematics education**

The difficulty of engaging students in mathematics is illustrated by the striking amount of literature that examines *disengagement* from learning mathematics (Boaler, 2000; Nardi & Steward, 2002a 2002b, 2003; National Survey of Student Engagement. Archives, 2007). Several studies (see, for example, Boaler, 2000; Education Quality and Accountability Office [EQAO], 2010) indicate that there is a large and disturbing drop in the number of children who express a liking for mathematics at the start of the intermediate grades when compared to earlier grades. Therefore, there is a need for studies that seek to understand more about student engagement with mathematics in these formative years of school.

A lack of engagement has both short and long-term consequences. In the short term, disengaged students have less opportunity to develop conceptual understanding in this important subject; a large part of the elementary curriculum (EQAO, 2010; Mullis et al., 2008). In the long term, disengagement from mathematics continues to grow in the secondary grades (Boaler & Greeno, 2000; Nardi & Steward, 2003) and in post-secondary education (Boaler & Greeno, 2000; National Survey of Student Engagement, 2007). For students who lack positive experiences with learning mathematics, the subject may become the “curriculum of the dead” (Ball, 1993, p. 195), something without relevance, meaning, or utility to their own lives and the world at large.

A lack of engagement with mathematics I would suggest becomes part of a cycle that leads to negative societal attitudes towards mathematics. Teachers who are themselves disengaged from mathematics may pass on their negative perceptions or their math anxiety in their own classrooms (Brady & Bowd, 2005; Ma, 1999); thus, lack of engagement can be transmitted from one group of learners to another.

As mentioned above, this cycle of disengagement from mathematics begins for many with negative experiences in elementary school. Thus, it is important for educators to gain a better understanding of how to teach mathematics in a more engaging way at the elementary level. If positive experiences with mathematics can be fostered in the early years, this will contribute to a more positive attitude towards this important subject.

## **Imaginative education**

Given the significant role mathematics plays in school curriculum, its relevance to further learning opportunities (British Columbia Ministry of Education, 2007; O'Brien, 2012), and the potential long-term implications of early disengagement from mathematics, it is especially important to understand students' engagement, or lack of engagement, in mathematics. Most importantly, we need

to understand what constitutes engaging mathematics experiences for our students. Despite a venerable and growing body of research related to the humanization of mathematics with particular reference to the affective domain, such an approach has not been implemented in mainstream mathematics teaching.

A variety of reasons have been put forward for this lack of implementation, (Leder, Pehkonen, & Törner, 2002; Cabral, 2004). However, all of these researchers acknowledge that consideration of the affective domain is a crucial factor in ongoing mathematics education research. Therefore, research that addresses the affective element while bringing forward a new perspective of using imagination has rich potential to help facilitate the implementation of affect into the teaching of mathematics. Such is the case with this study, in which use of the IE theory combines consideration of both affect and imagination.

IE takes a humanized approach to learning, is grounded in a sociocultural perspective to education, and can be applied to any subject area (Egan, 1997, 2005; Judson, 2008, 2010), including mathematics (Jonker, 2009). It considers both a student's emotive response and his or her imagination as important parts of the process of learning and developing understanding (Egan, 1997, 2005). As such, it is conducive to understanding how student engagement can be enhanced. Attending to human faculties that a learner already possesses, referred to as cognitive tools within the IE theory, may provide opportunity to enhance both learning and teaching at a critical juncture in students' mathematics journey, the intermediate years.

The IE theory (Egan, 1997, 2005) is complementary to research that has already taken place with the field of mathematics education with regard to use of the affective domain of learning. Martin and Reigeluth (2013) state "The affective domain may be equally if not more important than the cognitive domain in promoting student learning" (p.506). This supports important work that, as stated has already taken place specifically related to learning mathematics by Goldin (1988, 1998), DeBellis and Goldin (2006), McLeod (1992, 1994), Hannula (2002, 2006), which confirms that consideration of affect in learning mathematics is important, if not vital to student learning.

Within the IE theory there are five kinds of understanding that reflect a developmental progression by which individuals make sense of the world around them (Egan 1997, 2005). In the pre-language phase, somatic understanding, individuals make sense of their world primarily through their senses. This is followed by a phase of mythic understanding, in which primarily oral language is used to make sense of experiences. As individuals gain more experience of their world with the addition of written language, they enter the third phase, romantic understanding. In the fourth phase, philosophic understanding, learners make increased connections between aspects of the world around them, becoming aware of associations among experiences. In the final phase, ironic understanding,

individuals become aware of the limitations of logical thinking, which is now deemed insufficient to represent important aspects of life experiences.

In order to move from one phase of understanding to another, individuals utilize groupings of cognitive tools (Egan, 1997, 2005) to make increasing sense of their world. These tools, such as stories and metaphors, help individuals retain information by making it more relevant and engaging. These are ways of thinking that have been developed culturally over long periods of time to help individuals come to know and interact within their sociocultural environment (Vygotsky, 1962, 1978).

As stated above, a human response to learning is a key aspect of engaging learners in education. Because the IE theory provides a framework for developing pedagogical methods that are humanized to consider the affective domain and the use of imagination, the role IE can play in enhancing student engagement warrants investigation. This is especially so when students themselves, the recipients of the learning experience, are given the opportunity to make a legitimate and valid contribution to the research enquiry.

### **Research study & implementation**

My use of IE theory (Egan 1997, 2005) in recent years has given my students opportunities to work on mathematical tasks in ways that seem to have allowed them to better connect with the concept being studied and to express their understanding in a broader and creative manner. My experience suggests that one means to gaining a better understanding of students' mathematical engagement is to study lessons such as these, in which children explore and express mathematics beyond the conventional textbook. Given the need to find alternative ways to engage children in learning mathematics, a study into what IE means to children's mathematical engagement is warranted.

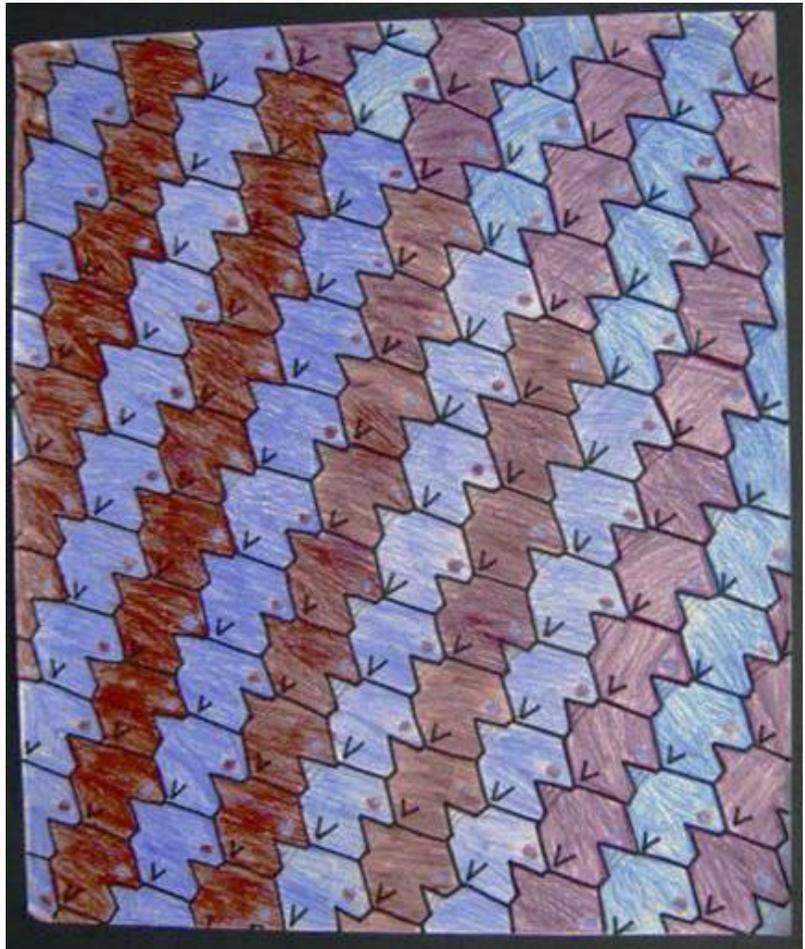
This study examined the use of IE in elementary mathematics teaching and its effects on student engagement. Using a qualitative case study design, this research examined a Grade 4 and Grade 5 unit on shape and space geometry that was framed using IE theory, with the binary opposites of vision and blindness, where six students were tracked throughout the study. Seeking to understand more about how blending imagination and emotive responses can affect the learning of mathematics, the question at the heart of this study was: What does the use of the theory of IE and its ILPFs mean to children and their engagement in elementary mathematics?

During the approximately six week unit a variety of lessons were included related to the shape and space concepts. A guiding question for the students was: How does a blind person learn about shapes and space? Resources included the use of children's literature such *The Shape of Me and Other*

Stuff by Dr. Seuss, What's Your Angle Pythagoras (Ellis, 2004), as well as videos such as Platonic Solids (Key Curriculum Press). Importantly the unit started off with a Vision Walk, to set the context of the study where students took turns with a partner to wear a blindfold or mask and "navigate" their way back to the classroom from a location around the school. On return to the classroom students wrote in their mathematics journals about the experience. This activity set the tone and context for subsequent lessons.

Part way through the unit students created tessellation designs and again wrote about their design and how it was created, as illustrated with Jason's example below

Tesselations – Morphing  
Shapes Template – My  
template used to be a hexagon.  
It used to have 6  $60^\circ$  angles,  
and 6 sides that are 2 cm long.  
After I morphed it, it became  
something else. This new  
shape has 4 sides that are 2 cm,  
4 sides that are 1.2 cm, 2 sides  
that are .5 cm, 1 side that is .3  
cm, and 1 side that is 6 cm. It  
has 6  $60^\circ$  angles, 2  $55^\circ$  angles,  
and 4  $65^\circ$  angles. Picture –  
My picture is a bit different.  
Since I used a hexagon like  
template, I could fit in much  
more than a square template. I  
changed my hexagon- like  
shapes into fish. It has many  
angles and sides, and many  
hexagon-like shapes make it  
up. My colour pattern goes  
red, purple, red ect. [*sic*] My  
hexagons are on an angle,  
and they all point north-east.



**Figure 2 Jason's tessellation design**

What proved to be an important part of the unit, which had been unplanned at the beginning, was a visit by the blind uncle of a student in the class, who visited and discussed with the class his experience of being blind. Students were able to connect the formal aspects of mathematics of what they were studying with the reality of another person, and their own sighted world.

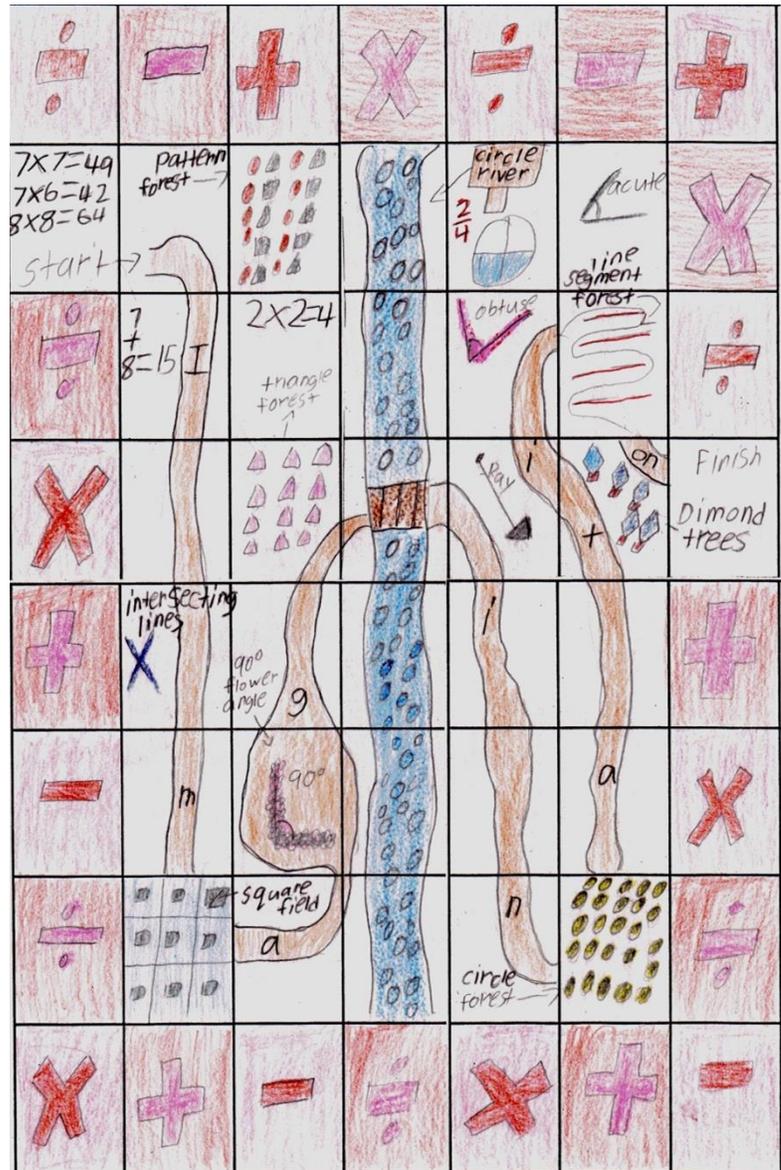
At the end of the unit rather than give the students the usual end of unit “test”, students were asked to design a quilt that would help a blind person learn about shape and space. This activity was initiated with the reading of “Sweet Clara and the Freedom Quilt” (Hopkinson, 1995). Again students were asked to write in their math journals about the quilt they had designed, as illustrated by Grace’s math journal entry and her quilt design.

My quilt symbolizes learning about Math. It is a math map, it teaches blind people about math. It has digrees (*sic*), circles and squares and other shapes. This quilt has a treasure. The treasure is, if you follow the path it will spell the word imagination. This map is made from imagination. My quilt represents to me special learning for the blind.

At the end of the unit, all six students, who took part in the actual research study, were interviewed in individual semi-structured interviews, and a group interview with the Teacher-Researcher.

A method of describing student engagement was used, Participatory Affective Engagement (PA Engagement) (Hagen, 2007; Hagen & Percival 2009) to help analyse the data. The value in the PA Engagement descriptors is in combining students’ emotions with participation, laying a

foundation for cognitive development. IE theory indicates that cognitive development is unlikely to occur unless learners participate with emotional commitment (Egan, 1997, 2005). Using the PA Engagement descriptors, two students were assessed as being Passive Positively Engaged (PPE), and four students were assessed as being Active Positively Engaged (APE). This assessment was independently verified by the Critical Friend.



Within-case analysis (Stake, 1995) was applied to student data, followed by cross-case analysis. Fore fronting factors and patterns that contributed to student engagement, two themes emerged: the first was that multi-dimensional opportunities and means by which students could connect with the mathematical concepts emerged in personally relevant ways for the students. Secondly, the incorporation of emotive (affective) responses and the use of imagination proved significant tools that helped the students to begin developing conceptual understanding.

The student's comments provided a wealth of understanding and much needed insight into how and why an innovative curriculum engages students in learning mathematics. This study significantly adds to a growing body of research and knowledge that has previously focused only on how IE is used by teachers (Nicol & Crespo, 2005; Gadanidis & Hoogland, 2003). Results indicate the students' demonstrated positive engagement with mathematics and that use of the IE theory utilizing the students' imagination and affective responses allowed multiple access points to connect with the mathematical concepts. Three conclusions of the study were that the students expanded their mathematical awareness through making a variety of connections, they were able to develop self-confidence in their learning of mathematics through using emotions and imagination, and they were able to use cognitive tools, particularly a sense of wonder, to engage with mathematics.

The value of this research is twofold. First, the infusion of imagination and affective responses to learning mathematics has not previously been considered in any substantive way in a humanized perspective of learning mathematics. Second, this research contributes to our knowledge about the use of IE theory. While there has been a significant amount of conceptual discussion and analysis of what an IE approach to learning entails (Buckley, 1994a, 1994b; Egan 1979, 1992, 1994, 2002; Pinar, 2005), no systematic examination of IE theory has been carried out from the student's perspective (K. Egan, personal communication, September 7, 2005, June 20, 2010; M. Fettes, personal communication, September 6, 2005). This investigation, therefore, adds to and broadens a growing body of research about IE theory that has thus far focused on the teacher's perspective (Fettes, 2007; Gadanidis & Hoogland, 2003; Jonker, 2009; Judson, 2010; Nicol & Crespo, 2005).

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