Evaluating fidelity of implementation for a powerful learning environment classroom intervention

Jeff Irvine
Brock University

ABSTRACT

Powerful learning environments (PLEs) are based on a social constructivist theory of learning, providing a stimulating, resource-rich and inquiry-supportive environment for student self-regulated learning. Fidelity of implementation (FOI) for such PLEs is dependent on several factors, the most critical factor being the teacher's belief system, philosophy of education, and dominant teaching style. This paper examines a classroom intervention implemented in Ontario, Canada grade 10 mathematics classrooms, using theoretical frameworks to first qualify the intervention as a PLE and then evaluate FOI, identifying the critical factors on which fidelity of implementation depend.

Keywords: powerful learning environment, fidelity of implementation, mathematics classroom interventions, Marzano's New Taxonomy

INTRODUCTION

This paper examines two evaluative dimensions of an instructional intervention in three tenth grade mathematics classes in Ontario, Canada, involving a total of 69 students. The instructional intervention was evaluated first as a powerful learning environment (PLE, Vandecandelaere, Speybroeck, Vanlaar, Fraine, & Van Damme, 2012) and secondly the instructional intervention was evaluated for fidelity of implementation (FOI) using a framework developed by Century, Rudnick, and Freeman (2010). Therefore, the research questions for this study were

(1) How can a classroom instructional intervention be evaluated as a PLE;
(2) How can FOI be evaluated for a classroom intervention that is a PLE;
(3) What are the key elements of an instructional intervention that must be included to both qualify the intervention as a PLE as well as facilitate and support FOI?

THEORETICAL FRAMEWORKS

This study employed three theoretical frameworks. For the creation of the instructional intervention, the framework was Marzano's New Taxonomy (MNT, Marzano & Kendall, 2007). For evaluation of the instructional intervention as a powerful learning environment (PLE), the framework was Vandecandelaere et al. (2012). Finally, a framework by Century, et al. (2010) was used to evaluate fidelity of implementation.

Marzano's New Taxonomy of Educational Objectives

Marzano's New Taxonomy of educational objectives (MNT) was utilized as a theoretical framework for the instructional intervention, (hereafter "the MNT intervention"). MNT consists of three domains or systems (self, metacognitive, cognitive) acting on three knowledge domains: information, mental procedures, and psychomotor procedures. The systems can be further subdivided by strategy (Figure 1): Self-system strategies include examining importance, examining emotional response, self-efficacy and overall motivation; metacognitive system strategies involve goal specification, process specification or process monitoring, and monitoring clarity and accuracy; and cognitive system strategies encompassing storage and retrieval, comprehension, analysis, and knowledge utilization processes.

Unlike Bloom, MNT is not a strict hierarchy but is based on two dimensions: flow of information; and level of consciousness. In top-down fashion, the self-system engages first, making decisions about whether to engage in a new task. This is followed by the metacognitive system that sets goals and strategies. Finally, the cognitive system engages at whatever levels are appropriate to resolve the task. There is no strict hierarchy within the cognitive system, similar to the full taxonomy. This flow of processing is illustrated in Figure 2. Marzano also argues that his taxonomy is hierarchical based on levels of consciousness, which increase as one proceeds up the taxonomy. For example, retrieval processes may be automatic, requiring a very low level of consciousness; however, knowledge utilization requires significantly more conscious thought, as does goal setting by the metacognitive system, while self-system involvement and decision making requires even more.

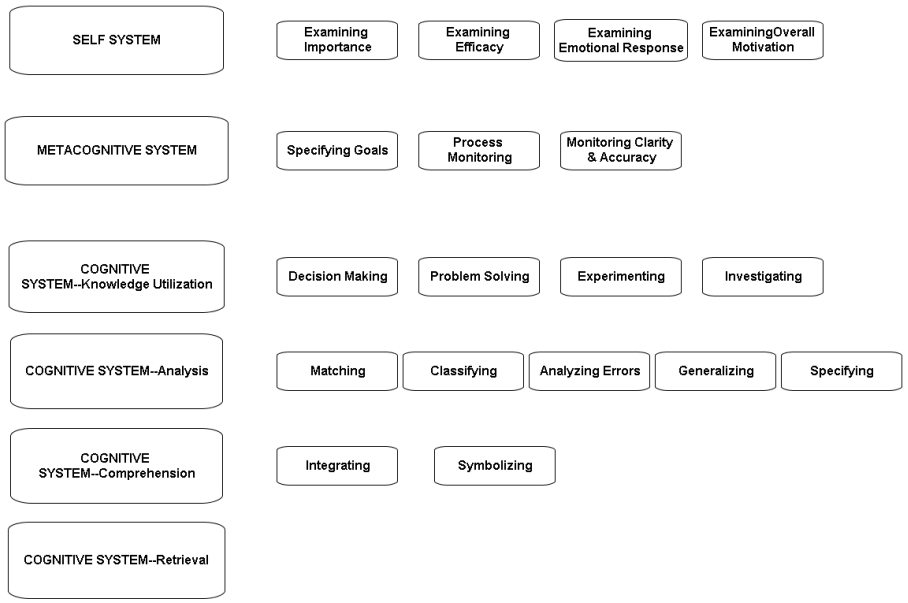

Figure 1. Marzano's New Taxonomy showing sublevels. Reproduced with permission from R. Marzano & J. Kendall (2007), *The New Taxonomy of Educational Objectives* (2nd ed.).

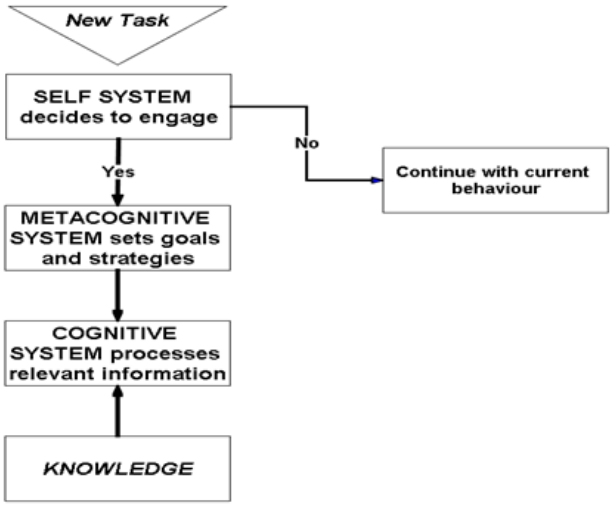

Figure 2. Flow of processing in Marzano's New Taxonomy. Reproduced with permission from R. Marzano & J. Kendall (2007), *The New Taxonomy of Educational Objectives* (2nd ed.).

Marzano and Kendall (2008) published *Designing and Assessing Educational Objectives* to help educators apply the taxonomy, although the work's instructional strategies are somewhat basic and need enhancement and augmentation before using them in classroom situations. MNT formed the theoretical framework for the instructional intervention used in the current study.

Powerful Learning Environments

Vandecandelaere et al. (2012) provide a framework of *powerful learning environments* (PLE) and identify teaching strategies across four dimensions. The first dimension is *motivate to exert learning*. Examples of these strategies include arousing interest by connecting to the real world, fostering a desire for intrinsic motivation and deep learning, and providing a variety of learning opportunities. The second dimension is *activate towards self-regulated learning*, which includes strategies such as cooperative learning, connecting to prior knowledge, communicating, and offering challenging yet achievable tasks for all learners (similar to Vygotsky's zone of proximal development). The third dimension is *give feedback and coach*; feedback should be given before, during, and after the task, and should focus on next steps. The final dimension is *structure and steer*, which emphasizes planning and sequencing, with the constant goal of deep learning and transfer. The current study addressed all four of these dimensions, as discussed following.

Fidelity of Implementation

Century, Rudnick, and Freeman (2010) have developed a framework for evaluating fidelity of implementation (FOI), which is described below and then used to assess implementation fidelity for the MNT instructional intervention. The framework uses a critical components lens within two major subdivisions, structural critical components and instructional critical components. Each major subdivision contains two dimensions. Structural critical components are divided into procedural and educative. Procedural critical components focus on how the intervention is structured to communicate to the teachers what they should be doing; educative critical components outline what knowledge and skills the teachers are expected to have or develop in order to implement the intervention. Instructional critical components are divided into pedagogical critical components, representing the behaviours and actions of the teachers with students when enacting the intervention; and student engagement critical components, which outline the expected behaviours of the students receiving the intervention.

METHODOLOGY

This qualitative study employed content analysis (Krippendorff, 2013) to identify the key elements of the instructional intervention that both qualify the intervention as a PLE and also facilitate FOI. Krippendorff (2013) describes content analysis as follows: "Content analysis is a research technique for making replicable and valid inferences from texts (or other meaningful matter) to the contexts of their use." (p.24) Krippendorff offers a conceptual framework for content analysis that consists of

- A body of text, the data that a content analyst has available to begin an analytical effort;
- A research question that the analyst seeks to answer by examining the body of text;
- A context of the analyst's choice within which to make sense of the body of text;
- An analytical construct that operationalizes what the analyst knows about the context of the body of text;
- Inferences that are intended to answer the research question, which constitute the basic accomplishment of the content analysis;
- Validating evidence, which is the ultimate justification of the content analysis. (p.35)

Artifacts that were analyzed included the lessons and activities of the instructional intervention, student work samples, pre- and post teacher interviews, student post-intervention interviews, and student achievement data.

REVIEW OF THE LITERATURE

In this section we will examine research literature related to PLEs and literature on fidelity of implementation. These two issues are not directly related. However, this paper will demonstrate how fidelity of implementation of an instructional intervention is affected by whether or not that intervention is a PLE.

Powerful Learning Environments

The origins of PLEs can be found in a social constructivist theory of learning (Koopman, Bakx, & Beijaard, 2014) in which students are expected to construct their own learning when provided with a stimulating and inquiry-supportive framework. Kester and Paas (2005) concur with this position and characterize PLEs as designed to stimulate active learning through collaboration, cognition and problem solving, as well as self-regulated learning. Rich resources based on realistic, real-life situations, inquiry, and appropriate use of other technologies, including manipulatives, support the development of deep cognitive learning strategies and self-regulation (Kester & Paas, 2005; Koopman, Bakx, & Beijaard, 2014). Koopman et al. identify increased student engagement, intrinsic goal orientations, socially constructed knowledge, and enhanced self-regulation as critical characteristics of PLEs. In tracing the development of PLEs, De Corte, Verschaffel, and Masui (2004) state that the foundations of PLEs can be traced to a better understanding of the process of learning due to research in the field in the latter half of the twentieth century. They point out that PLEs contain a balance between discovery and direct instruction, designed to foster student competence while sustaining interest and engagement. This is in agreement with Könings, Brand-Gruwel, and van Merrienboër (2005) who provide additional evidence for the effectiveness of PLEs as optimal for learning based on research in cognitive psychology.

De Corte et al. (2004) proposed a four-factor framework of PLEs consisting of competence, learning, intervention, and assessment (CLIA model). The CLIA model was an important forerunner of the Vandecandelaere et al. (2012) model, which refined the dimensions and provided more explicit instructional strategies for creating and supporting a PLE. Schelfhout, Dochy, Janssens, Struyven, and Gielen (2006) provide a list of five guiding principles for designing PLEs:

- Learning environments should induce and support constructive, cumulative, and goal-oriented acquisition processes in all learnings—even the more passive ones—through a good balance between discovery learning and personal exploration on the one hand, and systematic instruction and guidance on the other.
- Learning environments should embed acquisition processes as much as possible, using authentic contexts that have personal meaning for students, are rich in resources and learning materials, and offer ample opportunities for collaboration.
- Learning environments should foster students' self-regulation of their learning processes: as students' competencies in a domain increase, external regulation of

knowledge and skill acquisition should be gradually removed so that they increasingly become agents of their own learning.
- Learning environments should flexibly adapt the instructional support that is provided, especially the balance between external regulation and self-regulation, taking into account individual differences in cognitive aptitudes, as well as in affective and motivational characteristics, amongst learners.
- Because domain-specific and domain-general knowledge play complementary roles in competent learning and thinking, learning environments should integrate the acquisition of general meta-cognitive skills within the subject-matter domains. (p. 475)

Könings et al. (2005) position PLEs within a set of goals for education. They identify educational goals as high quality knowledge acquisition, problem solving, self-directed learning skills, and transferability of knowledge and skills. They argue that the characteristics of PLEs are able to address all of these goals, while simultaneously supporting and enhancing student engagement and motivation.

Fidelity of Implementation

One definition of fidelity of implementation (FOI) is "the determination of how well an intervention is implemented in comparison with the original program design." (O'Donnell, 2008, p.33) Somewhat surprisingly, there is not universal agreement on a definition of FOI and definitions are frequently tailored to a particular study (Crawford, Carpenter II, Wilson, Schmeister, & McDonald, 2012). There is also debate on the appropriate dimensions of FOI, although common dimensions include adherence, quality of delivery, implementation, and rating by a trained observer (Dane & Schneider, 1998). FOI is variously identified as a measure of internal validity (Crawford et al., 2012); a measure of external validity (O'Donnell, 2008); related to outcomes of an intervention (O'Donnell, 2008); a measure of intended versus implemented curriculum (Crawford et al., 2012); critical for scale-up of an intervention (O'Donnell, 2008). There is concern that FOI overlaps with other constructs including teaching, curriculum potential, curriculum-in-use, perceived curriculum (O'Donnell, 2008).

O'Donnell (2008) identifies two critical aspects of FOI as adherence and integrity of implementation. FOI can be separated into fidelity to structure (the extent to which the implementation conforms to the researcher's specifications) and fidelity to process, which includes emotional climate and quality of professional interactions (Crawford et al., 2012). Both dimensions need to be addressed in order to evaluate FOI. These two divisions are consistent with the framework developed by Century et al. (2010) for evaluating FOI, described under theoretical frameworks above.

A significant issue with FOI is the degree of adaptation that occurs when a teacher responds to their students. Some level of adaptation is expected due to individual student needs, teacher anticipation of student difficulties, and class composition. However, a large amount of adaptation would be expected to distort overall FOI (Dane & Schneider, 1998; O'Donnell, 2008).

THE MNT INSTRUCTIONAL INTERVENTION

The MNT intervention was structured to focus on two systems of MNT, self (motivation) and metacognition. In MNT, the self system is construed with four subdimensions: examining

importance, examining efficacy, examining emotional resp0onse, and examining overall motivation. The first two of these subdimensions locate the MNT self system as related to expectancy-value theory (Eccles & Wigfield, 2002). The third subdimension relates the MNT self system to theories of affect (DeBellis & Golding, 2006), and the fourth subdimension situates motivation as an amalgam of the first three subdimensions. Therefore, the MNT instructional intervention utilized activities and full lessons that addressed one or more of these subdimensions. An important consideration in structuring these activities and lessons was the role of student autonomy and choice, identified by self-determination theory (Deci & Ryan, 2008) as important factors in student motivation.

Metacognition was the second MNT system that was a focus of the classroom intervention. Each lesson involved one or more activities related to metacognition, such as goal setting, goal monitoring, or anticipation guides. Metacognition is a dimension of higher-order thinking skills (HOTS). The metacognitive activities and a number of cognitive activities in the MNT intervention promote HOTS. The unit also included a rich assessment task that was connected to the students' real world, encouraged HOTS, and utilized hands-on manipulatives as well as technology.

The MNT instructional intervention took a student-centred, active stance in which hands-on activities, manipulatives, and appropriate technology played a prominent role. There was an emphasis on relating mathematics to real-world situations as well as investigations that utilized student-generated data to increase interest (Irvine, 2016). Cooperative learning and other grouping strategies were used to generate mathematical conversations, student problem posing, and problem solving to increase student motivation (Irvine, 2017). The intervention began with an anticipation guide (Appendix E) to activate students' prior knowledge and emphasize the focus on metacognition. This was followed by a unit preview to acquaint students with the probable course of the unit's development (Appendix F).

The activities in the MNT intervention were designed to be *low floor high ceiling* (Gadanidis, Hughes, Scucuglia, & Tolley, 2009). Low floor describes an activity that does not require extensive prior mathematical knowledge; thus, every student has an entry point to the activity. High ceiling indicates that the activity leads to or can be extended to deeper mathematical ideas and concepts. For example, as noted above, activities in the MNT intervention promoted HOTS and fostered extended mathematical thinking.

Dimensions of quality instruction have been identified as: providing tasks with high cognitive challenge; providing learning supports for students; and teachers having adequate classroom management, thus minimizing distractions from student learning (Kunter, Klusmann, et al., 2013). The MNT intervention satisfied all of these dimensions: numerous tasks provided cognitive challenge and encouraged HOTS; feedback mechanisms such as individual white boards provided an avenue for real-time confirmation of student learning and the opportunity to address student misconceptions; and the teachers involved in the study were highly qualified, held mathematics specialist certification, had extensive teaching experience, and had clearly established classroom routines that minimized distractions.

POWERFUL LEARNING ENVIRONMENTS AND THE MNT INSTRUCTIONAL INTERVENTION

Vandecandelaere et al.'s (2012) discussion of "powerful learning environments" identifies teaching strategies across four dimensions. The first dimension is *motivate to exert*

learning. Examples of these strategies include arousing interest by connecting to the real world, fostering a desire for intrinsic motivation and deep learning, and providing a variety of learning opportunities. The instructional intervention in this study provided a wide variety of active learning opportunities and supported HOTS, a dimension of deep learning, through the inclusion of metacognitive strategies and activities, as well as cognitive activities that generated interest. Many of these strategies connected learning to the real world as well as to student's own lived experience.

The second dimension is *activate towards self-regulated learning*, which includes strategies such as cooperative learning, connecting to prior knowledge, communicating, and offering challenging yet achievable tasks for all learners. The MNT instructional intervention included numerous activities that fostered choice, cooperative learning, appropriate challenge, and communication.

The third dimension is *give feedback and coach*; feedback should be given before, during, and after the task, and should focus on next steps. The MNT intervention included opportunities for both teacher and peer feedback before, during, and after classroom activities: informal feedback during instruction using peer groups, instantaneous feedback using individual white boards, teacher feedback and scaffolding during student working groups and individual work time.

The final dimension is *structure and steer*, which emphasizes planning and sequencing, with the constant goal of deep learning and transfer. This intervention consisted of an entire unit of study coordinated with curricular expectations; all instructional activities were sequenced and resources were completely provided; activities and entire lessons were fully developed; assessment tasks were provided and discussed in detail with the teachers involved prior to the commencement of the unit. The teachers involved in this instructional intervention provided extensive feedback to the researcher, requested modifications to lesson order and to some of the activities, and provided additional activities that fit very well with the active stance of the intervention. These additional activities included the use of individual student white boards, which facilitated active feedback during classes; commit and crumple (Keeley & Tobey, 2011), which fostered HOTS using a fun and active strategy; and two truths and a lie (Small & Lin, 2010) again fostering HOTS in a fun and active way.

FIDELITY OF IMPLEMENTATION

Observed classes were assessed for fidelity of implementation against eight criteria identifying the degree to which the lessons reflected the expectations of the MNT intervention: matching given sequencing of topics; inclusion of all elements of the MNT intervention; instructional strategies; responses to student questions; use of manipulatives; use of technology; responsiveness to student needs. Of 20 classes that were observed by the researcher, 14 (72%) were assessed as representing a high degree of implementation fidelity, and an additional three classes (14%) as having a moderate degree of implementation fidelity. Some adaptation was expected (Dane & Schneider, 1998; O'Donnell, 2008) and was observed as the teacher responded to the needs of individual students and differentiation based on class composition. However, the overall fidelity of implementation was good.

Following is a detailed assessment of the MNT intervention using the Century et al.(2010) framework.

Structural—Procedural

The MNT intervention was structured to last 26 classes of 75 minutes each, the typical length of the quadratic relations unit in Grade 10 Academic Mathematics. For a number of reasons, this time period increased to 30 days. This included the teacher's decision to include several work periods to consolidate skills; teacher absences while she delivered professional development workshops at local elementary schools; and the interference of statutory holidays.

Lesson order was agreed upon prior to beginning the unit, and within lessons the order of presentation was generally consistent with the intervention as outlined. All essential elements were included in the lessons and lesson content was consistent with expectations. Class structures and instructional delivery were also consistent with expectations, resulting in significantly more group work and cooperative learning than had been the norm in these classes. Formative and summative assessment tools were also consistent, although the teacher included a second summative assessment midway in the unit to consolidate skills.

Structural—Educative

All lessons were explicitly linked to curriculum policy document expectations. Student prior knowledge (for example, knowledge of linear relations and finite differences) was relatively uniform, given that all students had successfully completed Grade 9 Academic Mathematics. Teacher content and pedagogical knowledge was strong, with the teacher holding a Mathematics Specialist qualification, and prior experience in teaching this grade and unit over her 22 years of teaching mathematics.

Instructional—Pedagogical

The teacher facilitated group work and student discussion by fostering an inclusive and risk-tolerant atmosphere, and the teacher was adept at involving students in investigations and problem solving. By utilizing the MNT materials as intended, the teacher supported student autonomy through choice of activities, acceptance of alternative solution strategies, and addressed individual learning modalities through the use of group work, cooperative learning, manipulatives, and technology as a normal and expected part of the classroom routines.

Instructional—Student Engagement

Most students contributed to small group and whole-class discussions, engaged in and completed intellectually challenging work, took risks, and demonstrated autonomy as learners. Essential activities were generally completed. The teacher reinforced this expectation through frequent formative checks (often using assessments employing individual white boards during the lesson) and through a homework check system that was clearly part of the normal classroom routine.

DISCUSSION

Addressing research question #1, the Vandecandelaere et al. (2012) provides an efficient and effective framework to evaluate a classroom intervention as a PLE, as demonstrated by the

evaluation of the MNT intervention. The Vandecandelaere et al. framework provides clear descriptions of the four important dimensions that must be addressed. Similarly, with respect to research question #2, the Century et al. (2010) framework identifies and describes the structural and instructional critical components for evaluating FOI. By comparing the elements of the MNT intervention to these critical components, it was possible to identify the level of FOI of the intervention as well as to identify which dimensions of the MNT intervention that contributed the most to FOI.

Research question #3 asked to identify the key elements of a classroom intervention that contribute both to a PLE and FOI. This study demonstrated that the most important contributing factor in such an intervention is the teacher. A critical factor in FOI for a PLE is the teacher's belief system, philosophy of education, and teaching style. For the MNT intervention, both teachers espoused beliefs in the necessity of engaging students and offering appropriate levels of challenge. However, in pre-intervention interviews, both teachers indicated that they subscribed to a fixed mindset with respect to student abilities (Dweck, 2006); they stated that some students would be unable to succeed despite teacher interventions and the implementation of the PLE. This is a significant detriment to implementing a PLE.

Table 1. Teacher characteristics.

	Sex	Pseudonym	Qualifications	Years of experience	Years in current school	Dominant teaching styles[1]
Treatment	Female	Ms. Beckham	Honours Specialist in Mathematics	22	<1	Command Practice Guided discovery
Control	Female	Ms. Alford	Honours Specialist in Mathematics	10	<1	Command Practice Guided discovery

Note: [1]Based on teaching styles classifications in Fernandez-Rivas & Espada-Mateos (2019*).*

The dominant teaching styles of both Ms. Beckham and Ms. Alford were command and practice (Table 1), which would be classified as traditional (Fernandez-Rivas & Espada-Mateos, 2019*).* However, both teachers also indicated that they sometimes engaged in guided discovery. Ms. Beckham stated "I do a lot of investigations" (pre-intervention interview, February 21, 2018). However, the researcher observed that in observed classes that were rated as *low* on FOI, Ms. Beckham utilized command and practice styles exclusively. The quantitative and qualitative results in this study were consistent with comments made by Ms. Beckham in her post-intervention interview: she indicated that she observed a noticeable difference in student engagement during the MNT intervention. She attributed this increased engagement to the active nature of the lessons; increased social interactions due to more group work; the use of manipulatives and technology. She also noted that when she reverted to more traditional, teacher-lead lessons, the levels of engagement decreased.

A second factor influencing FOI was the availability of resources. The PLE assumes a resource-rich environment with ready availability of technology, manipulatives, print and other resources. In the MNT intervention, there was a significant shortage of manipulatives in the school; the researcher found it necessary to provide additional resources in this area in order to implement the PLE effectively.

Another influencing factor was the support of the principal and school administration. In this case, there was wholehearted support from both the principal and other administration, based on the potential for the PLE to improve student achievement and student attitudes towards the learning of mathematics. Finally, to effectively implement a PLE, there must be sufficient flexibility in the district mathematics curriculum to allow students to explore mathematics in a non-linear manner.

CONCLUSION

In addition to promoting student motivation and metacognition as a PLE, the MNT intervention provided opportunities for students to appreciate the beauty of mathematics, which in itself is a motivating factor. The activities afforded opportunities to encounter

(1) the pleasure of experiencing the new, the wonderful and the surprising in mathematics;
(2) the pleasure of experiencing emotional mathematical moments "(either our own, or vicariously, those of others); and
(3) the visceral pleasure of sensing mathematical beauty. (Gadanidis et al., 2009, p. 2)

Implementation of a PLE was found to enhance student engagement and student attitudes towards mathematics.[1] FOI for this PLE was somewhat problematic based on dominant teaching styles of the two teachers involved. However, both teachers demonstrated a willingness to attempt to implement the intervention with minimal adaptation, to the best of their abilities. This good-faith attempt resulted in relatively good FOI for the majority of the MNT intervention. It is recommended that when implementing PLEs in the future, a sustained attempt to procure teachers whose philosophies of education align with the principles of the PLE be made. This should result in strong FOI based on teacher beliefs in the efficacy of the PLE concept. The probability of finding such teachers would be enhanced if a sustained professional learning program was implemented to acquaint teachers with the principles of PLE and aspects of PLEs such as the use of manipulatives, social groupings, and real-world connections.

ETHICS CONSIDERATIONS

The MNT instructional intervention was approved by the appropriate research ethics boards at both the university and the school district. Approval was also obtained from the principal of the school involved. Signed consent forms were obtained from all students involved in the study as well as their parents or guardians. Separate signed consent forms were obtained for the five students who were interviewed at the conclusion of the study. The teachers involved in the study also provided signed consent forms prior to the initial interviews.

[1] ES=0.54 for engagement; ES=0.32 for attitudes; significant at $p<0.01$

REFERENCES

Century, J., Rudnick, M., & Freeman, C. (2010). A framework for measuring fidelity of implementation: A foundation for shared language and accumulation of knowledge. *American Journal of Evaluation, 31*(2), 199-218.

DeBellis, V., & Golding, G. (2006). Affect and meta-affect in mathematical problem solving: A representational perspective. *Educational Studies in Mathematics, 63*, 131-147.

Deci, E., & Ryan, R. (2008). Self-determination theory: A macrotheory of human motivation, development, and health. *Canadian Psychology*, *49*(3), 182-185. doi:10.1037/a0012801

Dweck, C. (2006). *Mindset: The new psychology of success*. New York, NY: Ballantine Books.

Eccles, J., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Review of Psychology*, *53*, 109-132.

Fernandez-Rivas, M., & Espada-Mateos, M. (2019). The knowledge, continuing education and use of teaching styles in Physical Education Teachers. *Journal of Human Sport and Exercise, 14*(1), 99-111. http://dx.doi.org/10.14198/hse.2019.141.08

Gadanidis, G., Hughes, J., Scucuglia, R., & Tolley, S. (2009). Low floor, high ceiling: Performing mathematics across grades 2-8. *Conference Papers—Psychology of Mathematics and Education of North America, 2009 Annual Meeting*, 1-8.

Keeley, P., & Tobey, C. (2011). *Mathematics formative assessment: 75 practical strategies for linking assessment, instruction, and learning*. Thousand Oaks, CA: Corwin.

Krippendorff, K. (2013). *Content analysis: An introduction to its methodology* (3rd ed.). Thousand Oaks, CA: Sage.

Kunter, M., Tsai, Y., Klusmann, U., Brunner, M., Krauss, S., & Baumert, J. (2008). Students' and mathematics teachers' perceptions of teacher enthusiasm and instruction. *Learning and Instruction*, *18*(5), 468-482. doi:10.1016/j.learninstruc.2008.06.008

Kunter, M., Klusmann, U., Baumert, J., Richter, D., Voss, T., & Hachfeld, A. (2013). Professional competence of teachers: Effects on instructional quality and student development. *Journal of Educational Psychology*, *105*(3), 805-820. doi:10.1037/a003258

Marzano, R., & Kendall, J. (2007). *The new taxonomy of educational objectives* (2nd ed.). Thousand Oaks, CA: Corwin Press.

Marzano, R., & Kendall, J. (2008). *Designing and assessing educational objectives: Applying the new taxonomy*. Thousand Oaks, CA: Corwin Press.

Small, M., & Lin, A. (2010). *More good questions: Great ways to differentiate secondary mathematics instruction*. Toronto: Nelson.

Vandecandelaere, M., Speybroeck, S., Vanlaar, G., Fraine, B., & Van Damme, J. (2012). Learning environment and students' mathematics attitude. *Studies in Educational Evaluation*, *38*, 107-120.