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Math centers: A pedagogical tool for student engagement in intermediate math class

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This paper draws from a qualitative exploratory case study that aimed at exploring the learning experiences of teachers as they engage in professional learning project. The case study involved three elementary school teachers' professional learning experiences as they engaged in developing a practical, research-based approach to differentiated instruction using a flipped classroom and student-centered pedagogical approaches that would result in enabling students to be engaged with mathematics..

Keywords: Professional learning, flipped classroom, student-centered, engagement, intermediate mathematics.

Introduction

Research indicates that professional learning, which is job-embedded (Joyce & Showers, 2002), collaborative (Garmston & Wellman, 2003), occurs over time, and is driven by the needs of the teachers involved (Fullan, 1995; Lawler & King, 2000; Little, 2002), is effective. Furthermore, effective professional learning is focused on student outcomes, integrated into the teacher's day-to-day culture, and often tied to the school's improvement process (Way, 2001). The paper draws from a study that aimed at exploring the learning experiences of three teachers engaged in a professional development project in Ontario at an Intermediate level (grade 6, grade 7 and grade 8). The professional development project is part of an initiative of The Elementary Teachers Federation of Ontario (ETFO). ETFO invited and provided support for teams of teachers from the same school or in similar roles at different schools to come together and conduct professional learning projects relevant to their specific professional needs, circumstances and interests. In addition to the three teachers a university researcher was invited to collaborate with the group and conduct a case study of the professional development project. The three teachers in the professional development project collaborated in developing a practical, research-based approach to differentiated instruction *using a flipped classroom approach and student-centered pedagogical approach* that would result in enabling students to be engaged with mathematics. This flipped classroom approach and student-centered approach involved the use of grade-appropriate math centers where students would engage in a variety of math problems and/or topics; have opportunities to practice and consolidate basic facts and operational skills; use technology and manipulative as learning tools; become efficient communicators in math; and develop a sense of self-awareness toward their own math skills. Students would also grow in their ability to work independently and cooperatively as they work through various math centers, allowing the teacher(s) to conference with individuals and small groups of students. In this paper we describe some of the findings from the case study. The case study is guided by two questions: How did the professional development project facilitate teachers' understanding of the use of math centers in a flipped classroom and student-centered approach for

teaching and learning mathematics? How did the teachers negotiate constraints and possibilities as they engaged in their professional development project? .

Research has demonstrated that engaging students in the learning process increases their attention and focus (Jonathan & Aaron, 2012). Further it motivates students to practice in higher-level of critical thinking while promoting meaningful learning experiences. Chickering & Gamson (1987.), states that

“learning is not a spectator sport. Students do not learn much just by sitting in classes listening to teachers, memorizing pre-packaged assignments, and spitting out answers. They must talk about what they are learning, write about it, related it to past experiences and apply it to their daily lives. They must make what they learn part of themselves”.

In this sense, a flipped classroom and student-centered learning is essential. Educators who adopt to a flipped classroom and student-centered approach as a pedagogical method find that it increases student engagement, which allows for learners to successfully achieve the learning objectives (Jonathan & Aaron, 2012). For a flipped classroom and student-centered mathematics class to be effective, a shift in the role of the teacher and students in the classroom must be adapted. On the one hand, teacher’s role is viewed as a guide for students’ constructive processes towards mathematical meanings and mathematical ways of knowing. On the other hand, learning is viewed as an active, constructive activity in which students wrestle through problems that arise as they participate in the mathematical practices in the classrooms (Cobb, Yackel & Wood, 1992). Recently, there has been an upsurge of interest in instruction that focuses on flipped classroom approach for teaching mathematics.

Type of Math Centers

There were various types of math centers that each participating teacher used in their classroom. The choice of a math center was based on teachers’ professional judgment of the students and students’ needs.

Inquiry based Center: - A group of 4-5 students rotated from one station to another to learn about various topics. Examples of these topics included: explore and connect station, “what happens when...”, various word problems, “Reflection on this”, “Test your knowledge.” Each station had the option of students either working by themselves and/or in their respective groups. Teachers used as one or more of inquiry based centers to develop curiosity of a given topic among the students.

Resource Center: - This center was available for students all the time. This station consisted of graph papers, blank papers, mathematics dictionaries, mathematics textbook (e.g. *Math on call*, *Math on hand*, and *Math makes sense 8*). This center also included measuring tools such as meter -sticks, rulers, weight measuring scale and measuring tape. This center gave student the opportunity to select an appropriate tool for themselves in order to learn a topic/concept at hand.

Online Research Center: - Students had the opportunity to use their own technology or/and the computer station located in class to deepen their understanding of topic/concept at hand. Students also had the option of exploring a given topic at home via online research.

Debriefing Center: - This is usually available at the end of a lesson, where students come back into their respective groups. Here students are given the opportunity to consolidate their learning as a group, clarify any misunderstandings and learn from one another.

An example of inquiry based math center

Students were given the opportunity to solve a real life problem, using a task called, “how big is a trillion?”. In this problem, students were asked two open-ended questions: 1) Is it possible for trillion rice to fit into this room? Explain your solution 2) How much distance around the Earth can the rice cover if each rice is lined up in a line? Compare this with another non-metric unit. Students were asked to solve this problem in group of 4-5. Each group was given 6-7 classes (40 minutes each) to solve the problem in class. Students were allowed to do any background inquiry that they thought was necessary at home. The purpose of working on this problem in class was to have a common working place as a group, where they negotiated their learning and solution. At the end of the 7th class, groups were asked to submit their solution in form of poster which each group presented in the following class. Mathematically, this problem required students to learn about how to measure a unit in real life, length, metric versus non-metric units, volume, and capacity. Other than the mathematical knowledge, students had to discuss their ways of solving the problem, which means selecting appropriate tool to solve the problem in most efficient way, while self-regulating their learning and progress as a group. By the time this particular problem was given, students often became competitive. Teacher noticed that while students helped members of other groups with background mathematical knowledge, groups often tried to keep their solution a secret. This was because groups often wanted their solutions to be a unique solution.

Preparing the students for flipped classroom with math-center included teacher presenting and discussing math center code of conducts, where the purpose and the importance of self-regulation for one’s own learning was discussed in depth as a class. In order to utilize various centers, students were divided in groups of 4-5 students, these groups were often changed and redesigned either by the teacher or the students. Students were informed that they may seek help support from their teacher at any point, however they are encouraged to first discuss it with the members of their respective groups.

Flipped classroom

Flipped classroom approach for teaching mathematics is considered as an effective way for engaging students in active learning as well as in meaningful peer-to-peer and peer-to-teacher interactions during the in-class learning process (Forsey, Low, & Glance, 2013; Pluta, Richards, & Mutnick, 2013). Moreover, Bergmann and Sams (2012) indicated that flipped classrooms enable teachers to take individual students’ needs into account as well as to facilitate more interactions among peers and teachers in the classroom. The teaching and learning context of flipped classroom approach consists of two kinds of activities: in-class and out-class. In-class time is utilized for inquiry, application and assessment in order to better meet the needs of the individual learners. Technology-assisted out-of-class time involves personal instruction, where students acquire responsibility for their own learning, through studying course material on their own, using various sources (self-discovered and/or provided by teacher). The main goal in flipping a class is to cultivate deeper, richer, and active learning experiences for students where the instructor is present to coach and guide them. Further, emphasis is on higher-order thinking skills and application to complex problems, and which might include collaborative learning, case-based learning, peer instruction and problem set. In this sense the role of the teacher is to facilitate the learning process by helping students

individually and in groups. According to Bergmann & Sams (2012), there are many ways of implementing a flipped classroom approach. For this study, the participating teachers utilized various math-centers (discussed previously in the article) where students self-regulated their own learning in a math class.

Methodology

A qualitative research methodology was used to conduct this case study. According to Yin (2003) a case study design should be considered when: (a) the focus of the study is to answer “how” and “why” questions; (b) the behavior of those involved in the study cannot be manipulated; (c) you want to cover contextual conditions because you believe they are relevant to the phenomenon under study; or (d) the boundaries are not clear between the phenomenon and context. A case study was chosen because the study could not be considered without the context of flipped classroom approach, and more specifically the math centers classroom settings.

This case study involved three mathematics teachers at a Canadian middle school, who taught intermediate level (grade 6, 7 and 8) students. Two of the teachers were intermediate level mathematics teachers with their own classroom. One teacher was the resource teacher assigned by the district school board. The role of the resource teacher was to support the two classroom teachers by finding necessary resources needed to run the project. The two classroom teachers applied the flipped classroom approach in their mathematics classes. In preparation for the project, all three teachers sought opportunities to enhance their professional knowledge of using technology in mathematics teaching and learning. Further, each teacher read a number of monographs provided by the Ontario Ministry of Education in order to develop efficient knowledge of the Ontario elementary school mathematics curriculum, in particular knowledge of the mathematical processes such as problem solving, communicating, reasoning and proving.

Data was collected from:

- 1) Participating teachers’ observation of their teaching and learning experiences. Each teacher recorded field notes based on their own reflections as well as observation of their students in-class events related to math-centers (e.g., counting the number of students being engaged per center, how teachers guided the off track students to get back to work, etc.). In addition to these data was collected from teachers’ notes of their conferencing with students as individuals and in groups.
- 2) Transcriptions and field notes of group meetings (selectively audio-recorded). Each teacher’s observations were shared, discussed and reflected upon by teachers as a group for professional growth while focusing on their own professional growth and their students’ engagement in respective mathematics class.
- 3) Teachers’ artifacts such as lesson plans and assessment rubrics, and the teacher team’s final project report.

Findings and discussion

All transcribed data, field notes and teachers’ artifacts were analyzed by the university researcher and one teacher independently to identify major themes related to the guiding questions— How did the professional development project facilitate teachers’ understanding of the use of math centers in

a flipped classroom and student-centered approach for teaching and learning mathematics? How did the teachers negotiate constraints and possibilities as they engaged in their professional development project? The findings will be discussed in the following themes which emerged from the analysis: time for teachers to meet; awareness of initial resistance from parents and students; enhancement of student learning; and challenges. Findings from the study suggest that in order to sustain a collaborative professional development project teachers need time and need to meet. Teachers in this study were able to plan collaboratively and develop a practical, differentiated math program based on flipped classroom and student-centered pedagogical approach using math centers. The flipped classroom approach using math centers allowed students to engage in purposeful practice while freeing up the teacher to meet with individual and/or small groups of students for teaching and/or learning. However the two participating teachers taught different grades in different buildings of the same school, which became somewhat challenging to coordinate schedules for sit-down meetings. Often, the conversation between the three teachers would occur either in between classes (as the teachers would pass by each other's classroom) or through email (keeping each other informed on their status with the project). Although the teachers planned collaboratively, they had fewer time to compare what they had initially planned. This however, had an unexpected positive outcome which ended up by providing teachers with two different ideas of math-centers and student engagement. Both classroom teachers did utilize flipped classroom, student-centered pedagogical approach, however during their final group meeting, teachers discovered that they had each taken a different approach to the math center idea. This allowed for each teacher to talk about their thought process behind their choice for developing the math centers the way they did. Further, this provided both teachers to learn from one another's professional learning experience with their respective math centers. As different as each participating teachers' math centers were, the participating teachers observed that there were common themed categories to the math centers (these categories were presented earlier in this paper).

Another theme that emerged from the case study is that the professional development project provided opportunity for participating teachers to be aware of and understand about the initial resistance from the students and their parents toward flipped classroom and student-center pedagogical approach. Teachers developed awareness of the fact that both the students and their parents perceived mathematics teaching and learning in a traditional manner. And that for both the students and their parents, mathematics was a subject where the teacher taught a lesson, the students completed assigned tasks like doing practice questions from a mathematics textbook related to the lesson, followed by an assessment in form of a test. The students in participating teachers' classes and their parents' perception of how mathematics should be taught presented with complex challenges. This resulted in the professional development project allowing teachers to learn about strategies for alleviating these challenges including having to do a lot of community building exercise in class, while also having conversation with parents through emails, phone calls and/or one-on-one meeting, about the importance of math centers for their child's learning. These conversations with parents often revolved around the topic of how math centers not only helped students to become more engaged with mathematics but also helped to develop importance skill set of becoming more self-regulated toward their own learning.

Another theme that emerged is how the professional development provided opportunity for teachers to enhance students' learning and development through using math centers. Teachers noticed that

after the initial resistance, the students began to be engaged with math centers and by the end of school year, they began to self-regulate their learning. One teacher noted about a grade 8 student who reflected on his journey with math centers and stated that it helped him to become more resilient to mathematics learning.

First, I did not know why we were doing math centers. I felt that the teacher did not want to teach anything.... but now, when I go through different centers in class I know that I am able to do things on my own...I feel happy.... I have done these many [math centers] today...which means I can do math...I just have to take my time with each center and not worry about how much time my group members are taking with centers.

In relation to the same theme, another teacher expressed how her grade 8 student commented,

I used to think that my teacher should know everything...you know, like all the answers...but now I know that I can find all the answers...and if I am stuck, I can take help from my friends...which is okay, because we are learning together

Both of the participating teachers experienced a sense of fulfillment in terms of their professional development experiences in relation to their impact on growth in their students in terms of both mathematical understanding and self-regulation toward their own learning. Teachers noted that many of their students grew stronger in their ability to self-regulate, as they had to make choices toward their learning in terms of what to work on, how long to work for and with whom. Teachers expressed satisfaction on how the one-on-one time with the teacher allowed the struggling learners to take risk and seek clarification without feeling restricted by the classroom environment.

Given the many positive outcomes of the professional development project that focused on flipped classroom and student-centered pedagogical approach through math centers, there were some challenges. These were mainly due to the fact that teachers became aware that some students needed more time with this approach, which was not possible given that there was a limited time that these students were with their mathematics teachers and that the teachers were expected to cover the curriculum expectations. Also teachers in the professional development project realized that for a small number of students, it was extremely difficult to adapt to this approach, even if they loved mathematics. This was because these students had only experienced learning only from a textbook teaching approach in mathematics, and flipped classroom and math centers approaches were a significant departure from their past mathematics learning experiences.

Implications

This project utilized a case study research design and was conducted at one Canadian middle school. Hence, the findings of the study should not be read in terms of generalizability, but of transferability to other cases (Creswell, 2008). Recently, mathematics educators have realized the potential for a flipped classroom and student centered pedagogical approach for enhancing student engagement and learning. However, very little is known in terms of the implementation of this approach in elementary schools. This study explored the mathematics professional learning experiences of elementary school teachers as they implement the flipped classroom and student centered pedagogical approach. The professional development project provided opportunity for teachers to enhance their understanding of flipped classroom and its impact on students' learning. Teachers noted that their students became engaged with mathematics and self-regulated toward their own

math learning. The findings suggest that given opportunity to learn in a professional development setting that ensures autonomy, teachers learn and are capable of teaching through flipped classrooms and student centered pedagogical approach. The study also suggests that professional development project provides opportunity for teachers to be aware of the need for communication and collaboration among teachers, parents and students regarding the benefits and implementation of flipped classroom. As a result, further research is needed on how professional development can facilitate teachers' learning about how to communicate and collaborate with parents and students in flipped classrooms.

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