Self-determination theory as a framework for an intermediate/senior mathematics preservice course

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ABSTRACT

One of the primary goals of teacher education is to aid preservice candidates in formulating a personal philosophy of teaching that is research-based. Teacher candidates should recognize that their philosophy of teaching and learning must be grounded in research-affirmed theory, certain dimensions of which (e.g., motivation) are critical to student success. Such a theory into practice stance must be transparent in teacher candidates' preservice courses and modeled by instructors. This study used content analysis (Krippendorff, 2013) to investigate one such instance of modeling theory into practice through the use of self-determination theory as the framework for a preservice mathematics course for preservice teachers of grades 7 to 12.

Keywords: teacher education, theory into practice, motivation, self-determination theory, content analysis

INTRODUCTION

As instructors of preservice teacher courses, it is incumbent upon us to prepare our teacher candidates not only to survive but also to thrive in the classroom and to deliver effective, high-quality instruction, as measured by student achievement. Teaching is a complex activity (Lampert et al., 2013) whose fluid and dynamic nature imposes a very high cognitive load on teachers (Feldon, 2007) and requires a high degree of energy and the ability to respond quickly to a myriad of student responses, both expected and unexpected. Schön (1983) points out that such professional situations require both reflection-on-action (learning after practice) and reflection-in-action (concurrent learning and modifying during practice). Such an onerous demand may overwhelm novice teachers and consequently they may revert to teach the way they were taught (Feldon, 2007; Hiebert, Morris, Berk, & Jansen, 2007), with a reliance on transmission-style teaching and lecturing, both of which have been found to be suboptimal to student learning (Kunter, Klusmann, et al., 2013).

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). In the case of mathematics teaching, additional factors include expectations that teachers have greater pedagogical content knowledge, enthusiasm for teaching mathematics, and constructivist beliefs (Kunter, Klusmann, et al., 2013). In addition, Hill, Blazar, and Lynch (2015) found that mathematics teachers need to address student affective characteristics and encourage student motivation for learning mathematics. Kunter, Tsai, et al. (2008) found that mathematics teachers' enthusiasm for their subject transferred to their students, particularly when teachers created a supportive social environment in the classroom, and structured activities within the students' zone of proximal development; such findings were echoed in studies by Blazar (2015) and by Frenzel, Goetz, Ludke, Pekrun, and Sutton (2009).

Several mathematics education studies have identified the term *ambitious teaching* to describe effective teaching in mathematics. Anthony and Hunter (2013) summarize ambitious mathematics teaching as teaching "in which conceptual understanding, procedural fluency, strategic competence, adaptive reasoning, and productive disposition are intertwined in mathematical practice and learning" (p. 699). It is worth noting here that "productive disposition" is identified as an outcome variable for students. Inculcating ambitious teaching in new teachers also has been found to be difficult due to the impact of their prior experiences as students, typically in transmission-oriented classrooms (Hiebert et al., 2007).

In sum, Lampert et al. (2013) claim that "we are faced with two challenges: preparing beginning teachers to actually be able to do teaching when they get into classrooms and preparing them to do teaching that is more socially and intellectually ambitious than the current norm" (p. 226). The Intermediate/Senior Mathematics preservice teacher course described in this paper employed backward design to identify the exit criteria for graduating teacher candidates, and then construct an atmosphere, a classroom culture, and specific activities to achieve those goals.

METHODOLOGY AND METHOD

This qualitative study used content analysis (Krippendorff, 2013) to examine tests generated by the preservice course described subsequently. 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)

Research Questions

This current study seeks to answer the following research questions through content analysis:

1. How well does the course described in this paper inculcate a theory into practice stance among preservice teachers?
2. Is self-determination theory (SDT) an appropriate theoretical framework for such a course and what is the evidence?
3. How well do the components of this course inculcate the need to address student motivation explicitly in every mathematics course taught?
4. How will students demonstrate that these theory-into-practice principles have been internalized as they transition into their professional practice?

Content analysis (Krippendorff, 2013) was used to analyze four sets of texts: student journal entries, student responses to guided questions related to required readings, student assignment products, and student comments and behaviours as observed by the instructor and recorded in field notes.

Settings, Context, and Constraints

The context of this content analysis was a one-year course for preservice teachers of Intermediate/Senior Mathematics (grades 7 to 12). The preservice teacher education course was offered at a faculty of education in Ontario, Canada. Ontario currently has a surfeit of teachers—one estimate places the surplus at more than 30,000 teachers (Ontario College of Teachers, 2017)—the majority of whom are recent graduates of faculties of education, along with a minority of new teachers trained outside of Canada. In addition, the Ontario Ministry of Education (2012) has implemented a hiring system based on seniority, which mitigates against new graduate teachers successfully finding full-time teaching positions in Ontario for, in some cases, 5 to 7 years. There are two paths to teacher certification in Ontario: Concurrent students' undergraduate (major) studies are in education, followed by a 1-year intensive teacher training program; consecutive students complete an undergraduate degree in another discipline, followed by a 2-year education training program. Each faculty of education structures courses with different program goals, which may include an emphasis on social justice issues, Indigenous education, environmentally conscious education, or other region-specific emphases.

The course described in this paper was offered in a multi-campus, blended format, with classes consisting of a mix of concurrent and consecutive teacher candidates. This course was the first year of two for the consecutive students and was the first and only year for the concurrent students. Consecutive and concurrent students had different school-year start and end dates, as well as different teaching practicum and class schedules during the year. Because of these constraints, the course involved a blending of face-to-face and online components. The following description is for one section of the course; the other section, taught by a different instructor, had some but not all of the components in common with this section. The study described in this paper involved only the single section of the course taught at one specific campus.

COURSE GOALS

Teacher education programs' overarching goal is teacher success, measured by their (i.e., teachers') students' achievement. As such, education programs must impart to teacher candidates a student-centred philosophy that puts students first and encourage teacher ownership of student achievement. Towards that end, Maynes and Hatt (2013) have proposed a *professional shift theory* that seeks to identify characteristics of new graduate teachers that encourage future success in teaching. Professional shift theory postulates that while new teachers are initially classroom-survival focused when they begin their careers, those who are truly successful (again, measured by their students' success) shift their focus from teacher- to student-centred approaches to education. New teacher preparation programs therefore need to feature content and activities that support the potential for their graduates to have a high probability of shifting their focus on student-centred learning early in their careers. One method of addressing this priority is to provide preservice teachers with a theoretical framework upon which to base their personal teaching philosophy, such that the teaching philosophy is founded on a research-affirmed student-centred focus.

This overarching goal of teacher education programs encompasses a number of subgoals, including:

- Recognizing the key role that motivation plays in mathematics achievement and learning how to foster student engagement. A significant body of evidence indicates that motivation in mathematics has a major role in mathematics achievement (Hannula, 2006; Koller, Baumert, & Schnabel, 2001; Malmivuori, 2006; Middleton, 1995; Middleton & Spanias, 1999).
- Enacting a student-centred philosophy in planning and executing the learning–teaching continuum (Fosnot & Dolk, 1995).
- Learning the mechanics of teaching, including lesson and unit planning, classroom management, instructional strategies, and differentiated instruction.
- Learning and enacting authentic student-centred assessment practices, including assessment for, as, and of learning, based on the tenets of *Growing Success* (Ontario Ministry of Education, 2010).
- Becoming a reflective practitioner, assessing and responding to the results of the teacher's own actions. Reflective practice is the hallmark of a professional educator and includes both reflection-in-action and reflection-on-action (Schön, 1983).
- Understanding the concepts of theory into practice and putting these principles into action in lesson planning and pedagogy (Nuthall, 2004).
- Increasing mathematical content knowledge and teacher self-efficacy. The latter has been linked to student achievement and is the focus of much job-embedded professional learning in Ontario (Irvine & Telford, 2015).

- Increasing content knowledge for teaching mathematics (CKTM), which Ball and Bass (2003) identify as critical for teacher success, and therefore student success. CKTM is qualitatively different from subject content knowledge and involves: knowing alternative solution methods that are valid and the circumstances that make them so; identifying appropriate scaffolding opportunities; and being able to encourage students to investigate and go beyond their current level of knowledge (Ball & Bass, 2003).

THE NEED FOR A THEORETICAL FRAMEWORK

One of the major learnings in any preservice course is the bridging of theory into practice. Preservice teachers must recognize that teaching is grounded in research-affirmed practices, and that the "teach the way you were taught" approach to pedagogy is insufficient. Thus, preservice courses must model theory-into-practice linkages and immerse preservice teachers in an environment that fosters deep learning vis-à-vis the ways in which the theory-into-practice paradigm can be translated into classroom actions (Nuthall, 2004). Combined with the very large impact of motivation in mathematics achievement, there was a clearly identified need to establish a theoretical framework for this course that recognizes motivation as a key component of course planning, together with a foundation in motivational theory. One way to model this paradigm is through the use of self-determination theory (SDT) as a transparent framework for the preservice course development.

SELF-DETERMINATION THEORY AS A FRAMEWORK FOR THIS COURSE

SDT encompasses three human needs: autonomy, competence, and relatedness (Deci & Ryan, 2008; Deci, Vallerand, Pelletier, & Ryan, 1994). Autonomy refers to the need for some level of control over one's activities (in this case, learning); this can often be achieved by providing students with choices in their content, activities, or output/demonstrations of learning. Competence is the need to demonstrate a level of mastery in an area and to be recognized for such expertise. Relatedness is the social need—the need to have caring relationships with others; this is a foundational concept in the social constructivist classroom, and almost all activities in this preservice course utilized flexible groups.

SDT is closely related to Choice Theory (GCT, Glasser, 1998), which identifies five basic needs: freedom, power, belonging, fun, and survival. The autonomy need of SDT parallels the freedom need of GCT; competence in SDT is reflected in power in GCT; and relatedness is similar to the belonging need. Both of these theories are related to motivation, particularly intrinsic motivation, which is key to self-regulation, interest, engagement, and lifelong learning (Deci et al., 1994).

Deci et al. (1994) propose that students act intentionally to address needs within these three dimensions, which has implications for student motivation. Ryan and Deci (2000a, 2000b, 2006) point out that there is a direct link between autonomy and intrinsic motivation: Intrinsic motivation requires autonomy in the form of free choice to participate in an activity, without requiring or desiring an external reward.

Hannula (2006) provides an example of the operationalization of SDT in the mathematics classroom, by differentiating needs and goals based on their levels of specificity:

> In the context of mathematics education, a student might realize a need for competency as a goal to solve tasks fluently or, alternatively, as a goal to understand the topic taught. A

> social need might be realized as a goal to contribute significantly to collaborative project work and a need for autonomy as a goal to challenge the teacher's authority. (p. 167)

The goal linked to autonomy in the above example is simplistic and quite negative. A preferred choice for such a goal could be choice in activities undertaken, thus increasing intrinsic motivation as well as addressing the autonomy need.

Irvine (2018) has proposed a framework for comparing theories related to motivation. The framework consists of two perpendicular axes. The first axis places the theory on an Intrinsic-extrinsic motivation continuum. Ryan and Deci (2000b, 2006) have demonstrated that extrinsic motivation is a continuous variable, measured by the degree of *internalization* that the learner attaches to the extrinsic motivator. For example, if the student is not driven by a desire to achieve high marks, extrinsic rewards are a very low motivational factor, and can even be demotivating. Alternatively, if the desire for high marks is congruent with a student's personal goals, such as demonstrating competence, or gaining entrance to a specialized program, the external motivator is said to be highly internalized into the student's motivational system and is relatively close to acting as an intrinsic motivating factor. In the same way if the student is seeking certification or credentialing in a skill area, this extrinsic factor can be very motivating. However, once the certification is obtained, there is little motivation to continue learning in that area, and the extrinsic motivation does not contribute to lifelong learning. On this axis, SDT is almost entirely on the intrinsic side of the axis, although some aspects of relatedness may be influenced by extrinsic factors. The second axis is expectancy-value. Expectancy-value theory posits that students' choice of tasks, persistence, and achievement depends on two factors: students' beliefs about their probability of success and the value they place on the task (Eccles, 1994, 2005, 2009; Eccles & Wigfield, 1995, 2002; Wigfield & Eccles, 2000). The expectancy-value axis does not represent a dichotomy but instead consists of two different constructs: expectancy and value. This axis is clearly not dichotomous, since a theory may posit high levels of expectancy as well as high levels of value. Such a situation would be represented on the framework by an elongated ellipse on the expectancy-value axis. A theory of motivation for which expectancy is a major attribute will be closer to the expectancy end of the axis; alternatively, a theory for which value is a major attribute will be closer to the value end of the axis. Theories for which expectancy and value are both emphasized will be close to the middle of the axis. Expectancy and value function as mediator variables (Baron & Kenny, 1986) in that they are part of the causal link between independent and dependent variables, with both direct and indirect effects (Bailey, 2015; Eccles, 2009; Penk & Schipolowski, 2015). Thus, a theory situated on the expectancy-value axis indicates the degree to which the components of that theory function as mediator variables. For SDT, competence lies on the expectancy side of the axis, while autonomy is on the value side of the axis (Figure 2).

This study used SDT in a completely transparent manner as the theoretical framework in the Intermediate/Senior mathematics course for preservice teachers. At the beginning of the course, students were introduced to the basic tenets of SDT, and it was explained that SDT would be used as a framework. As activities and assignments were outlined, the role of SDT was clearly articulated, as were the reasons for employing SDT. The critical role of student motivation in mathematics achievement was described, as well as the need to base personal teaching philosophies on a research-affirmed theory of learning. While there is a wide array of theories of learning (Davis, 1996, estimates there are more than 400 such theories), the Ontario Ministry of Education (2005, 2007) espouses constructivism, specifically social constructivism.

The course emphasized that each student teacher's personal theory of teaching, which the course would help to develop, must be coherent with a theory of learning (Irvine, 2017) in order to facilitate and optimize their respective students' learning.

CLASSES

Much of the content of the face-to-face classes were common to most teacher education programs. This included: the philosophy of student-centred pedagogy; lesson, assessment, and unit planning; classroom management; technology in math class; mathematics content; and interrogating the curriculum policy documents. Figure 1 illustrates the elements of the course. Class structure involved flexible groupings, activities, and learning instructional strategies through "being the student" role playing as well as creating and delivering activities as "practice teachers." Student choice was a major aspect of all these activities, because research has shown that student choice is a significant facet of motivation, as well as enhancing cognitive function (Katz & Assor, 2007). Autonomy (e.g., choice) is one of the central tenets of SDT and all activities were explicitly related to SDT.

More unique aspects of the classes involved regular student journaling using the institution's learning management system (LMS); this activity encouraged reflective practice. In some cases, the journal was a verbal discussion among table groups rather than being in a traditional written format. Appendix A presents some samples of required journal entry questions. The journal entries are an example of how this course addressed SDT-related student needs of competence and relatedness. For the purpose of this study all students were given pseudonyms. As one student-teacher participant noted,

> Last class allowed me to discover many different routes to assessment. They can be formal or informal, large or small, authentic or traditional. My mind began racing about the different ways to use the assessments from our gallery walk. How could I make them applicable to everyday life? I want assessments to shake up the way we think about math, allowing students to enjoy it more, with less anxiety. I believe developing a range of assessments will take time, collaboration, and troubleshooting. They cannot be made overnight or put together in a weekend. When assessing students' work it is important that there are many different styles of questions. Some people excel at knowledge-based questions, while others find it easier to explain what has happened or what steps were used, and why. As well, questions should come from a couple of curriculum expectations, to give variety to the assessment. (Darren)

Analyzing this journal entry using content analysis yields a number of important though implicit features of how Darren is internalizing SDT. He identifies several features of assessment that denote autonomy (variety, applicability to students' real lives, student enjoyment, reduced student anxiety). He also recognizes different ways to assess student competence depending on the student's primary learning modality. In addition, Darren implies that belonging is important, referring to collaboration and the need to make risk-taking a safe dimension of his classroom.

An additional feature of the classes required electronic responses to research articles based on a set of guiding questions. This component and follow-up discussions in class supported the theory-into-practice dimension. Students read articles by Jo Boaler (Boaler & Humphreys, 2005), Deborah Ball (Ball & Bass, 2003), Marian Small (2010), Marshall and Horton (2011), and other researchers. Each article was linked to the content and activities that occurred in the class, and students responded electronically to guiding questions about the articles (see Appendix B). In general, preservice teachers' responses to guided questions yielded the least volume of text material that could be analyzed using content analysis, since the guided questions were quite explicit and did not explicitly ask for links to SDT. However, some responses provided an in-depth look at how SDT could be internalized. One such response, by Lydia, is discussed below.

> After reading Beyond One Right Answer I began to think about the different strategies for questioning. Small outlined four different strategies for questioning. This made me realize that although I was aware I should use questioning in my math class, I did not know how. This article gave me some great ideas on how to implement questioning that develops higher-order thinking. Having students work backwards or choose their own values is also a great way to assess their knowledge of math and how comfortable they feel with numbers. (Lydia)

Once again, the references to SDT in this response were implicit. Lydia recognizes that teacher questioning can be used to both support her students' need for competence and to promote increased competence in higher-order thinking. Additionally, Lydia his identified her students' need for comfort (belonging) in class, while providing autonomy through her students being able to choose their own values for problems.

Another activity involved viewing a video clip of the "Border Problem" (Boaler & Humphreys, 2005) and "being the student"—looking for as many different solution strategies as possible prior to discussing the teaching techniques employed by Cathleen Humphreys in the video clip. This activity, which occurred early in the first term, is an example of how preservice teachers' own SDT needs for autonomy and competence could be developed, as well as a sense of belonging since the activity was initiated in groups and then snowballed into a whole class discussion. After the class discussion, the instructor explicitly linked SDT to the activity and invited students to suggest additional strategies for the activity that could support SDT. Students found this activity very motivating and indicated that the activity stimulated them to engage since it had multiple entry points and a low threshold of required prior knowledge.

In the second term, each class was dedicated to a particular mathematics course or courses. In these classes, one-third of class time involved group teaching activities (outlined below). The remainder of each class let students "be the students" as they worked through activities appropriate for the course or courses under consideration, usually in a carousel format. After completing each activity, students evaluated the activity by responding to questions:

- What expectations does/could this activity address?
- Would you use this activity? Why/Why not?
- What would you assess?
- How would you assess it?

A reflection by Caroline illustrates how SDT was embedded in this format.

> Asking me to decide for each activity whether I would use it or not was very freeing. It was also very new, since through my career as a student I had never been asked to make evaluative decisions like this. My assignments were always 'do these questions and don't ask why' so being asked for my personal input was great. I would like to see more activities like this one, where I get to decide. (Caroline)

This reflection emphasizes how motivating Caroline found having autonomy in her decision process. It also unfortunately illustrates that student autonomy was rarely seen in her education before this course, and how demotivating Caroline found that structure to be.

ASSIGNMENTS

Assignments in this course included traditional ones involving lesson planning and a (four-part) unit plan which included a concept map. These assignments offered students a complete choice of topics and teammates. Two of the assignments were particularly engaging for students. The first was constructed by another instructor at the institution and involved working with problems from previously published Education Quality and Accountability Office (EQAO) standardized assessments. In Ontario, all students write EQAO assessments in grades 3, 6, 9, and 10. Grade 3 and grade 6 students are assessed in mathematics, reading, and writing; grade 9 students are assessed in mathematics; and grade 10 students must write and pass a literacy test as a graduation requirement. For this assignment, which addressed student needs for autonomy and competence (SDT), students individually

- completed solutions to the problems in at least two different ways and reflected on their work;
- observed two volunteers complete the problems and reflect on what they observed; and
- completed a written report reflecting on their experiences during this assignment and relating the activity to overall and specific curriculum expectations.

This assignment was incredibly popular with students, and almost all them commented on the utility of the assignment, and on how it energized them to engage in their teaching careers.

> This was a great assignment. I could work with people of my choice .I chose two classmates who before this I didn't really know—we took turns being the teacher and the students. It was really interesting to see the different methods that they chose to solve these problems. Some of these methods I would never have thought of. This really emphasized to me that I can't just have one way of solving a problem, since my students will have some different ones. I am a bit worried that if the solution is really far away from what I would do, I might not realize that it's a correct solution and my student will suffer. This could really turn off a kid if he does it a right way and I mark it wrong. Will we be looking at ways to recognize correct solutions in this course, I think that is really important? (Michelle)

Michelle's reflection began by identifying the needs for autonomy and belonging. She was pleased that she was free to choose who she worked with (autonomy) and used this to become acquainted with two classmates that she had not previously known (relatedness). Michelle also commented on her own need for competence in recognizing correct student work and followed this with a request that the course would support her competence need. Her comment about "this could really turn the kid off" was important recognition of the link between motivation and achievement, which is critical in mathematics (Ontario Education Quality and Accountability Office, 2014).

The second assignment asked groups of students "being teachers" to construct and teach to their classmates ("being students") three student-centred activities applicable to a particular mathematics course being addressed in that class based on the following guidelines:

- One activity had to involve technology;
- One activity had to employ manipulatives;
- The third activity was open (it could involve technology, manipulatives, or any other active strategy);
- A total of 45 minutes was allotted for these three activities;

- Classmates ("students") had to be active at least 80% of the allotted time;
- The activities had to be situated within the specific mathematics course by identifying what expectations the activities addressed, what accommodations could be made to address exceptional students' needs, and what modifications could be made to make the activities useful in other courses;
- Peer assessment and instructor assessment occurred for each group;
- Any resources that were developed were uploaded to the LMS site so that the entire class had access to them.

The group teaching assignment addressed all three needs pertaining to SDT (autonomy, competence, relatedness) due to its group structure and the group becoming experts in one area of their own choosing. Jennifer's comments were typical:

> I really liked this assignment. When it was my group's turn to teach, we had complete choice in what course and what activities to use. It really made me think about keeping students engaged and that some students need different supports like technology or manipulatives to make their learning better and more engaging. I am a very visual learner and I didn't often get a chance to work with anything other than paper and pencil, but Tanya in my group was really excited to be doing technology, and Mark loved making the manipulatives activity. He said that in his own math classes he had never had a chance to do anything fun like that. (Jennifer)

Jennifer's comments emphasized that she recognized that some learners are more engaged by alternative teaching strategies and that paper and pencil can be demotivating for many students. Her comments reflected the need for competence by all students and that that competence can be supported in different ways. She also commented on the autonomy of having complete choice of activities. Further, Jennifer's comments indicate that she is internalizing the student-centred focus that this course sought to inculcate.

Blended Portion of the Course

The course's blended portion was its most unique feature, in that it addressed the constraints of different schedules, practice teaching blocks, and start/end times for consecutive versus concurrent students. More importantly, it addressed students' need for autonomy (SDT), with complete freedom of choice as to which activities were selected. Outside of class time, students completed 12 nominal hours of activities selected from a list (see Table 1). Required postings were made to each student's Professional Portfolio in the LMS. This requirement was extremely popular with students because it allowed them to investigate a topic of interest in more detail or to examine other resources and activities for classroom use. Complete choice in selecting which activities to complete generated high levels of engagement and motivation. Some of the choices (e.g., book studies) were completed in student-selected groups. While no single activity was chosen a large number of times, Elise, who chose "Gap Closing and ePractice" as one of her activities, made some very insightful comments.

> I read the Gap Closing materials on the ministry website and did a bunch of the ePractice questions. While I can see some value in these materials since I will prob ably have students who have learning gaps in my class and the materials are easy to access 24/7 I was really struck by how these questions focus on the deficit model instead of the attribute model that we talked about in class. I think all students will have some gaps, sometimes really big gaps. When I start teaching I will have lots of gaps in what I do.

> But I'd like to think that every one of my students will be able to do some things right when they come to my class. Instead of fixating on what they can't do, are there materials out there that focus on what students CAN do? My PMI has a lot of pluses and some minuses, but I think this is the biggest minus of these materials.

Elise's comments demonstrate a sophisticated understanding of student-centred teaching, and the need to address every student's need for competence. By seeking to provide other resources that support this student competency need, Elise shows a maturity of thought that is often absent in preservice teachers.

Book study was another choice that some students selected. This choice (autonomy), done in self-selected student groups, promoted the relatedness dimension of SDT while explicitly linking theory to practice. Kaylie's group chose *The Art and Science of Teaching*, which offers research-affirmed instructional strategies and discusses links to student-centred pedagogy.

> My group really enjoyed working with this book. We all learned lots of strategies that we can apply in our classrooms. I liked the format for the chapters, with their titles What will I do to… My favourite chapter was What will I do to engage students. It had lots of basic strategies like wait time and games and response cards that I can use immediately in my practice teaching block. But I also liked that the book presents some research to back up what they say. I was amazed that just getting students engaged in class can increase their performance by 30 percentile points. We had some very active discussions/arguments about what were the best strategies for us new teachers to start with. Everybody chose different ones but we finally came to agreement that we should all use as many of these strategies as possible. This book gave us a great starting point for our own teaching. (Kaylie)

The autonomy dimension of SDT is interwoven into Kaylie's response. She chose the members of her group; she chose her favourite chapter; she chose teaching activities that she felt fit her teaching goals. The relatedness dimension of SDT was also clear in her comments, as was the need to engage students and motivate them to learn. Kaylie's reflection illustrates that she (and her group) understand the link between theory and practice, and that research can identify high-yield instructional strategies and quantify those strategies to allow teachers to differentiate among alternatives. This is a perspective on theory into practice that goes beyond SDT to identify a more general theory to practice stance.

DISCUSSION AND CONCLUSIONS

Inferences were drawn from four text sources. First, student journal entries routinely linked classroom activities and assignments to the elements of SDT. Second, classroom observations by the instructor identified students who vocalized the links between course activities and SDT, as well as those who demonstrated through their actions and assignment submissions that they had internalized the concepts. Student responses to guided questions from assigned readings supported this internalization of SDT. Finally, student artifacts from the course demonstrated that the majority understand the principles of SDT and were able to apply these principles to produce teaching strategies and activities that resonated with SDT.

The construct under examination in this study was theory into practice, specifically the use of SDT as a framework for a preservice course in order to inculcate in preservice teachers the attitude that their teaching philosophy needs to be grounded in research and that this philosophy needs to recognize the key role that motivation plays in learning of mathematics. Research question #1, how well does the current course described in this paper inculcate a theory into practice stance among preservice teachers, was strongly supported. Anecdotal comments by the preservice teacher participants indicated that a research-affirmed stance became a major dimension of their developing professional philosophy. Some student comments were indicative of a deep understanding of the issue of theory into practice. Sharon's final reflection demonstrated this stance.

> I was able to reflect and grow as an educator. I now understand the need to have a personal teaching philosophy before I go into my first class and that what I do in class is based on that philosophy. Self-determination theory is a good one, although I may move away from it as I get more experience if I can find something that fits my style better. Thank you so much for your guidance and all the advice you gave about teaching. I can tell you have a lot of experience. (Sharon)

Sharon's response also supports research question #4, how will students demonstrate that these theory-into-practice principles have been internalized as they transition into their professional practice. This stance was echoed by another student's final reflection:

> Thank you for giving us information on SDT and how it can be used to provide a framework for our professional practice. As I move into the teaching phase of my career, I can use SDT to give me a solid foundation on which to base my first year of real teaching. Meeting the needs of my students will be easier with the base that you provided, along with the great resources that you shared with us. (Maroni)

With respect to research question #2, is SDT an appropriate theoretical framework for such a course and what is the evidence, SDT is a richly-researched theory that makes practitioners aware that teachers need to not just consider subject content but also address other dimensions of student learning, especially motivation. While other theoretical frameworks were considered for this course, SDT provides a relatively straightforward set of principles that almost every student in the course recognized as echoing their own educational experiences. This personalization of the theoretical framework made comprehension much easier, as well as providing motivation for the students in the course to apply their learning about SDT to the course activities. It would be useful to examine instances of other courses taught using alternative theoretical frameworks to determine whether a similar level of application and inculcation of theoretical principles occurred.

The importance of explicitly addressing motivational and affective dimensions was clearly articulated by the majority of the preservice teachers, supporting research question #3, how well do the components of this course inculcate the need to address student motivation explicitly in every mathematics course taught.

> This course was lots of fun and very useful and practical. My math classes in the past were really rigid and boring, with us just following what the teacher did at the board and then doing lots of questions. I looked forward to coming to this class and had fun every day. Plus I learned lots of activities and teaching strategies that I plan to use to make my own classes fun for my students. You always showed respect for us as adults and that is something I will take to my own classes as well. (Natalie)

Table 2 shows the approximate number of instances that students demonstrated their understanding of SDT either explicitly or implicitly. By the end of the course, 54% of students were in the "often" category, and 73% in the "often" or "sometimes" categories. Implicit evidence of SDT internalization included student in-class comments and observations recorded by the instructor in field notes, student lesson plans and unit plans that showed that students understood the needs for student choice (autonomy), groupings (relatedness) and differentiated assessment practices that allowed students to demonstrate competence.

Validating evidence for these inferences will only truly be obtained once these preservice teachers enter their own classrooms and demonstrate through their professional practice that they have internalized the concept of theory into practice and formulated a philosophy of teaching that recognizes the need to address student motivation and affective dimensions.

Based on the text analysis, all four research questions were answered in the affirmative. The course described in this paper represented a theory into practice paradigm that a large percentage of students both accepted and in some case, embraced. SDT proved to be a rich theoretical framework, both easy for students to understand and use as well as a fulsome theoretical stance that placed a priority on students' needs and fit very well within a student-centred teaching philosophy. All the components of the course received favourable ratings from the students, and the tenets of SDT interwoven into the activities were clearly articulated by the majority of the students. While the degree of internalization of this theoretical framework will only be truly demonstrated by the actions of the graduates once they begin their professional careers, the quality of the products produced in this course and the depth of their comments and linkages to SDT are strong indicators that the goals of this course structure were attained.

LIMITATIONS

A limitation of this study is that this was only one class section, in one particular year of one faculty of education. Further, SDT is only one of many theoretical frameworks that could be selected. So the conclusions from this study may not be replicable in other circumstances. However, the results of this study are encouraging in identifying one route to addressing the theory into practice issue, which is a thorny issue for the research community (Nuthall, 2004).

In sum, this course illustrates how a research-affirmed stance can be used both to demonstrate a theory-into-practice linkage as well as inculcate in our preservice teachers an awareness of grounding a teaching philosophy in research, and identifying major aspects of such a philosophy, such as addressing student motivation and affective dimensions, with a student-centred lens on their professional practice.

REFERENCES

Anthony, G., & Hunter, R. (2013). Learning the work of ambitious mathematics teaching. In V. Steinle, L. Ball, & C. Bardini (Eds.), *Mathematics education: Yesterday, today, and tomorrow. Proceedings of the 36th annual conference of the Mathematics Education Research Group of Australasia* (pp. 699-702). Melbourne, Australia: Mathematics Education Research Group of Australasia.

Bailey, S. (2015). Thinking positively: Using the expectancy-value model of achievement motivation to teach college composition. *CEA Critic*, *77*(3), 263-268. doi:10.1353/cea.2015.0023

Ball, D., & Bass, H. (2003). Toward a practice-based theory of mathematical knowledge for teaching. In E. Simmt & B. Davis (Eds.), *Proceedings of the 2002 Annual Meeting of the*

Canadian Mathematics Education Study Group (pp. 3-14). Retrieved from https://files.eric.ed.gov/fulltext/ED529557.pdf

Baron, R., & Kenny, D. (1986). The moderator-mediator variable distinction in social psychological research: Conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology*, *51*(6), 1173-1182. doi:10.1037/0022-3514.51.6.1173

Blazar, D. (2015). Effective teaching in elementary mathematics: Identifying classroom practices that support student achievement. *Economics of Education Review*, *48*, 16-29. doi:10.1016/j.econedurev.2015.05.005

Boaler, J., & Humphreys, C. (2005). *Connecting mathematical ideas*: *Middle school video cases to support teaching and learning*. Portsmouth, NH: Heinemann.

Connor, J., & Pope, D. (2013). Not just robo-students: Why full engagement matters and how schools can promote it. *Journal of Youth and Adolescence*, *42*(9), 1426-1442. doi:10.1007/s10964-013-9948-y

Davis, B. (1996). *Teaching mathematics: Toward a sound alternative*. New York, NY: Garland.

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

Deci, E., Vallerand, R., Pelletier, L., & Ryan, R. (1994). Motivation and education: The self-determination perspective. *Educational Psychologist*, *26*(3-4), 325-346. doi:10.1207/s15326985ep2603&4_6

Eccles, J. (1994). Understanding women's educational and occupational choices: Applying the Eccles et al. model of achievement-related choices. *Psychology of Women Quarterly*, *18*(4), 585-609. doi:10.1111/j.1471-6402.1994.tb01049.x

Eccles, J. (2005). Subjective task value and the Eccles et al. model of achievement-related choices. In A. J. Elliot & C. S. Dweck (Eds.), *Handbook of competence and motivation* (pp. 105-121). New York, NY: Guilford.

Eccles, J. (2009). Who am I and what am I going to do with my life? Personal and collective identities as motivators of action. *Educational Psychologist*, *44*(2), 78-89. doi:10.1080/00461520902832368

Eccles, J., & Wigfield, A. (1995). In the mind of the achiever: The structure of adolescents' academic achievement related beliefs and self-perceptions. *Personality and Social Psychology Bulletin*, *21*, 215-225.

Eccles, J., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Review of Psychology*, *53*, 109-132. doi:10.1146/annurev.psych.53.100901.135153

Feldon, D. (2007). Cognitive load and classroom teaching: The double-edged sword of automaticity. *Educational Psychologist*, *42*(3), 123-137. doi:10.1080/00461520701416173

Fosnot, C., & Dolk, M. (1995). "Mathematics" or "Mathematizing? " In L. Steffe & J. Gale (Eds.), *Constructivism in Education* (pp. 175-192). Hillsdale, NJ: Lawrence Erlbaum Associates.

Frenzel, A., Goetz, T., Ludke, O., Pekrun, R., & Sutton, R. (2009). Emotional transmission in the classroom: Exploring the relationship between teacher and student enjoyment. *Journal of Educational Psychology*, *101*(3), 705-716. doi:10.1037/a0014695

Glasser, W. (1998). *Choice theory: A new psychology of personal freedom.* New York, NY: Harper.

Hannula, M. (2006). Motivation in mathematics: Goals reflected in emotions. *Educational Studies in Mathematics*, *63*(2), 165-178. doi:10.1007/s10649-005-9019-8

Hiebert, J., Morris, A., Berk, D., & Jansen, A. (2007). Preparing teachers to learn from teaching. *Journal of Teacher Education*, *58*(1), 47-61. doi:10.1177/002248710629526

Hill, H., Blazar, D., & Lynch, K. (2015). Resources for teaching: Examining personal and institutional predictors of high-quality instruction. *AERA Open*, *1*(4), 1-23. doi:10.1177/2332858415617703

Irvine, J. (2017). From description to prescription: A proposed theory of teaching coherent with the Pirie-Kieren Model for the dynamical growth of mathematical understanding. *Journal of Instructional Pedagogies*, *19*, Art. 5. Retrieved from http://www.aabri.com/jip.html

Irvine, J. (2018). A framework for comparing theories related to motivation in education. *Research in Higher Education Journal, 35,* Article 5, 1-30. Retrieved from http://aabri.com/rhej.html

Irvine, J., & Telford, W. (2015). Mathematics coaching and the coaching cycle: The Math GAINS project. *Journal of Case Studies in Education*, *7*, 1-16. Retrieved from http://www.aabri.com/manuscripts/152317.pdf

Katz, I., & Assor, A. (2007). When choice motivates and when it does not. *Education Psychology Review*, *19*, 429-442. doi:10.1007/s10648-006-9027-y

Koller, O., Baumert, J., & Schnabel, K. (2001). Does interest matter? The relationship between academic interest and achievement in mathematics. *Journal for Research in Mathematics Education*, *32*(5), 448-470. doi:10.2307/749801

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

Lampert, M., Franke, M., Kazemi, E., Ghousseini, H., Turrou, A., Beasley, H., ... Crowe, K. (2013). Keeping it complex: Using rehearsals to support novice teacher learning of ambitious teaching. *Journal of Teacher Education*, *64*(3), 226-243. doi:10.1177/0022487112473837

Malmivuori, M. (2006). Affect and self-regulation. *Educational Studies in Mathematics*, *63*(2), 149-164. doi:10.1007/s10649-006-9022-8

Marshall, J., & Horton, R. (2011). The relationship of teacher-facilitated, inquiry-based instruction to student higher-order thinking. *School Science and Mathematics*, *111*(3), 93-101. doi:10.1111/j.1949-8594.2010.00066.x

Maynes, N., & Hatt, B. (2013). Hiring and supporting new teachers who focus on students' learning. *Canadian Journal of Educational Administration and Policy*, 144, 1-37. Retrieved from https://files.eric.ed.gov/fulltext/EJ1017211.pdf

Middleton, J. (1995). A study of intrinsic motivation in the mathematics classroom: A personal constructs approach. *Journal for Research in Mathematics Education*, *26*(3), 254-279. doi:10.2307/749130

Middleton, J., & Spanias, P. (1999). Motivation for achievement in mathematics: Findings, generalizations, and criticisms of the research. *Journal for Research in Mathematics Education*, *30*(1), 65-88. doi:10.2307/749630

Nuthall, G. (2004). Relating classroom teaching to student learning: A critical analysis of why research has failed to bridge the theory-practice gap. *Harvard Educational Review, 74*(3), 273-306.

Ontario College of Teachers (2017). *Transition to Teaching.* Retrieved from https://www.oct.ca/-/media/PDF/2017%20Transition%20to%20Teaching/2017%20T2T%20Main%20Report%20EN_Final.pdf

Ontario Education Quality and Accountability Office. (2014). *Research Bulletin #13*, February 2014. Retrieved from http://www.eqao.com/Research/research.aspx?Lang=E

Ontario Ministry of Education. (2005). *The Ontario curriculum, grades 9 and 10: Mathematics (Revised).* Toronto, ON: Queen's Printer for Ontario.

Ontario Ministry of Education. (2007). *The Ontario curriculum, grades 11 and 12: Mathematics (Revised).* Toronto, ON: Queen's Printer for Ontario.

Ontario Ministry of Education. (2010). *Growing success: Assessment, evaluation, and reporting in Ontario schools.* Toronto, ON: Queen's Printer for Ontario.

Ontario Ministry of Education. (2012, September). Fair and transparent hiring practices. *Principals Want to Know*, 22. Toronto, ON: Queen's Printer for Ontario. Retrieved from http://www.edu.gov.on.ca/eng/policyfunding/leadership/pdfs/issue22.pdf

Pang, X., & Rogers, W. T. (2013). *Comparative examination of the influence of selected factors on achievement in Grade 9 Academic and Applied Mathematics courses in English-language schools in Ontario*. Toronto, ON: EQAO.

Penk, C., & Schipolowski, S. (2015). Is it all about value? Bringing back the expectancy component to the assessment of test-taking motivation. *Learning and Individual Differences*, *42*, 27-35. doi:10.1016/j.lindif.2015.08.002

Ryan, R., & Deci, E. (2000a). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology*, *25*, 54-67. doi:10.1006/ceps.1999.1020

Ryan, R., & Deci, E. (2000b). Self determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist*, *55*(1), 68-78. doi:10.1037/0003-066X.55.1.68

Ryan, R., & Deci, E. (2006). Self-regulation and the problem of human autonomy: Does psychology need choice, self determination, and will? *Journal of Personality*, *74*(6), 1557-1586. doi:10.1111/j.1467-6494.2006.00420.x

Schön, D. (1983). *The reflective practitioner: How professionals think in action*. New York, NY: Basic Books.

Small, M. (2010, September). Beyond one right answer. *Educational Leadership*, *68*(1), 29-32.

Wigfield, A., & Eccles, J. (1992). The development of achievement task values: A theoretical analysis. *Developmental Review*, *12*, 265-310. doi:10.1016/0273-2297(92)90011-P

Wigfield, A., & Eccles, J. (2000). Expectancy-value theory of achievement motivation. *Contemporary Educational Psychology*, *25*, 68-81. doi:10.1007/BF02209024

Table 1
The Activity Choice Table

Activity	Description	Resources	Posting	Nominal hours
Compare *Desmos* and *GeoGebra*	Compare and contrast *Desmos* and *Geogebra*. Consider ease of use, functionality, flexibility, breadth of coverage, any missing functions.	Desmos.com Geogebra.com	Written comparison of these two resources. Can be in table form.	2
Compare the Math Processes with the US Math Practices	Identify similarities and differences between the Ontario Mathematical Processes and the US Common Core Mathematical Practices. In your opinion, is either set of processes/ practices missing important concepts?	Math Processes: Any Ontario curriculum policy document, or on www.edugains.ca US Math Practices: Posted on Sakai in Online Resources folder.	Written analysis of similarities and differences.	1
SMART Exchange	Identify an artifact from the SMART Exchange site and outline how it could be used in class. Be explicit about what grades and expectations this would address.	Smartexchange.com SMART Notebook activation code is XXXXXXX	Artifact and written analysis of how it could be used.	1
SmartBrief article	Identify one article from this service and critically analyze it, particularly how it applies to the Ontario context.	SmartBrief.com Sign up for any or all of these (free) eletters: Accomplished teacher by SmartBrief; education week.org; NCTM smartbrief; smartbrief on education, ASCD smartbrief, smartbrief on edtech.	Written reflection.	1
CLIPS	Work through one of the CLIPS modules. Decide how or where the module could be used by your students.	www.edugains.ca Search CLIPS	Written report.	1

Table 1
The Activity Choice Table (Cont'd)

Activity	Description	Resources	Posting	Nominal hours
OAME assessment	Analyze one of the assessments found in the member's section of the OAME website. Conduct a PMI and post your findings.	www.oame.on.ca username: XXXX password: XXXX	PMI analysis.	1
Become a TIPS4RM lesson author	Develop a TIPS4RM lesson on a specified expectation (see additional information).	See sheet "Become a TIPS4RM Lesson Author"	TIPS4RM Lesson plan.	2
Border Problem Part 2	Watch Border Problem Part 2 and identify teacher strategies to encourage math talk in her class.	Border Problem Part 2 posted on Sakai in Online Resources folder.	Written reflection.	1
Kahoot quiz	Construct a quiz or survey using Kahoot.	www.getkahoot.com	Quiz or survey.	1
Learning style survey	Take one or more learning style surveys on the Internet. Discuss how using such a survey with your students could enhance their learning.	Internet. Search learning styles or learning modalities.	Written report, plus sample of the survey.	1
TI resources	Identify an artifact from the education portion of the Texas Instruments website. Outline how it could be used in class. Be explicit about what grades and expectations this would address.	Education.TI.com Also TI-Math; TI-Nspired Math	Artifact and written analysis of how it could be used.	1
Gap Closing and *ePractice*	Examine the Gap Closing materials and try some ePractice activities. Reflect on the strengths and weaknesses of these materials and conduct a PMI analysis.	Edugains.ca Search gap closing	PMI analysis.	1

Table 1
The Activity Choice Table (Cont'd)

Activity	Description	Resources	Posting	Nominal hours
Poll Everywhere	Construct a survey for use in your classroom. Identify the grade, strand, and topic(s), including the expectations that the survey would address. Try the survey out on a few willing volunteers.	Polleverywhere.com (free)	Survey and comments on its implementation.	2
Gizmos	Identify an artifact from the Gizmos website. Outline how it could be used in class. Be explicit about what grades and expectations this would address.	Explorelearning.com Math: **XXXX** Grade 7-8 and Science:XXXX	Artifact and written analysis of how it could be used.	1
TIPS interactive SMART Board lessons	Examine a sample TIPS interactive whiteboard lesson, and then modify it for a different topic or grade.	Edugains.ca Search TIPS IWB	Modified lesson.	1
GSP applets	Examine the available GSP applets, identify 3 that you would consider using in class, with reasons. Your reasons should include which course and expectations the applets would address.	Edugains.ca Search technology	Name the 3 applets, and provide the reasons, courses, and expectations.	1
GSP lessons	Identify an artifact from the Geometer's Sketchpad Lesson Link website. Outline how it could be used in class. Be explicit about what grades and expectations this would address.	http://keyonline.keypress.com Use login : XXXX Password: XXXX	Lesson title and analysis.	1
Algebra Tiles extended	Investigate the additional algebra tiles resources posted on Sakai. Identify at least one resource that you would use in class, with grade and expectations.	Sakai Online Resources	Identify resource and analysis.	2

Table 1
The Activity Choice Table (Cont'd)

Activity	Description	Resources	Posting	Nominal hours
Math Manipulatives	Examine the resources available for manipulative use. Select one of the manipulatives and critically reflect on the resource that is provided.	Edugains.ca Search manipulatives	Written reflection.	1
Ontario Educational Resource Bank	Identify an artifact from the OERB website. Outline how it could be used in class. Be explicit about what grades and expectations this would address.	https://resources.elearning ontario.ca/ Login: XXXX Password: XXXX	Artifact and written analysis of how it could be used.	1
TED Talk	Watch a Dan Meyer TED Talk and write a reflection on what he said. Do you agree with him?	https://www.ted.com/talks	Written reflection	1
Understanding by Design	Reflect on Wiggins and McTighe's *Understanding by Design*.	Wiggins & McTighe (2005). *Understanding by Design framework* Available at: http://tiny.cc/xx7wqy	Written reflection	1
Mindful Learning	Read this article and reflect on how it applies to you as a beginning teacher.	Langer, E. *The Power of Mindful Learning* Posted on Sakai, Online Resources	Written reflection	2
Professional Shift Theory	Read the Sakai article on professional shift theory and write a reflection on how it applies to you.	Maynes & Hatt (2013). *Professional shift theory*. Posted on Sakai, Online Resources	Written reflection	2
Tailoring math curriculum	Read the article and critically reflect on the contents.	Simmt, Sookochoff, McFeetors, & Mason. *Curriculum Development to promote visualization and mathematical reasoning*. Posted on Sakai, Online Resources	Written reflection	2

Table 1
The Activity Choice Table (Cont'd)

Activity	Description	Resources	Posting	Nominal hours
Book Study:	This activity is best done in a group. 1. Read the book. I suggest reading one chapter at a time and then discussing that chapter. 2. As a group, discuss the chapter. Especially consider how the information applies to you, a beginning teacher. 3. Write up a summary of your discussion. 4. Post your writeup to Sakai. 5. Repeat steps 1-4 for each chapter.		Chapter discussion summaries	
Book Study 1: *The Art and Science of Teaching*	See above	Marzano, R. (2007). *The Art and Science of Teaching.* Will be on reserve in the IRC (multiple copies)		6
Book Study 2: *Mathematics Formative Assessment*		Keeley & Tobey (2011). *Mathematics Formative Assessment: 75 Practical Strategies for Linking Assessment, Instruction, and Learning.* Will be on reserve in the IRC (multiple copies)		6
Book Study 3: *Visible Learning For Teachers*		Hattie, J. (2012). *Visible Learning For Teachers: Maximizing Impact on Learning.* Will be on reserve in the IRC (multiple copies)		6

Table 2. Student references to self-determination theory

	Often	Sometimes	Rarely	Never	Total number of students
Term 1 September to December	8	6	5	3	22
Term 2 January to April	12	4	4	2	22

Look fors:

- Explicit mention of SDT terminology (autonomy, competence, relatedness)
- Mention of related concepts (motivation, choice, mastery, group processing, engagement, attitude, peer, consensus, justification, confidence, self-efficacy, explain, independence, counter-example)
- Imputed concepts of SDT from instructor observations and field notes
- Imputed concepts of SDT as demonstrated in assignments

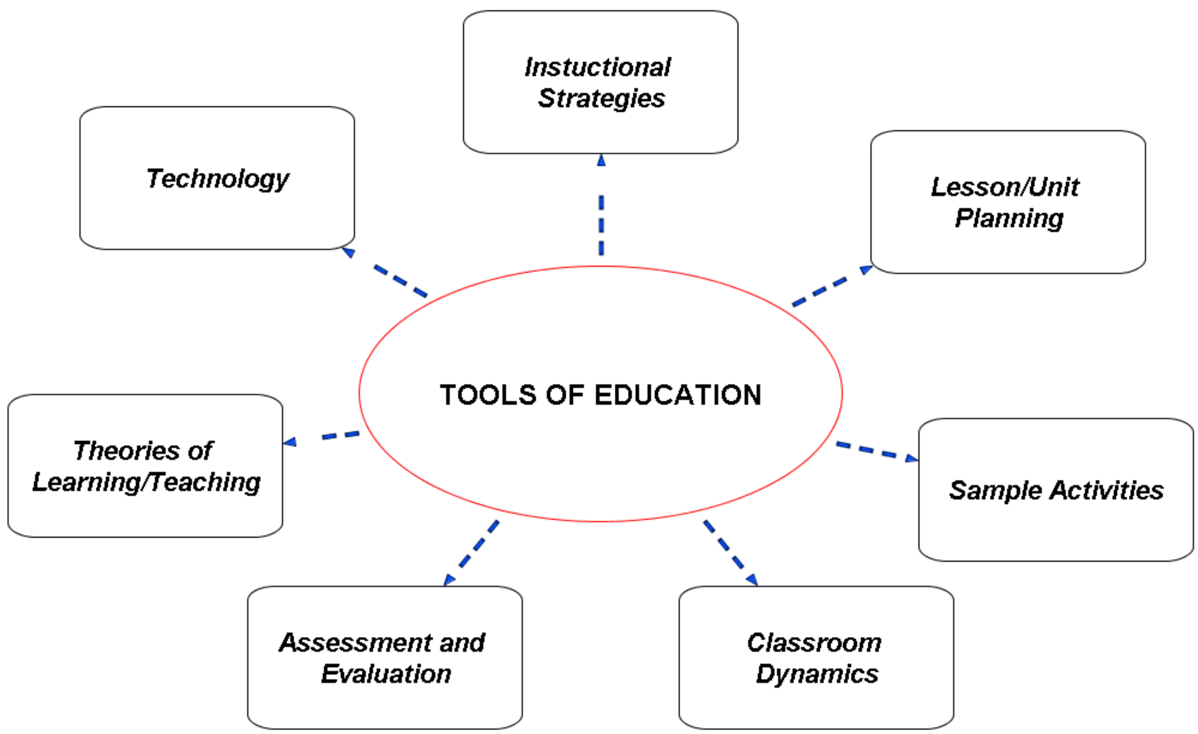

Figure 1. *Tools of education.*

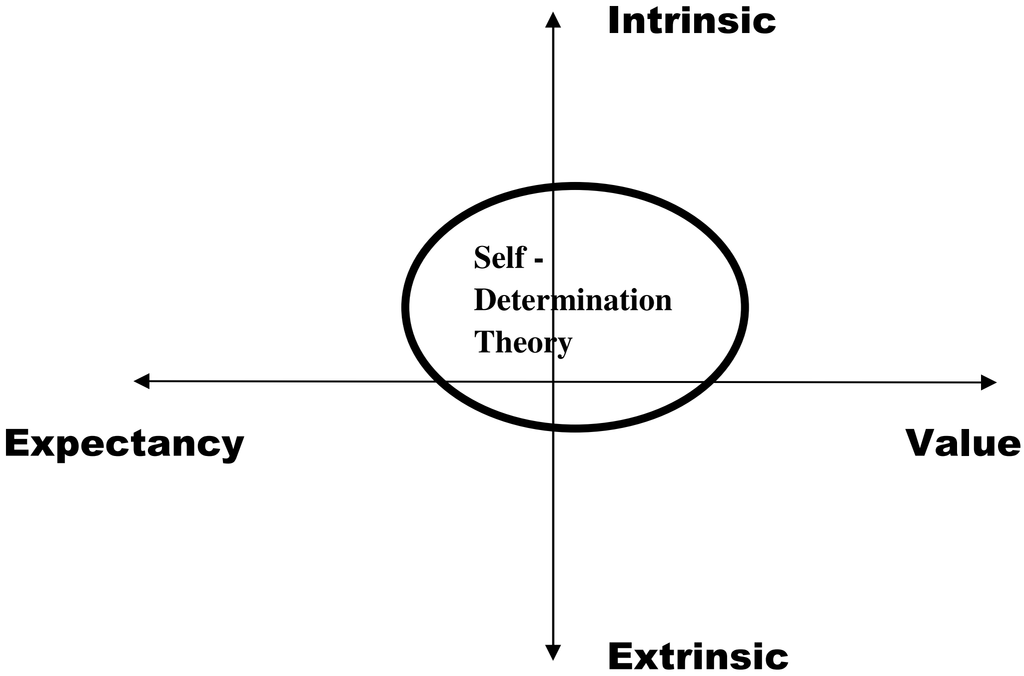

Figure 2. *Location of SDT on Irvine's (2018) framework for comparing theories related to motivation. Reprinted with permission.*

Appendix A: Selected Journal Entry Questions

- Why are you here?
- With reasons, what was today's most interesting fact, activity, strategy?

On the page *Underlying views of mathematics & learning mathematics for school*, the column "View reflected in the Ontario Curriculum" is **POLICY (non-negotiable)**

- Which aspects of this policy do you find:
  - Encouraging
  - Disturbing
  - Exhilarating
  - Counter to your personal philosophy of teaching mathematics
- Assess your knowledge of assessment
- What questions do you have about questioning?
- Which of the heuristics best matches your current teaching style?
- Assess the effectiveness of your current teaching style
- What if anything do you need to change?
- Why?

Midterm report card for the instructor:

- I would like to see more of ……..
- I would like to see less of ………..
- I would like to see about the same amount of ………..
- The best thing in this class so far is ……….
- The worst thing in this class so far is ……..
- How are the overall expectations in the curriculum policy documents similar to big ideas?
- How are they different?
- In your own words, what is a big idea in mathematics and why does it matter?
- In this course, I have emphasized a vision of student centred learning, in which students take an active part in developing their math concepts. Are there some topics in the math curriculum that do not fit this vision well, and that would be better developed through direct instruction (NOT lecture)?
- Give some examples and justify why you have chosen these examples.

For the first lesson of your unit plan topic:

- Identify 5 different ways to introduce your topic (Minds On)
- If you choose an activity we have done, just the name is sufficient. If you choose an activity we have not done, some description will be needed.
- If you choose a strategy (e.g. placemat), provide a brief description of what you expect students to do/respond to.

Tell me what the second-year math course should look like:

- Consider:
- topics,
- format,
- student input
- anything else you think should be considered

- What is your assessment of SDT as a research-affirmed framework for your personal teaching philosophy?
- Cite examples from your class participation or your assignments to support your assessment of SDT.

Appendix B: Guiding Questions for Selected Readings

The Role of Teacher Questions
(Jo Boaler)

1. Sort the Question Types in Appendix A into surface learning and deep learning. Use your own definitions of surface learning and deep learning.
2. Sort the Question Types in Appendix A into higher order thinking and lower order thinking. Use your own definitions of higher order thinking and lower order thinking.
3. Boaler claims that Type 3 questions, Exploring mathematical meanings and relationships, is the most important type of question. Do you agree or disagree? Justify your answer.

Beyond One Right Answer
(Marian Small)

1. Use each of Small's four strategies for creating open questions to create four questions for Grade 9 Applied Mathematics (MFM1P).
2. What is the difference between open questions and parallel tasks?
3. Use each of Small's two strategies for creating parallel tasks to create two parallel tasks for Grade 12 Calculus and Vectors (MCV4U).
4. How do open questions and parallel tasks relate to SDT?

Toward a Practice-Based Theory of Mathematical Knowledge for Teaching
(Deborah Ball and Hyman Bass)

1. What is *pedagogical content knowledge*, and how is it different from mathematical content knowledge?
2. Describe what is meant by *unpacking*, and by *connectedness*, in the context of teaching mathematics.
3. Ball and Bass list eight activities in which math teachers must engage. What are they? Are any of the eight more important than others? Justify your response.
4. Are you convinced by the article that pedagogical content knowledge is different from mathematical content knowledge? Which is more important to a math teacher? Justify your response, citing evidence from the article.

The Relationship of Teacher-Facilitated, Inquiry-Based Instruction to Student Higher-Order Thinking

(Jeff Marshall and Robert Horton)

1. Why use inquiry learning?
2. Briefly describe the 4 Es of inquiry learning.

Answer the following questions TRUE or FALSE:

3. Student cognitive levels are higher when more time is spent on ENGAGE.
4. Student cognitive levels are higher when more time is spent on EXPLORE.
5. Student cognitive levels are higher when more time is spent on EXPLAIN.
6. Student cognitive levels are higher when more time is spent on EXTEND.
7. When more time is spent on EXPLORE, the amount of time students spend in higher order cognitive skills increases.
8. When more time is spent on EXPLORE, the amount of time students spend in lower order cognitive skills increases.
9. When more time is spent on EXPLAIN, the amount of time students spend in higher order cognitive skills increases.
10. When more time is spent on EXPLAIN, the amount of time students spend in lower order cognitive skills increases.
11. Relate the article's definition of higher order cognitive skills to one of:
    a) the original Bloom's taxonomy
    b) revised Bloom's taxonomy
    c) Marzano's taxonomy