Psychology, Pedagogy, Mathematics and Culture

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Abstract

In this paper we present the relationship between the psychological concept of flow, mathematics pedagogy and culture. Interest and motivation are two qualities essential to learning. As such, linking academic subject matter, such as mathematics, to culturally relevant activities can lead to an interest in mathematics. Bringing real world situations, such as weaving, and introducing cultural artefacts, such as tapestries and woven baskets, into school mathematics is effective in making mathematics meaningful and real. Students become involved in mathematics rather than just doing mathematics. The psychological concept of flow has been found to increase student engagement in educational settings. The eight characteristics of flow are outlined, followed by an example of a mathematical activity that could lead to a state of flow. Two conditions necessary to achieving a state of flow are motivation and interest. Culture is a vital part of learning mathematics. The use of concrete materials related to cultural practices can be a source of motivation and interest. Drawing from the culture and practices of the school community provides learners with knowledge of how mathematics is embedded within their own culture and the culture of others. The basket weaving activity presented in this paper, linked to cultural artefacts, can motivate students and help them achieve a state of flow. Achieving a state of flow is an individual experience and not all students will achieve a state of flow. The use of family, cultural, community knowledge and experiences have a positive effect on learning, which helps students achieve a state of flow.

1. Introduction

Mathematics is often seen as a set of rules, algorithms, and theorems to memorize [6], [10]. If mathematics is taught simply as a body of knowledge, motivating students becomes challenging and students then perceive mathematics as a difficult subject. Learning mathematics under these impressions can be burdensome, challenging, and even traumatic [11]. Attitudes towards mathematics tend to worsen throughout childhood and adolescence, hindering development, education, and engagement in mathematics-related activities [21]. Thus, student engagement in mathematics education is problematic [3].

Principles from psychology can greatly impact the teaching and learning of mathematics. Cognitive psychology is concerned with learning processes and can influence teaching and learning. Context personalization [38] can advance mathematical understanding. The purpose of this paper is to illustrate how the positive psychology concept of flow theory can be applied to mathematics learning and teaching by the use of cultural representations. Flow, defined as a state of deep absorption in an activity that is intrinsically rewarding and enjoyable [14], has been found to increase student engagement in various educational settings [4], [7], [13], [20], [34]. Csikszentmihalyi [15] suggests that educators can help students want to learn mathematics by turning mathematics activities into flow experiences. He states that when an experience becomes intrinsically rewarding, students are motivated, engaged, and self-directed in their acquisition of knowledge.

Children begin school with a vast amount of knowledge. This knowledge is based on informal experiences with family, friends, and activities within their community. These experiences provide the foundation on which to build academic knowledge [5],[27]. Cultural identity is part of our personal identity and one we share with other members of our community. Many teachers of mathematics and science are under the impression that these subjects are culture free [19]. It is clear that this is not the case [41]. Acharya [1] has indicated that mathematics seems to be influenced by learners' cultural backgrounds and should be connected to students' lives and culture [23]. The purpose of this paper is to demonstrate how basic level mathematics is rooted in culture by using the cultural activity of weaving as an example. It is possible with such an activity for students to achieve a flow-like state.

2. Flow: The psychological state of optimal experience

The concept of flow was discovered by Dr. Mihaly Csikszentmihalyi, a Hungarian psychologist best known for his work on flow, happiness, and creativity

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[9]. A prisoner during World War II, he wondered how individuals that experienced pain and suffering were able to find happiness and create a life worth living. He found that happiness could be consciously cultivated and maintained through a state of flow [14]. While interviewing athletes, musicians and artists in order to determine how they experienced optimal performance levels, he noticed their work “flowed” out of them, leading them to their best creations and achievements.

Flow is considered an ‘autotelic experience’ resulting from an activity that produces its own intrinsic motivation, rewards, and incentives without extrinsic goals or rewards [16], [20]. Autolelic personalities are receptive to activities that are challenging and require perseverance and active engagement. Csikszentmihalyi [14] states that “the key element of an optimal experience is that it is an end in itself. Even initially undertaken for other reasons, the activity that consumes us becomes intrinsically rewarding” (p.67). Numerous studies have evaluated the benefits of flow states, including increased creativity, happiness, and productivity [17]. Zhao and Li [42] found that flow states allowed students to learn more efficiently, Hou [24] determined that flow states affect student learning behavior patterns related to in-depth processes, while Brom et al. [12] found that flow increased positive affect, and dos Santos et al. [20] stated that flow states resulted in an increase in students’ learning, more in-depth reflective process, and increased student satisfaction.

While any task has the potential for flow, certain conditions must be met prior to entering a flow state. These include a challenge-skill balance, a merging of action and awareness, a clear set of goals, unambiguous feedback, concentration on the task at hand, a sense of control, a loss of self-consciousness, and a transformation of time [9].

3. Flow in mathematics

Flow experiences have been identified in a variety of fields such as sports [25],[36] and in music [40]. The importance of flow has spread to other fields such as education [8]. A significant body of literature outlines the concept of flow yet very little research explores the concept of flow in a specific educational setting, such as learning mathematics. A number of studies have however dealt with the topic. Golnabi [22] and Chiru [13] have examined the characteristics of flow involved in the learning of mathematics. Allan [2] conducted a small research project that confirmed mathematical flow is a valid construct, and concluded that “mathematical flow is a positive experience of full engagement with mathematics where joy is experienced through solving a challenging problem, seeking understanding, or constructing a proof” (p.14). They found that a single mathematical flow experience could result in an increased enjoyment of mathematics and a long-term increase in engagement with mathematics. Specifically, student participants in their study indicated they experienced an intense focus on a task where nothing else mattered and a desire to keep working in order to build on new and existing knowledge to solve the next problem.

Psychologists have documented the potential benefits of intrinsic motivation, doing something for the pleasure of doing it, doing something that is enjoyable and interesting [18]. Mathematics has not been a subject that most students do because it is enjoyable and interesting. When mathematics is presented in a formal, abstract manner, it is far from motivating and certainly not enjoyable. This manner of presenting subject matter does not provide students with proof of the practical aspects of the subject that relate to their personal experiences. Newcombe et al. [28] indicate that “teachers are decontextualizing it from the students’ everyday experiences” (p.545). Motivating students to learn mathematics can be challenging. Walkington [39] indicates that personalized contexts may elicit interest and in turn motivation and improve achievement. Fostering connections to personal interests makes the subject matter interesting. Linking mathematics to personal cultural referents not only provides the basis for motivation but provides a connection to community. Students’ learning is influenced by their cultural background [37]. Using cultural knowledge and personal frames of reference can make learning encounters more relevant and strengthen the connection to mathematics and therefore enhance learning [32]. Taking into account students’ prior knowledge related to their cultural community and motivating students by personalizing learning can help students achieve a flow like state.

4. Designing flow-inducing activities

Based on the eight characteristics of flow, several researchers have put forth suggestions for inducing flow states in educational settings, including in mathematics education.

4.1. Establishing interest

We’ve all heard it, “I can’t do math!”, “I’m not a math person.” One of the authors (Yvette) is a math person and she loved math class in school as there was always a way to get the right answer. Doing proofs in geometry was not only motivating but stimulating, it was like putting a puzzle together. However, not all of her classmates felt the same. Stimulating interest in a subject that is perceived to be difficult, abstract and not practical can be difficult. Conventional teacher-led instruction does not automatically create interest in the subject matter. Interest is a fundamental aspect of flow experiences as it provides the foundation for becoming engaged with a topic for its own sake [34]. Csikszentmihalyi [16] indicates that “the more difficult a mental task, the harder it is to concentrate on it. But when a person likes what he does and is motivated to do it, focusing the mind becomes effortless even when the objective difficulties are great” (p.27). Spencer [35] states that “one of the best ways to intrinsically motivate students is to connect assignments to their interests” (p.12). It has been documented that students’ learning is influenced by their cultural background [30], [37], [41]. Integrating references to home and community into the subject matter can make mathematics more meaningful, more relevant, and therefore more motivating [19], [31], [32]. A mathematical task is likely to develop motivation if it sparks student interest [2]. Such referents can lead to student engagement, the first step to achieving a state of flow.

4.2. Balance of challenge and skills

Two of the most important factors for flow to occur are the balance between the challenge of the task or the activity and the skills of the person [17]. Flow states require a balance of challenge and skills. Kiili et al. [26] state that flow experiences usually occur when a person’s mind or body is stretched to its limits in a voluntary effort. A mismatch in balance and skills can result in different emotional states (see Figure 1). The match between challenge and skill as perceived in flow theory can be summarized into four categories: flow (high challenge and high skill), boredom or relaxation (low challenge and high skill), apathy (low challenge and low skills, and anxiety (high challenge and low skill). The slightest imbalance between challenge and skill can disrupt a state of flow and lead to boredom or anxiety. According to Csikszentmihalyi [16], when challenges are too high, a person tends to experience worry and anxiety; whereas when challenges are too low, relaxation and boredom occur. In order to experience a flow state, both skill and challenge level must be moderately high [17]. Additionally, Allan [2] found that pressure and stress were found to trigger flow experiences, supporting the notion that challenge is an important aspect for flow. Although stressful, participants reported the experience as being emotionally demanding yet rewarding as they reached new levels of understanding.

According to Golnabi [22], mathematical problem solving provides an appropriate context for flow to occur, since both challenges and skill level are measurable in a mathematical context. Allan [2] found that problems were best at inducing a state of flow when they had multiple solutions for variable skill levels. In other words, they are open-ended, having a low entry and a high ceiling [11].

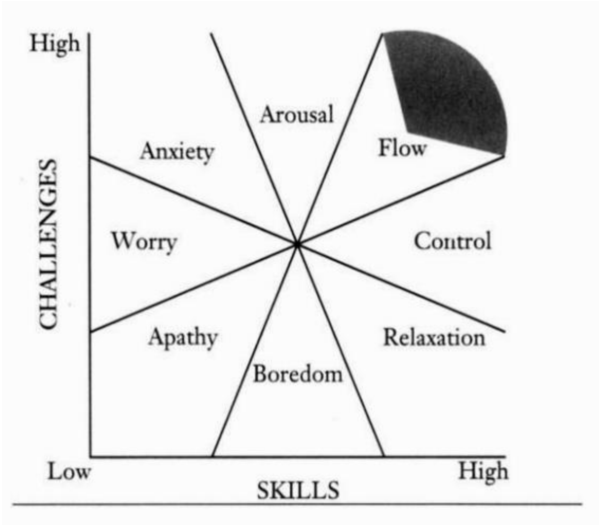

Figure 1. Emotional states associated with challenge and skill levels
(From Finding Flow: The psychology of engagement with everyday life (p.60), by M. Csikszentmihalyi, 1997, Basic Books**)**

4.3. Feedback

Another characteristic of a flow activity is that it provides immediate feedback. A student learning to play the piano will get immediate feedback when a wrong note has been played. Flow states require consistent feedback [17]. If a student is unsure that their work is on the right path, they are also easily discouraged to continue. However, if a student has access to timely feedback, they are more likely to feel motivated to finish their work. Feedback can be obtained via discussions with the instructor, group work with peers, or a clear set of assignment guidelines. In order to maximize feedback, it is important that students are able to share their mathematical thinking without fear of judgment, as mistakes are to be expected and should be seen as a part of learning mathematics [11]. The timing of the feedback is important. Specific feedback supports student learning and should be continuous during the learning, not just at the end. Effective feedback gives focused information that the student can act on. The task or activity should in itself provide immediate feedback.

4.4. Goals

The term ‘goal’ is an umbrella term that can be used to mean purpose, objective or final outcome. There are goals related to mathematics instructions and goals related to mathematics learning. Mathematics instruction is complex and involves a lot of material, planning, thought, commitment, and time. Goals related to mathematics learning should be specific, attainable, realistic and relevant to the proposed curriculum. Flow states also require a clear, attainable goal [17]. Some students have difficulties portioning their work into smaller, more achievable steps. If a student attempts a task that is too large in scope, they can be easily discouraged. If a student accomplishes a series of small tasks, they are more motivated to continue their work. Allan [2] determined that mathematical flow experiences were goal driven with an aim to solve a complex problem, prove something, or understand a complex situation. Shernoff et al. [34] indicate that goals are an important precondition to flow, but only if the goals are related to the task and not imposed externally as a performance criterion. Being familiar with the three domains of Bloom's Taxonomy (cognitive, effective, and psychomotor) and the corresponding hierarchy that corresponds to the different domains will benefit educators and students in attaining specific goals related to the subject content.

4.5. Control

Flow is a mental state that requires a sense of control, the ability to control and balance challenge and skill. Csikszentmihalyi [14] pointed out the important role of attention in relationship to control. We control our mental processes by the attention devoted to the task. Flow experiences tend to come from doing math activities, rather than listening to explanations [2], [33]. Waterman et al. [39] suggest that the importance of student choice is related to the necessity for control in achieving a flow state. According to Golnabi [22], being in control is central to the experience of mathematical flow. As such, interventions and activities should be designed to maximize student choice and control. Chiru [13] was able to determine that a balance between demands and control is as important as the balance between challenge and skills, suggesting that increases in challenge should also be accompanied with increase in decision latitude for students.

Allan [2] ascertained that questions which best encourage mathematical flow states were open-ended, involved student choice, and required the use of student creativity. Flow was highest when activities focused on conceptual understanding and proofs, with complex and challenging open-ended questions, when compared to activities with procedural solutions. These open-ended tasks allowed students to make choices and experience more control, both important for both flow and intrinsic motivation.

5. Basket and tapestry weaving: A mathematical activity

Students by nature want to learn. They bring their personal values and beliefs from home and community into the classroom. The perpetual and constant change in the cultural diversity of the classroom lends itself to the development of mathematics based on traditional symbols and practices related to culture. Culture is a complex term incorporating beliefs, values, attitudes, traditions, customs, social relationships, art and literature [19].

A variety of cultural practices such as knitting, quilting, weaving, rug making, hair braiding, and basket weaving make use of mathematics. Weaving, in one form or another, is a skill that is valuable in many cultures around the world and examples can be seen in artefacts and practices of various ethnicities. Math is perhaps not the first thing you think of when you think about basket and tapestry weaving yet mathematical content and competencies are embedded in the process. Whether it be weaving in the production of textiles, weaving of a rug or tapestry, or basket weaving, the application of mathematical concepts is involved. By combining cultural knowledge and traditions, skill, creativity, and mathematics, weavers produce works of art. The tapestry created by Paula James of the Katzie First Nation in British Columbia, Canada (see Figure 2) is an example of Coast Salish weaving. This tapestry can be used to illustrate a variety of mathematical concepts: symmetry, tessellations, and the geometrical transformations of reflections, translations, and rotations. Analyzing the pattern in this tapestry can lead students to discuss mathematics in a way that is culturally relevant. Incorporating artefacts created within the community provide opportunities to not only study mathematical concepts, but to learn more about a specific culture. It also provides an opportunity to link school, home, and community. d'Entremont [19] states that, "community participation is important for a number of reasons: it strengthens the link between home, school, and community; it strengthens the link between school and the cultural diversity of students, and it demonstrates the importance of incorporating cultural elements in the teaching of mathematics, all of which motivates students to learn about their culture and that of others while also learning mathematics" (p. 2822).

Basket weaving is another example of a cultural practice that can be used to study mathematical concepts. Woven baskets are another artefact that can be used to study mathematical patterns. When studying First Nations woven tapestries and woven baskets, it becomes apparent that the traditional Indigenous skills are based on mathematical principles. The woven basket in Figure 3 demonstrates properties of transformational geometry. Just as the tapestry in Figure 2 demonstrates a variety of mathematical concepts, so does the basket in Figure 3.

Figure 2. Example of Coast Salish Weaving by Paula James, Katzie First Nation, BC (From McSpadden, N. *Exploring Patterns Through Coast Salish Weaving* https://aboriginalresourcesforteachers.weebly.com)

Figure 3. West Coast Salish basket (Pegasus Gallery of Canadian Art British Columbia http://www.pegasusgallery.ca/artist/Coast_Salish_baskets.html)

Students can use their mathematical knowledge of symmetry, tessellations, translations, reflections and rotation to create their own pattern and design (see Figures 4 and 5). Asking students to create a concrete pattern using grid paper, will allow them to use the mathematical concepts studied to create a work of art. Properties of transformational geometry have been applied to create the designs in figures 4 and 5.

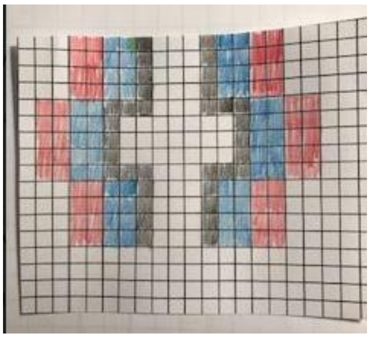

Figure 4. Weaving design

A different design is created by placing the design in a different position, vertically or horizontally. All designs can be interpreted, analyzed and discussed in class. Discussion provides a venue for the student to communicate his/her knowledge of the mathematical concepts involved in the design. Communication is an important element of learning.

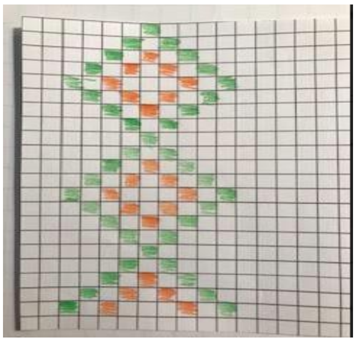

Figure 5. Weaving design

Weaving is an art form and a skill that is learned and mastered. Invited artists from the community are excellent teachers of their work. If the real artefact is not available, images could serve the purpose. Having understood the concept of design creation pertaining to weaving, using a paper cup and colored wool or yarn, students can practice weaving. Cup weaving (see Figure 6) is an activity where students create a design and complete a product.

Figure 6. Cup weaving

This activity has the potential to induce flow for several reasons. It connects out-of-school experiences and knowledge with school mathematics creating interest in the activity. By creating their own design, students themselves determine the balance between their skill level and challenge with the complexity of their design, while also maintaining creative control over their own project. This type of activity allows students to explore, compare and select among different strategies, and flexibility in their reasoning. The goal of such an assignment is clear, and it allows for consistent feedback, as students will recognize whether or not their weaving fits into their desired patterns. Students can share their project with their peers and teachers as an additional source of feedback.

6. Discussion

The conditions of flow theory outlined in this paper can serve as a template for teaching any subject. It may be easier to establish flow in some subjects than in others. Mathematics and science may have the disadvantage of being perceived as difficult as compared to learning a sport or game. The goals of a game are clear and feedback is less ambiguous than in mathematics and science. However, if the materials are stimulating, the task is interesting, and the activity is related to something they know, it is possible to achieve flow or a flow-like state in mathematics. Matching challenge and skill can be challenging in a classroom as students do not all have different levels of skill. It is all the more important that the activity be flexible allowing for control by the student. Using references related to the ethnicities of the students creates motivation and interest, conditions of flow. When using cultural references, it is important to use them in a context that makes reference to the community. Simply using these traditional artefacts as objects does not allow students to become personally involved and will not be interesting or motivating. Students who are unfamiliar with these practices will be able to learn about a different culture. By recognizing the various cultural ethnicities within the classroom, the teacher can take advantage of this by using community resources to demonstrate the skills involved. It has been my experience that members of the community are more than willing to share and demonstrate cultural knowledge and traditions.

7. Conclusion

Mathematics is more than a set of predetermined procedures resulting in right or wrong answers. It is a multidimensional subject that requires reasoning, creativity, connection making, and interpretation [11]. Connecting knowledge to students' lived experiences will create interest and motivation. In order for teachers to focus on culturally contextualized mathematics, they must be conscious of local culture. Pradhan [29] connects mathematics to daily experiences through games and artefacts. Mathematics that is interesting and motivating can lead students to a flow like state. The flow experience is multifaceted. It is a cognitive demanding process that must also take into account motivational and emotional components. With flow theory, students can experience the satisfaction of learning something new. Flow experiences can contribute to a growth mindset by encouraging students to see effort as their path to mastery, and to perceive mistakes as learning opportunities [2], [11]. Csikszentmihalyi [17] states "science and math, for instance, have the initial disadvantage of presenting too many challenges to students, who start out being anxious and often remain in that state without ever enjoying the learning process" (p.185). The goals, the rules, and the constant feedback provided in mathematics class are criteria that could lead to a flow experience. Educators must also realize that not all students experience flow in the same manner, nor does the same activity lead to a flow experience for all students. Achieving a state of flow is an individual experience, some people are more likely to experience flow than others. Educators must themselves understand the concept of flow if they are to lead their students to achieving flow. Educators who recognize the link between mathematics and culture will be able to create motivating learning opportunities for students. Flow does not come easily. Athletes and musicians train for many years before performing and being in a state of flow. Therefore, it is unrealistic to conceive that students will reach a complete state of flow. We can, however, help students reach a flow-like state.

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