The Conditions of Flow and Mathematical Problem Solving

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Introduction

As a mathematics teacher, you may have heard the phrase, "I hate math" more than once. You have probably even made attempts at showing your students how "fun" mathematics can be, and how useful it is in real life. However, this hasn't taken us very far with students who are not particularly interested in applications of mathematics. It may be time to think about how we can make the process of learning mathematics enjoyable for students. In fact, in this paper, I propose a direct link between mathematics and happiness.

In the past, many scholars have attempted to understand the nature of human happiness, and recently, a new area of psychology called positive psychology emerged with an attempt to study positive human development. One of the co-founders of this branch of psychology, Dr. Mihalyi Csikszentmihalyi, introduced the concept of *flow* as a state of absorption where one's abilities are well-matched to the demands at hand. According to this theory, happiness can be developed when individuals learn how to achieve a state of flow in their lives.

Flow has been studied in various contexts (including education) ever since the concept was first introduced in the 1970's. In an educational vein, many studies relating flow to classroom have been conducted. In an article on this connection, Csikszentmihalyi (1991) notes that, "A teacher who understands the conditions that make people want to learn – want to read, to write, and do sums – is in a position to turn these activities into flow experiences. When the experience becomes intrinsically rewarding, students' motivation is engaged, and they are on their way to a lifetime of self-propelled acquisition of knowledge." The notion that a teacher is empowered to set up favorable conditions for flow leads the way for a discussion on how mathematical problem solving can be an ideal setting for teachers to engender flow.

To better understand when and how individuals around the world experienced this state, in the 1970's, Csikszentmihalyi conducted a series of long interviews, and collected questionnaires and other data with the objective of understanding how people felt (and why they felt that way) when they were most enjoying themselves (Csikzentmihayli, 1990). Csikzentmihalyi's studies analyzed the responses of several thousand respondents from various cultures. A compilation of this data yielded a list of characteristics of this positive experience reported by the respondents. The studies showed that every respondent shared at least one, but often times all, of the short list of feelings. From there, Csikszentmihalyi was able to conclude that in order for a state of flow to occur, there must be factors, both within the individual as well as externally, that favor a state of flow. For the purposes of this discussion, the external conditions will be considered in the context of mathematical problem solving.

The Conditions of Flow

The first condition stated by Csikszentmihalyi (1990) is that the activity one engages in should contain a clear set of goals. This is the first, and possibly most initially obvious, connection between problem solving and activities that are favorable for a flow state. However, it is important to clarify that not all problems share this characteristic. In fact, cognitive psychologists have categorized problems into two classes: well-defined and ill-defined. For this condition to be met, one must be dealing with well-defined problems, which are described as "those problems whose goals, paths to solution, and obstacles to solution are clear based on the information given" (Pretz, et. al, 2003).

In the case of mathematical problem solving, the majority of the problems that students are presented with could be considered as being well-defined. In fact, Polya (2004) argues that a student can follow a four-step process which will further allow the student to break up the ultimate goal of solving the problem into additional more attainable goals.

Beyond containing a clear set of goals, Csikszentmihalyi's (1990) suggests that a state of flow is achieved when the activity presented to the individual falls within a certain golden ratio between their skill level and the challenge level of the problem. If the task at hand lies outside of the so-called "flow channel", then, according to Csikszentmihalyi, it will likely cause either anxiety or boredom. This is the second of three conditions that Csikszentmihalyi outlines, and is illustrated by Figure 1.

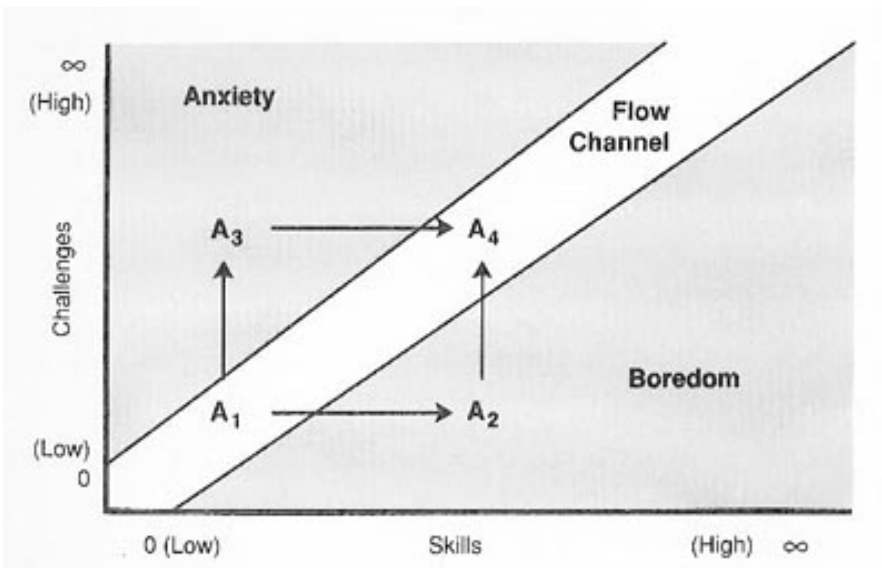

Figure 1: Flow channel diagram. (Csikszentmihalyi, 1990, p.74)

With the second condition in mind, it seems natural to think of mathematical problem solving as an appropriate context for flow to occur since both skill level and challenge level are measurable in a mathematical context. That is, one can measure the difficulty of a problem within a specific sequence of concepts given that in mathematics concepts tend to build upon previous ones. Also, consequently, "Mathematics learning exhibits such a high order of sequential dependence that unless the student masters each step in the development of the subject, further progress is impossible" (Ausuble, 1969, p.143). As a result, mathematics teachers are able to determine the skill level of the student within that sequence. Therefore, it would be plausible to expect that a problem presented to a student can be chosen so that it falls within the ideal flow channel as proposed by Csikszentmihalyi (1990). In the same manner, if a student is presented with a problem that does not lie within that channel, then the two variables can be adjusted accordingly.

Additionally, Polya (2004) makes some mention of the advantages of presenting students with problems that are within this channel both implicitly and explicitly in his book *How To Solve It* by stating, “If the student is lacking in understanding or in interest, it is not always his fault; the problem should be well chosen, not too difficult and not too easy, natural and interesting” (Polya, 2004, p.6). Furthermore, one of the problem solving strategies proposed by Polya (2004) is to attempt an easier problem than the one at hand if you are having difficulty with the one at hand. The purpose of the strategy can be considered in the context of this discussion where the point is for students to successfully complete a similar problem that is lower on the challenge level scale, and with that, raise their own skill level so that the subsequent, more challenging problem moves into their flow channel.

The third condition considered by Csikszentmihalyi as being favorable for flow to occur is for the activity to have clear and immediate feedback. As was the case with the previous two conditions, mathematical problem solving is an activity that meets this condition. Polya’s (2004) four step procedure for problem solving includes a final step where the students are expected to check their answers. This is a practice that, if implemented consistently by students, will allow them to discover their own feedback without the input of their teacher.

Furthermore, metacognition can play a central role in this aspect of the discussion. Flavell (1976) describe metacognition as, “the active monitoring and consequent regulation and orchestration of those processes in relation to the cognitive objects or data on which they bear, usually in the service of some concrete [problem solving] goal or objective” (Flavell, 1976, p.232). Students can serve as monitors of their own progress thus provide themselves with immediate feedback. To encourage this, Lester et al. (1989) created a series of teaching actions for problem solving that was designed to focus on fostering students' metacognitive development. This suggested that while students are working on problems, the teacher should facilitate discussion among students. This, in turn, provides additional opportunities for immediate feedback from peers during the problem solving process.

Closing Remarks

Csikszentmihalyi's studies of how our best moments are those when we are in control of our conscious and in what he calls a state of flow, bring to light a new found dimension in mathematics education. The purpose of this paper is to introduce this connection and set the framework for deeper exploration. The points made in this discussion relate only to the conditions of flow that can be met through appropriate problem solving, and do not thoroughly consider the complexity of either fields. A further discussion would be necessary to discuss the nature of the connection between flow and problem solving and to measure to what extent mathematical problem solving can be a context for a state of flow to occur.

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