UNDERGRADUATE STUDENTS' EXPERIENCES OF IDENTITY AS CAPABLE MATHEMATICS LEARNERS

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This study explored how undergraduate mathematics students perceive themselves as capable mathematics learners and whether differences exist between male and female students' perceptions. A concurrent mixed method design was used in which qualitative and quantitative data was collected and analyzed separately. The findings from quantitative data suggest that gender differences exist with regard to some participant's perceptions of their self-efficacy and their environment. Qualitative data analysis revealed that undergraduate mathematics students describe their experiences of being a capable mathematics learner from two positions: from their direct experience and from their perceptions of ideal images of a capable mathematics learner.

Keywords: Post-Secondary Education, Gender, Mathematics, Identity, Perceptions

INTRODUCTION

Researchers have highlighted various aspects of the mathematics learning process and have presented it from a range of theoretical standpoints (Grootenboer et al., 2006). Recently, the notion of identity has been explored to bring an understanding of mathematics' learning (Boaler & Greeno, 2000; Sfrad & Prusak, 2005). Learning mathematics involves the continuous development of a student's identity as capable mathematics learners. Identity can be defined as a perception of self in an academic environment that develops through relationships and experiences with peers, educators, family, and community and an individual's own connections and meaning of mathematics to the broader context (Anderson, 2007; Solomon, 2007). Sfrad and Prusak (2005) refer to identity as the way in which one defines him/herself and how others define him/her.

Most of studies on identity have focused on school mathematics learning. Recently research has highlighted the importance of identity for understanding learning at undergraduate mathematics level (Solomon, 2007). There is a need to understand how mathematical identity contributes to the experiences and educational success of students at the undergraduate mathematics level. Undergraduate mathematics students' identity is essential to students' beliefs about themselves as capable mathematics learners and as potential mathematicians (Solomon, 2007). There is evidence from literature that gender plays a significant role on mathematical identity (Anderson, 2007; Solomon, 2007; O'Brien, 1999;). This raises the question on whether male and female undergraduate students perceive their identity as capable mathematics learners differently. This study aimed at exploring how undergraduate mathematics students identify themselves as capable mathematics learners and whether gender differences exist. The study was guided by the following questions: 1)What are undergraduate students' perceptions of capable mathematics learners? 2) What does it mean for undergraduate mathematics

students to be a capable mathematics learner? 3) How do their perceptions compare with their meanings of a capable mathematics learner? 4) Are there any gender differences?

CONCEPTUAL FRAMEWORK

Literature shows various factors that may contribute to one's mathematical identity as a capable mathematics learner. Most of the studies on mathematical identity have focused either on self-efficacy (mainly from psychological perspective) or on environment (mainly from a socio-cultural perspective) (Grootenboer et al., 2006). Grootenboer et al., argue the plurality of theoretical perspectives may provide a richer and more comprehensive understanding on the issues of identity in mathematics education. Following Grootenboer et al., this study looked at identity as a capable mathematics learner at the undergraduate mathematics level from the plurality of the three approaches: self-efficacy, environment, and four faces of learner's identity (Figure 1). In this study, self-efficacy refers to as the way in which one may perceive him/herself and may ask, *Am I a capable mathematics learner*. My perception of mathematical self-efficacy is influenced by the social cognitive theory (Bandura,1986; Pajares, 1996). According to Bandura (1986), self-efficacy is learned and self-efficacy expectations are acquired through various sources. The essential source of self-efficacy is accomplishments where one's successful experience on a given task will increase the self-efficacy connected to that task (Bandura, 1986). A second source, vicarious learning, can affect one's self-efficacy where one sees others, peers and classmates, succeed or fail on a given task, assessment, or class. In observing others' behavior, performance, grade, etc., an individual is able to reflect on his/her experiences and make meaning of its relevance in a new situation. Other sources of self-efficacy are verbal persuasion and emotional arousal. In verbal persuasion, beliefs about one's self are influenced by the messages conveyed by others (e.g., what others are telling me about my capability to learn mathematics). Emotional arousal refers to the stress and anxiety in a given task and its effect on self-efficacy.

According to O'brien, Martinez-pons, and Kapala, (1999) environment factors may negatively affect the self-perceived academic skills and career goals. Furthermore, Boaler and Greeno (2000) emphasize that identity is decisive to the belief that one can be a creative participant in mathematics as a social practice. Given this orientation, this study explored identity as a capable learner from the environment approach, where one's identity as a capable mathematics learner might be influenced by how others define him/her. In this study, environment refers to the surroundings of an individual, which may compel him/her to question; *do my peers, classmates, educators, etc. perceive me as a capable mathematics learner*? In addition, my study explored identity from Anderson's (2007) four faces of learners' identity: engagement, imagination/relativity, alignment, and nature. Engagement face refers to the experience and active involvement of an individual with people within their environment/ the world around them. Relativity/imagination face refers to the images one has of him/herself and of how

mathematics fits into the broader experience of life. Third face of learner's identity alignment refers to how one aligns their energies within given institutional boundaries and requirements in response to their imagination face of identity. Finally, nature looks at the connection one makes of their natural characteristics, which one has no control over them such as sex, and is dependent on their relationships and broader social settings (2007). Anderson (2007) conceptualization of identity in terms of four faces of learner's identity, might lead one to ask: *Why should I learn this*?

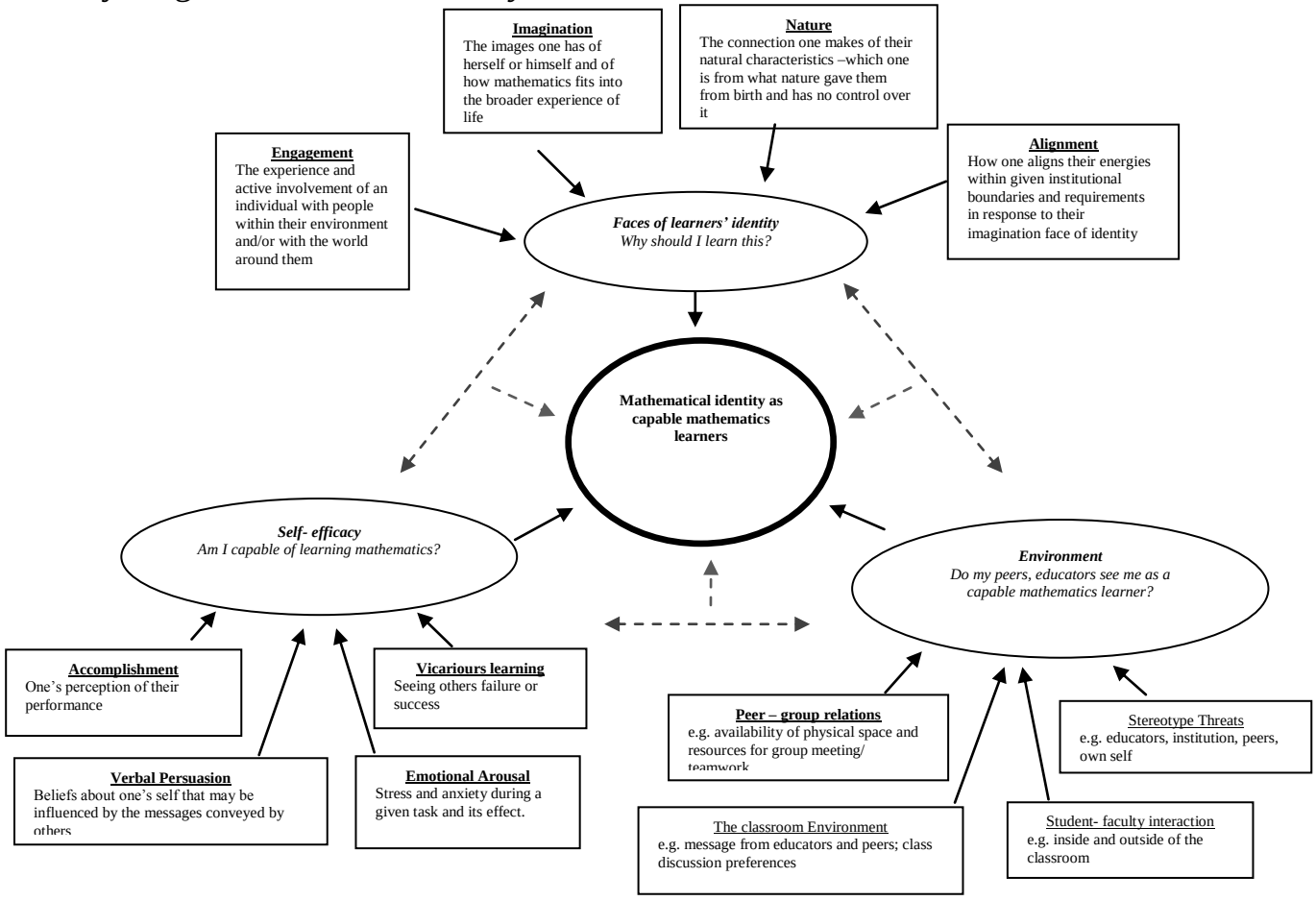

Figure 1: Conceptual framework: Mathematical identity as capable mathematics learners. The figure has two levels. First, the three approaches contributing to mathematical identity (in the solid circle), showed by the concepts within the elliptic shapes. Second, the sources/ factors/each face contributing/influencing/impacting to each of the approaches, showed by the concepts within the rectangular shapes. The solid arrows represent contribution/influence/impact; the dotted arrows represent possible contribution/influence/impact; and bi-directional dotted arrows represent possible relationship among the approaches.

METHODOLOGY

A mixed methods research design was conducted, where both qualitative and quantitative methods were utilized in order to better gain insights on the ways in which

undergraduate mathematics students see themselves as capable mathematics learners. Participants in this study comprised of undergraduate mathematics students majoring in mathematics and those enrolled in the concurrent education and mathematics program at a Canadian university. Quantitative data was collected from an online questionnaire. A total of 30 participants, 10 males and 20 females responded to the online questionnaire. Out of the 30 participants, 4 were in first year, 5 in each of second, third and fourth year of undergraduate mathematics program, and 11 in the others category including graduates and students who were in the programs for more than four years (to complete the program). In terms of the area of study, 27 participants were from the honors program (20 credits base program) and 3 from the pass program (15 credits base program). The online questionnaire consisted of 24 statements utilizing the 5-point likert scale. Both parametric and non-parametric measures for descriptive statistics were used to analyze the data. Given the assigned rating of 1-5 of the Likert scale level, the means of response rate of each statement, along with corresponding standard deviations and associated modes, were calculated using SPSS software in terms of all the participants and male and female participants. The Mann- Whitney U test was used to test significant differences between male and female participants at $p < 0.05$ level.

The qualitative data were obtained from individual semi structured interviews with 3 males and 3 females. The 6 participants were given the pseudonym of Adam, Brent, Craig, Andrea, Britney and Carole. Adam is a graduate of a mathematics undergraduate program, and is currently pursuing his PhD in History of Mathematics. Brent is in the last year of mathematics undergraduate program. Craig is in his third year of undergraduate intermediate/senior concurrent education with mathematics as his first teachable. Andrea has completed a mathematics undergraduate program and a Master of Statistics. Britney has completed a junior/intermediate undergraduate mathematics program with mathematics as her teachable, and currently she is beginning her career as a teacher. Carole is in the last year of a mathematics undergraduate program. The questions for the interviews were designed using the three approaches of understanding identity in the conceptual framework. The purpose of the interview was to get an in-depth understanding of students' experiences at the undergraduate mathematics level, which, in turn, informed their perceptions of themselves as capable mathematics learners. The interview took about 25-30 minutes, and was conducted at the participants' choice of location. The process of analysis for the qualitative data was essentially inductive in nature, proceeding from the particular, such as interview transcriptions, to the general, including codes and themes. Therefore, sentences and/or paragraphs that support the research problem were highlighted. The conceptual framework and the research questions from which themes and codes emerged guided the interpretation of data.

QUANTITATIVE FINDINGS

The results from quantitative data indicate that participants have strong perceptions of their self-efficacy, and strong perceptions of the influence of their environment. Majority of participants responded, 'Strongly agree'/'Agree' to the statements related to self-efficacy and environment. With respect to the four faces of learner's identity, the results indicate that participants have strong perceptions of preferences for dispositions to nature face and strong perceptions of the influences of imagination face. Majority of participants responded, 'All of the time'/'Most of the time' to 2 out of 3 statements related to nature face of learner's identity. In relation to imagination face, 76.6% of the participants responded 'Strongly agree'/'Agree' to the statement *Mathematics will help you further your career goals.*

Table 1
Average of Participants' Responses to the online questionnaire

		Male					Female				
		A	B	C	D	E	A	B	C	D	E
Self- efficacy		44.9%	31.9%	18.6%	4.3%	0.0%	22.1%	45.77%	23.0%	7.9%	1.2%
Environment		27.7%	36.0%	22.2%	11.1%	0.0%	26.6%	52.51%	14.9%	5.0%	0.8%
Four faces of learners identity	Engagement	33.3%	33.3%	22.2%	11.1%	0.0%	33.3%	46.7%	20.0%	0.0%	0.0%
	Imagination	89.9%	0.0%	11.1%	0.0%	0.0%	73.3%	26.7%	0.0%	0.0%	0.0%
	Alignment	0.0%	44.4%	22.2%	33.3%	0.0%	6.7%	26.7%	26.7%	26.7%	13.3%
	Nature	16.6%	33.3%	40.0%	10.0%	0.0%	20.0%	30.0%	38.3%	11.6%	0.0%

Note: Ratings: A =strongly agree/all of the time, B= agree/most of the time, C = neutral/some of the time, D = disagree/few of the time, E = strongly disagree/never

Furthermore, the qualitative results shows that there are significant gender differences in the perceptions with regards to the statement related to self-efficacy *if someone oppose to your idea*, *you can find the means to prove your idea* (note: p=0.003), and a statement related to environment *there is enough physical space available and mathematics resources in your institute for you to work by yourself* (note: p=0.014).

QUALITATIVE FINDINGS

The data obtained from the transcriptions of the interviews were coded and analyzed, where six themes emerged with regard to the ways in which participants see themselves as capable mathematics learners. The six themes are: (a) when I contribute and fit in, (b) if I can teach others and others understand it, (c) when I have opportunities interact with my peers, (d) when I am recognized by my professors, (e) if I have a previous knowledge of the course content, and (g) if I fit in with my image of a capable mathematics learner. In addition to these six themes, two positions from which participants described their experiences of being a capable mathematics learner emerged: from direct experiences and from their ideal images of a capable mathematics learner.

Participants described their perceptions of their mathematical identity from their own, direct personal experiences. For example, in relation to the theme 'when they contribute to and fit in the class', Britney expressed:

> I usually see what other students got…how other students did… so I try to compare myself with others and I try to see well okay if the rest of the class did bad …okay I guess we are all just bad together …if I see that I am on the lower end…I know something …you know something is up like I need to myself do something.

In relation to the theme, 'if they can teach others and others understand it' Craig stated:

> For me, I learn a lot by teaching and so if and when I have a study group, I can maybe help out some of the other students that might struggle a little bit. And through that I learn better, and because by teaching you sometimes have to think of it [problem] in different ways, and through thinking different ways you are learning yourself new ways, new techniques to do these problems.

For the theme, 'when they have opportunities to interact with their peers' Britney reflected on her experience and stated

> When I had support of friends who were able to basically be the professors for me. And they were the ones who were able to explain things in a different way, interpret it for me, give me concrete examples and spend the time, work with me, problem solve with me. Because I am not the type where I can just have a professor standing in front of me, they do their own thing on the board, and I don't try out much in the class with them. I need to do a little bit of problem solving, dialogues …I really learn from the interpretations of others.

In relation to the theme, 'when they are recognized by their professors', Carole commented,

> Yea I had chance to work with one of my professor during the summer time…that influenced me because that increased my level of interest into the subject…

In relation to 'if they have a previous knowledge of the course content', when asked the question, *How do you see yourself succeeding in a course*, Craig responded,

> Some courses I see that I might not do so well in and for that, it would be based on my prior experience with the course. So, for instance, when I went into the second year statistics, I knew that I would do well in the course because it is very much similar to the data management course. Whereas the first year calculus … my calculus background was not even that strong …

In contrast to participants' descriptions of their direct experiences of capable mathematics learners, in this position, participants used their ideal images to describe their experiences of capable mathematics learners. Participants described their experiences by giving definitions or characteristics of their ideal images, which they then compared themselves with. Carole's response to the interview question demonstrates this way of perceiving. She said,

> Once I am in the range on As …that's very happy…like for the outcome. But once I am not As but Bs and Cs, like which is lower… I start to question myself if I am doing my work…

Carole's response shows that she perceives a capable mathematics learner to be someone whose grades are in the range of As and she perceives herself to be a capable mathematics learner if she fits in with that image. If she does not measure up to her image of a capable mathematics learner, then she begins to question herself as a capable mathematics learner. In the interview with Britney, she pointed out the importance of dialogue in mathematics classes for learning. She comments,

> Frankly, in the mathematics courses there isn't that much room for dialogue …and if there is dialogue it's with the smartest students in the class and the professor …so I am kind of cut out of that part.

Britney notes that given a limited dialogue in mathematics courses, it would seem that the only dialogue that occurs is between "the smartest students in the class and the professor." This situation provides the participant with an image of a capable mathematics learner as someone who dialogues with the professor in the class. She then compares herself with this image where she notes that she is "cut off" from the dialogue. This suggests that the participant perceives herself as a capable mathematics learner if she fits in with her image of those students who dialogue with the professor in the class. Further, in the same interview with this participant, she revealed some other ways in which she perceived an image of a capable mathematics learner and how she compared herself with that image. She added:

> I could tell that there were students who somehow, I guess, had a math gene in them but I didn't …and they were the ones who could teach math at a higher level, understand at the higher level and do more mathematical things.

Here, in this response, Britney's image of a capable mathematics learner is someone who is born that way - "had a math gene." Therefore, she sees herself as a capable mathematics learner if she fit in with her image, someone who has "math gene".

Brent's response to how he sees himself as a mathematics student further provides evidence of participants' ideal images of a capable mathematics learner. During the interview, the participant mentioned that initially right after high school he enrolled in a chemistry undergraduate program. Due to his relationship with his professor in 1st year mathematics course, he decided to switch his undergraduate program from chemistry to mathematics in his second year. The interview revealed how Brent negotiated his image of a capable mathematics learner in his undergraduate mathematics studies. He notes:

> Well, one thing that I didn't like was the fact that mathematics students were always perceived as nerdy. And I didn't like that impression that everyone is like you are in math, you are nerdy. Well, like I am not…that is not necessarily the case. So I didn't like to associate myself with other math majors…like I guess because of that. So that didn't last too long …first I was like okay it really doesn't matter…I don't identify myself as a nerd so it doesn't matter…I can still talk to people and talk to them…so then now I am like, yea, I guess I fit into the nerd category.

Brent's response indicates that he did not want to be perceived as a "nerd" by others just because he was an undergraduate mathematics student and hesitated from associating himself with the image of a nerd. However, upon interacting with others, he realized that his image of a capable mathematics learner fits with the nerd. In other words, he sees himself as a capable mathematics learner if he fit in with his image; a nerd.

DISCUSSION OF RESULTS

This section presents discussion of the results of the study. The discussion is guided by the research questions and framed by the conceptual framework discussed above. Throughout the discussion, we weave together the results from both qualitative and quantitative data. The two positions and six themes in which undergraduate mathematics students describe their experiences of being a capable mathematics learner and see themselves as capable mathematics learners point to undergraduate students' perceptions and their meanings of a capable mathematics learner from their learning experiences in a mathematics community (class, learning centers, labs, seminars, etc.). Results from quantitative data indicate undergraduate students' perceptions of their mathematical identity in terms of self-efficacy, environment and four faces of learner's identity and whether gender differences exist. For example, results from qualitative data show that undergraduate mathematics students perceive themselves as capable mathematics learners if they can teach others and others understand it. Participants noted that teaching others provokes one, to think of different ways of solving a problem and to think how others understand the concepts. Additionally, teaching others validates one's understanding of the concepts or skill and/or provides them with an opportunity to learn concepts and/or skills. Undergraduate students' perceptions and meaning of a capable mathematics learner in terms of teaching others and others understanding it might lead to their perceptions of self-efficacy in terms of verbal persuasion. In verbal persuasion, beliefs about one's self can be influenced by the messages conveyed by others (Brown, 1999). Undergraduate student's experiences of teaching peers and seeing that they understand it provides an opportunity for her/his understanding of concepts/skills to be validated by peers. Further, teaching others and others understanding it may provide opportunities for undergraduate students to assess their confidence in their ability to succeed/accomplish a variety of tasks and problems. Being able to teach others and others understanding it requires undergraduate students to be able to deal with questions, curiosities, and different ways of thinking that their peers might bring to them. The quantitative results indicates that most of the participants agreed/strongly agreed that they are confident that they could deal efficiently with the unexpected (70.0%), they can solve most problems if they invest the necessary effort (66.7%), they can always manage to solve difficult problems if they try hard (53.4%), and they can find the means to prove their ideas if someone opposes their idea (66.6%). This suggests that majority of the participants have strong perceptions of self-efficacy for these tasks related to teaching others. Results from qualitative data suggested that undergraduate mathematics students

perceive themselves as capable mathematics learners when they contribute to and/or fit in the class. For research participants, in order to see if one is a capable mathematics learner in terms of contributing to the class, one would assess their performance (of tests, exams, assignments etc.) to see whether his/her grade is above or below the class average. This in turn would show, whether one's performance is contributing positively or negatively to the class average and consequently determine whether one is a capable mathematics learner. In the case of fitting in the class, one would assess his/her performance to see if it belongs to a majority or a minority of overall class performance. For instance, if the majority of the class did not do well on a test and one's performance is one of this majority, then one will judge his/her performance as not something to do with his/her capability as a mathematics learner but rather to do with other factors out of his/her control. On the other hand, if his/her performance belongs to the minority that did not do well on a test then one would see oneself as not being a capable mathematics learner. Undergraduate students' perceptions of contributing to and fitting in the class might not only contribute to their perceptions of self-efficacy in terms accomplishment and vicarious learning but also to their perceptions of both self-efficacy and their classroom environment in terms of their readiness to participate in class (Shunk & Pajares, 2004). Following Shunk and Pajares, we might argue that an undergraduate student's perceptions of contributing to and fitting in the class might have an influence on their participation in class. For example, an undergraduate student seeing himself or herself as contributing negatively or positively to the class average might lead him or her to feel (un)worthy or (in)competent (i.e. (not) a capable mathematics learner), which in turn might contribute to his or her timid or passive behaviour in class.

The results from quantitative data may shed some light regarding the relationship between undergraduate students' perceptions of contributing to and fitting in the class and their participation in class. The results suggested that the majority of participants (60%) agreed or strongly agreed that their participation in class depends on their comfort level in that class. Additionally, the results showed no significant gender differences. Following these results from both quantitative and qualitative data one might postulate that one of the contributors to undergraduate students' feeling (un)comfortable to participate in class may well be their perceptions of contributing to and fitting in the class. It is interesting to note that in my study the majority of participants (46.7%) indicated that they participate in their mathematics classes all the time or most of the time. There were also no significant gender differences.

IMPLICATIONS

To conclude this article, recommendations are offered to educators. The study suggests that undergraduate mathematics student' perceptions of their mathematical identity as capable mathematics learners are influenced by their perceptions of themselves as being recognized as learners by their professor. Subsequently, while teaching/providing explanations, educators might benefit from taking undergraduate mathematics students'

understanding of mathematics into account, by spending the necessary time that a student require for clarification and by providing explanation for mathematics concepts in multiple ways. Educators might also benefit from being aware that their intentional/unintentional messages influence undergraduate mathematics students' perceptions of their mathematical identity. Furthermore, this study indicates that undergraduate mathematics students' learning experience deepens when they develop personal relationships with professors. Consequently, there is a need for educators to provide students with a comfortable learning environment where both educators and other students invite one another's ideas, and where an individual feels comfortable to ask questions and find answers. Hence, educators should provide opportunities where undergraduate mathematics students have opportunities to interact with them and other students in the undergraduate mathematics level.

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