Self-Efficacy and Professional Development for Mathematics Educators

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Abstract

Our proposed study aims to test the influence that a 16-week course using the Concrete-Representation-Abstract (CRA) approach has on the self-efficacy of pre-service math educators.Each participant will participate in an interview and complete two pre and post surveys that gagetheir attitudes towards math along with their self-efficacy. The surveys are Attitude Toward Mathematics Inventory (SF-ATMI) and the Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ). Our theoretical foundation derives from Bandura's (1986, 1994) workon social cognitive theory and the role of self-efficacy in an individual's trajectory. Our study is an attempt to answer the following questions: How do attitudes toward mathematics change in pre-service teachers that receive CRA instruction? Moreover, is there a change in motivation and value towards mathematics after receiving CRA instruction? Currently, this is a work in progress and has not rendered results. We aim to examine any statistical correlations obtained bythe survey results and insights gathered during the interviews.

Keywords: self-efficacy, concrete-representation-abstract, communities of practice, mathematics, preservice teachers

Self-Efficacy and Professional Development

When we think of designing professional development, we typically think of it in terms of one type of instructional session will influence this one type of individual. Moreover, if we provide the same 1 to 1 treatment with everyone, eventually the entire system will be transformed. Instead, we ought to think of individuals as active members within various types ofcommunities of practice. This line of thinking is a vital difference because, within a community of practice, all individuals are not replicated or have identical backgrounds. In other words, a community of practice is fluid. If we begin to think of communities of practice as an ecosystem and want the ecosystem to sustain or provide individuals with definite room for growth, we mustunderstand how the individual works and relates to their surroundings before we can create the appropriate ecosystem or community of practice.

Moreover, research has shown that the most predominant psychological factor that predicts achievement is self-efficacy within academia (Robbins et al., 2004). Therefore, this study aims to explore what happens when a math educator receives professional development that targets explicitly their self-efficacy. Once we understand how we can provide professional development that influences an educator's self-efficacy, future research can begin to explore howinstructional systems for math education have been influenced and modified across academia.

Communities of Practice

Communities of practice are essential to study because they highlight and demonstrate dynamic changes within learning spaces experienced in academia and corporate America. Communities of practice are pockets or groups of people that form because the individuals within that group share a common niche. With the developments and social changes, the most significant limitation that communities of practice face are the boundaries of the community andthe ways these communities emerge. While research has recognized the benefit of understandingthe concepts of communities of practice, it has become a challenge to formalize and implement these communities of practice effectively and strategically because of the ambiguity (Robbins etal., 2004).

Furthermore, Roberts (2006) begins to analyze how research studies conducted in the 1990s still have relevance because the studies highlight the psychological factors that are underemphasized yet stand at the heart of the limitations. These concepts would include power dynamics, trust, and predispositions. Roberts (2006) concludes that power dynamics are directly correlated to the creation of knowledge and the dissemination of this knowledge. A corporation's power dynamic directly influences that knowledge creation within a community of practice. Meanwhile, trust within a community of practice is the vehicle that drives the information sharing. Roberts (2006) references Andrew's and Delahaye's (2000) concept of thepsychosocial filter and asserts that ultimately the "power dynamic shapes social interactions andperceptions of how the information is used in knowledge transfer" (p. 628).

These concepts of power and trust, however, are influenced by predispositions. In other words, the structure of communities of practice are not closed circles, but rather communities of practice resemble constellations because each has predispositions that originate from their participation in peripheral communities of practice. This constellation structure makes defining the boundaries of the communities of practice increasingly difficult if not impossible. More importantly, communities of practice within corporations become either too institutionalized, making them at times ineffective, or too obtuse. Roberts (2006) however does recognize that theresearch does still show benefits to these communities of practice, but certain company cultures and structures are conducive to productive communities of practice over others. As Roberts (2006) continued to explore in great depth peripheral concepts of the limits to communities of practice, there are three general categories that these limitations can be categorized into: "socio-cultural environments, organizational context, and variations in the prevalence and success of communities of practice in organizations of varying sizes" (p. 636).

Social Cognitive Theory

Fundamentally, Lave and Wenger (1991) define communities of practice as "a system of relationships between people, activities, and the world; developing with time, and in relation to other tangential and overlapping communities of practice." Moreover, communities of practice are founded on Reification and Participation (Wenger, 1998). Reification being "the process of giving form to experience by producing objects" (p. 58) and participation being the acts of mutual engagement, joint enterprise, and shared repertoire (Wenger, 1998). In other words, participation considers how individuals interact with one another, how individuals come togetherto form a group, and how individuals produce or share communal resources (Wenger, 1998).

Participation is a crucial component of communities of practice, and therefore, the understanding social cognitive theory is relevant because it addresses the internal dynamic of the individuals that form communities of practice. Understanding that self-efficacy influences the types of endeavors individuals to engage in is essential and social cognitive theory expands our understanding on how an individual sets goals (goal attainment and motivation) which eventuallydirectly affects the dynamics and formation of communities of practice. Therefore, understanding how these concepts intermingle will empower educators and practitioners to reshape current instructional systems.

Social Cognitive theory is founded on four components that work together: Self-observation, Self-reaction, Self-efficacy, and Self-evaluation (Bandura, 1986). Self-awarenessand observation come into play as the individual cognitively assigns meaning to the things thatthey observe from themselves. As individuals begin to assign meaning, individuals begin to form their standards which lead to self-evaluation (Bandura, 1986). It is this evaluation that causes individuals to have a positive or negative reaction (Bandura, 1986). The observations, evaluations, and reactions all build self-efficacy. In essence, the relationships between the internal dynamics of an individual influence their integration into a community of practice, butthe community of practice is equally influenced by these internal dynamics creating a snowballeffect (Eun, 2018). According to Robbins et al. (2004), self-efficacy is one of the most significant factors of achievement and surpasses other psychological components.

Self-Efficacy as a Means for Improvement

According to Bandura (1994), self-efficacy is a root cause of an individual's behaviors, motivation, emotions, and thinking. An individual's perceived self-efficacy is the individual's beliefs about their capabilities (Bandura, 1994). In short, if an individual has a strong sense of efficacy, challenges are perceived as challenges to overcome rather than threats to avoid (Bandura, 1994). Four sources affect self-efficacy: Mastery Experiences, social models, social persuasion, and somatic and emotional states. Mastery experiences are the experiences of successand failure experienced by the individual (Bandura, 1994). The retrospective trajectory of an individual's balance of failures and successes shapes how the individual approaches future successes and failures. Social models are the group of individuals or social group that a person has as an example. Often, these are individuals that mirror certain similarities or aspirations. Forinstance, a child aspires to be a police officer and uses their relative who is a police officer to validate beliefs or form judgments. Social persuasion is the external verbal feedback received byothers (Bandura, 1994).

Somatic and emotional states are the emotional and physiological reactions experienced. Individuals will rationalize their response and assign positive or negative meaning to validate beliefs (Bandura, 1994). When individuals assign meaning, this can begin to drive their intentionality which goes beyond the assignation of connotation and drives their commitment tocarry out a set of actions (Bandura, 2001).

Proposed Research Questions

The proposed study seeks to build self-efficacy in pre-service teachers through a self- paced online course with feedback that allows them to acquire a conceptual understanding of mathematics. The proposed research will be framed using the Concrete-Representation-Abstract(CRA) instructional approach to bridge the connection between concrete and abstract.

1. How do attitudes toward mathematics change in pre-service teachers that receive CRA instruction?
2. Is there a change in motivation and value towards mathematics after receiving CRA instruction?

Framework

The instruction that pre-service teachers receive will be framed using the CRA instructional model. An attempt will be made to connect their abstract knowledge of mathematics back to the conceptual to build self-efficacy, thereby improving their quality ofinstruction.

A benefit to CRA is that it allows students to retain learned concrete representations and connect them while working with problems more abstract (Fyfe et al., 2014). This method is consistent with Bruner's research contributing to cognitive learning theory wherein Bruner describes three modes of representation of cognitive development (Bruner, 1966). CRA instruction sequence aligns with Bruner's work (1966) that sought to explain how students arriveat an abstract representation of concrete objects.

The CRA instructional framework leans on scaffolded instruction which allows students to connect back to the concrete stage as necessary to develop their meaning (Flores, 2009). As students move along the CRA continuum, those who display mastery of the concept can move onto enrichment activities (Flores, 2009).

To argue against rote memorization only, Milton, Flores, Moore, Taylor, & Burton (2019) showed that CRA instruction increases fluency in multiplication and division giving thema more profound understanding of the content. Furthermore, the basis of ratios, proportions, andfractions are founding in basic multiplication and division; therefore, a conceptual understandingis needed to experience long-term success (Milton et al., 2019). CRA has shown to yield positive results in the acquisition of knowledge and skills (Fyfe et al., 2014).

The need for conceptual understanding is not limited to the primary grades. Strickland (2016) wrote about the successes of CRA sequences to teach quadratic expressions. Students have been found to have higher levels of transferability by showing that they can apply their acquired knowledge to different situations (Scheuermann, Deshler, & Schumaker, 2009). Themultimodal nature of CRA allows students to experience the curriculum through a variety of senses (Witzel, Riccomini, & Schneider, 2008). As CRA provides different learning experiences, engagement increases and attitudes improve (Witzel et al., 2008).

Importantly, for successful CRA instruction, students need mastery of each level before moving onto the next (Witzel et al., 2008). In other words, if the student has not made appropriate meaning at the concrete or representation level, they will not be successful long-termat the abstract level.

Delicate attention to the types of manipulatives selected for each lesson will promote the acquisition of content successfully. If manipulatives are misused, their use will impede the academic growth of the student (Boggan, Harper, & Whitmire, 2010). Goals and objectives mustbe on the mind of the teacher while using the manipulatives (Boggan et al., 2010). Students will resort to mimicking the movements of the teacher or other students if they do not understand their purpose (Boggan et al., 2010). Virtual manipulatives have become more common as schools acquire more technology and teachers learn how to integrate technology into their classroom. As with physical objects, virtual manipulatives are ineffective if the student is unableto relate and articulate the conceptual understanding behind its use (Finti, Shahrill, & Salleh, 2016). Students require attention while working with computer-assisted software to ensure they understand the connection between models in the physical realm versus the virtual realm (Mendiburo, Hasselbring, & Biswas, 2014). According to Finti et al., (2016) the use of virtual manipulatives was effective and received positive feedback on student surveys.

Design

The online course will be open to pre-service teachers for a 16-week research period. This timeframe is within the typical long semester. There will be ten, 45-minute lessons available. The suggested pace will be one lesson per week. Two weeks are factored into thetime frame allowing for pre and post-test data collection. The difference of three weeks will allow pre-service teachers to work accordingly within their schedules.

Pre-service teachers will access materials through a learning management system. Within the course, the pre-service teachers will have access to lessons that correlate to their coursework, or certification area. Furthermore, a discussion board will be available for questions and peer-social support.

Participants and Setting

The proposed research will recruit undergraduate pre-service teachers in a large metropolitan area in the south-central part of the United States. The design of this study assumesthat participants are enrolled in an undergraduate degree in Education for the K-12 level.

Diversity will be intentionally sought by connecting with several universities and colleges acrossthe geographical area. An email requesting participation will be sent to appropriate administration and faculty requesting volunteers. Details of the study along with a preview link to the course will accompany the correspondence. Once classrooms with potential pre-service teachers are identified, contact will be made with the instructor. After the participants are identified and verified by the researcher, they will receive relevant paperwork to start the study along with times and dates for orientation. If requested, or deemed appropriate, orientation will be held on campus.

Data Collection

Pre and post-study quantitative data will be collected and analyzed. Each participant willbe asked to complete two surveys, twice; once at the beginning of the study and again at the endof the study. The short form of the Attitude Toward Mathematics Inventory, or SF-ATMI (Lim& Champan, 2012), will measure their attitude toward mathematics. The Mathematics Self- Efficacy and Anxiety Questionnaire, or MSEAQ (May, 2009) will measure the aforementioned affects.

In addition to surveys, qualitative data will be collected through semi-structured interviews. Participants are randomly selected for semi-structured interviews. Using this method, the researcher promotes a more informal-type discussion which will encourage an informal discussion with the intent of placing the interviewee at ease (Frankel, Wallen & Hyun,2015). The interviews will be recorded, transcribed, and coded to facilitate analysis. These interviews will take place at the start of the study and upon the conclusion of the 16-week research period. Contingent on availability, the target number of participants for the semi- structured interviews is, minimally, two pre-service teachers from each course.

Discussion

An outcome of the is a proposed study is to dissect any significant statistical difference inthe data. The analysis will include determining if a correlation exists between the qualitative data, the semi-structured interviews, and the quantitative data as well as a specific analysis on theeffect CRA instruction had on any change.

Potential Limitations

Possible limitations recognized for the study include small-scale participation, securing diverse participation across demographic identifiers. In some ways, we would use a convenience sample for the study. Additionally, because the study is 16-week course, participants may not fully complete the study which would reduce our sample size and data. Furthermore, it might bedifficult to find professors or academic programs with pre-service teachers willing to accommodate this study. Lastly, potential technical difficulties may become a limitation.

Future Implications and Conclusion

The data collected from this proposed study will be analyzed to determine if a self-paced, online course framed within the CRA model of instruction changes levels of mathematics related anxiety and self-efficacy. Moreover, data collected from the SF-ATMI, MSEAQ and the semi-structured interviews will be used to evaluate if the course changed attitudes towards mathematics. Analysis of the data will be made to revise the course as well as the process. Thisstudy will serve as a basis for future work regarding the adult-learners' acquisition of conceptualmathematics.

Future studies will include other stakeholders who work directly with students such as veteran teachers (as part of their continued professional development), parents, and tutors. Furthermore, exploratory research needs to be conducted to determine the feasibility of adaptingthe course to target ninth and tenth-grade students who need intervention and remediation.

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Appendix A

Short form of the ATMI. Adapted from "Development of a short form of the attitudes toward mathematics inventory," by S. Y. Lim and E. Chapman, 2013, *Educational Studies in Mathematics*, *82*(1), p. 160.

ENJ2	I have usually enjoyed studying mathematics in school.
ENJ4	I like to solve new problems in mathematics.
ENJ6	I really like mathematics.
ENJ7	I am happier in a mathematics class than in any other class.
ENJ8	Mathematics is a very interesting subject.
SC3	Studying mathematics makes me feel nervous.
SC5	I am always under a terrible strain in a mathematics class.
SC7	It makes me nervous to even think about having to do a mathematics problem.
SC10	I am always confused in my mathematics class.
SC13	I feel a sense of insecurity when attempting mathematics.
VAL1	Mathematics is a very worthwhile and necessary subject.
VAL4	Mathematics is important in everyday life.
VAL5	Mathematics is one of the most important subjects for people to study.
VAL6	College mathematics lessons would be very helpful no matter what I decide to study in future.
VAL10	A strong mathematics background could help me in my professional life.

Appendix B

Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ) Section I			
In order to better understand what you think and feel about your college mathematics courses, please respond to each of the following statements. If there are questions you do not wish to answer, please select "No Response."			
1. What is your gender?	No Response	Male	Female
2. How many mathematics classes did you take in high school?	No Response	______________	
3. What was the highest mathematics course you took in high school?	No Response	______________	
4. What was your average grade in your mathematics classes in high school?	No Response	______________	
5. What was your score on the math section of the SAT?	No Response	______________	
7. What was your score on your the most recent exam in a math course?	No Response	______________	
8. How many mathematics classes have you taken in college?	No Response	______________	
9. How many more mathematics classes do you believe you will have to taketo complete your major?	No Response	______________	

Section II	No Response	Never	Seldom	Sometimes	Often	Usually
1. I feel confident enough to ask questions in my mathematics class.	NR	1	2	3	4	5
2. I get tense when I prepare for a mathematics test.	NR	1	2	3	4	5
3. I get nervous when I have to use mathematics outside of school.	NR	1	2	3	4	5
4. I believe I can do well on a mathematics test.	NR	1	2	3	4	5
5. I worry that I will not be able to use mathematics in my future career when needed.	NR	1	2	3	4	5
6. I worry that I will not be able to get a good grade in my mathematics course.	NR	1	2	3	4	5
7. I believe I can complete all of the assignments in a mathematics course.	NR	1	2	3	4	5
8. I worry that I will not be able to do well on mathematics tests.	NR	1	2	3	4	5
9. I believe I am the kind of person who is good at mathematics.	NR	1	2	3	4	5
10. I believe I will be able to use mathematics in my future career when needed.	NR	1	2	3	4	5
11. I feel stressed when listening to mathematics instructors in class.	NR	1	2	3	4	5
12. I believe I can understand the content in a mathematics course.	NR	1	2	3	4	5
13. I believe I can get an “A” when I am in a mathematics course.	NR	1	2	3	4	5
14. I get nervous when asking questions in class.	NR	1	2	3	4	5
15. Working on mathematics homework is stressful for me.	NR	1	2	3	4	5
16. I believe I can learn well in a mathematics course.	NR	1	2	3	4	5

17. I worry that I do not know enough mathematics to do well in future mathematics courses.	NR	1	2	3	4	5
18. I worry that I will not be able to complete every assignment in a mathematics course.	NR	1	2	3	4	5
19. I feel confident when taking a mathematics test.	NR	1	2	3	4	5
20. I believe I am the type of person who can do mathematics.	NR	1	2	3	4	5
21. I feel that I will be able to do well in future mathematics courses.	NR	1	2	3	4	5
22. I worry I will not be able to understand the mathematics.	NR	1	2	3	4	5
23. I believe I can do the mathematics in a mathematics course.	NR	1	2	3	4	5
24. I worry that I will not be able to get an "A" in my mathematics course.	NR	1	2	3	4	5
25. I worry that I will not be able to learn well in my mathematics course.	NR	1	2	3	4	5
26. I get nervous when taking a mathematics test.	NR	1	2	3	4	5
27. I am afraid to give an incorrect answer during my mathematics class.	NR	1	2	3	4	5
28. I believe I can think like a mathematician.	NR	1	2	3	4	5
29. I feel confident when using mathematics outside of school.	NR	1	2	3	4	5