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Pre-service Teachers' Self-efficacy of Interdisciplinary Team Teaching through the Use of Collaborative Concept Map

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The ability to work with people from different disciplinary is a skill for workplace and it is an important skill for teachers too. This study helps gain a better understanding of how engaging in interdisciplinary design teams impacts student teachers' self-efficacy through the use of collaborative concept maps. A statistically significant positive change was reported in pre-service teachers' pre and post study self-efficacy in interdisciplinary design teams. Qualitative data shows that using collaborative concept map in interdisciplinary design teams strengthened pre-service' teachers understanding of interdisciplinary team teaching and broadened their pedagogical awareness for future teaching. The findings enhance our understanding of how teacher education programs could use interdisciplinary project teams to prepare future teachers.

Keywords: interdisciplinary teaching, collaborative concept map, self-efficacy, technology integration, teacher education

INTRODUCTION

There is a national-increased interest in interdisciplinary approach in K-12 teaching (Honey, Pearson, & Schweingruber, 2014; National Academy of Sciences, 2007). Recent studies regarding professional development for in-service teachers showed that more exposure to interdisciplinary teaching in collaborative and team environments enhances teachers' likelihood in building students' successes in problem-solving (DiDonato, 2013) as well as transferring Science Technology Engineering and Mathematics (STEM) skills in their teaching (Hardré, Ling, Shehab, Nanny, Nollert, Refai, Ramseyer, Herron & Wollega, 2013; Weinberg & McMeeking, 2017; Wong & Dillon, 2019; Zell, 2019). Nevertheless, there appears a lack of understanding of pre-service teachers' experiences on interdisciplinary teaching in teams and the support that would facilitate such experiences. To address this gap, the researcher of this study adopted a project-based learning approach to engage pre-service teachers in interdisciplinary team teaching tasks. The purpose of this study is to explore the change of self-efficacy for pre-service teachers participating in such interdisciplinary teams with facilitating collaborative tools, such as collaborative concept

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maps. The findings of the study can contribute to the field with pedagogical implications to better prepare pre-service teachers for future teaching.

INTERDISCIPLINARY TEACHING AND INTEGRATED CURRICULUM

The need to focus on interdisciplinary teaching or integrated curriculum has been advocated since 1980s in the middle school movement. Beane (1995, 1996) advocated the integration of curriculum with multidisciplinary knowledge taught towards the benefit of students' learning. Beane (1995) proposed the integrated curriculum be centered around "problems, issues and concerns posed by life itself in two spheres: 1) self-or personal concerns and 2) issues and problems posed by the larger world" (p.616). It would be beneficial to the students when teachers who specialized in one single subject, such as English Language Arts, math, social studies, science and etc. to teach around a central focus with multi-subjects knowledge embedded. This idea was also elaborated by researchers in humanities (Klein, 1996) as well as problem-based learning researchers in professional fields (Chen & Yang, 2019), such as medical fields (Baxter, 2000), computer science (Nuutila, Törmä, & Malmi, 2005), engineering (De Graaf & Kolmos, 2003; Uziak, 2016), management (Garnjost, & Brown, 2018), and social sciences (Permatasari, 2019). The idea of teaching in interdisciplinary teams would allow multiple disciplines of knowledge to be integrated into the process of instruction and facilitate students' learning through the exploration of the posed problems, issues and concerns. Making learning meaningful with problems or projects stemmed from personal or societal concerns has been proven to engage students' participation as well as facilitate their learning as a whole. This vision was further promoted by Longsbury (2009) when he advocates a school curriculum that would enhance students' social and emotional learning.

In the past decade, as the development of science engineering and math technologies advances, the idea of Beane's (1995) and Longsbury's (2009) integrated curriculum extends the connection among different disciplines while teaching in school. Learning standards of K-12 students have shown a focus on skills to work across disciplines, thus teachers from various teaching concentrations, such as math, English Language Arts, social studies, sciences, and foreign languages are expected to integrate knowledge and skills from other subjects to design cohesive learning units for students to acquire such interdisciplinary learning skills. Another example is the idea of integrated science, technology, engineering and mathematics learning (Zell, 2019), when teachers and schools are both challenged and welcomed to integrate knowledge from science, technology, engineering and mathematics to advance students' learning in such fields; and more researchers called out the need to expand the practice to include art.

The idea of integrated curriculum has been welcomed by many researchers and practitioners. Flowers, Mertens, & Mulhall (2000) argued that teaching in interdisciplinary teams have a positive impact on students' learning and school performance at the middle school level, including higher teacher satisfaction and better student achievement scores. Vangrieken, Dochy, Raes, and Kyndt (2015) conducted a systematic review on teacher collaboration in schools and the researchers emphasized the importance of building schools as "learning organization" so that teachers can collaborate and learn from one another, as well as modelling such collaboration to their students to prepare for the growing importance of collaboration in society.

However, the challenges of designing integrated pedagogical practice and preparing teachers to implement appropriate pedagogy rises. There are challenges, one being teachers are often not trained or prepared to work on teams, which often leads to frustration in the team work process. Flowers, Mertens & Mulhall (2000) identified three major issues were identified by teachers participating in interdisciplinary team teaching practices: " (a) curricular and instructional issues; (b) student-centered issues, and (c) issues about communication" (p.54). Such issues would appear in teacher planning, co-teaching scheduling, as well as assessing student learning. However, with the development of educational technology, it is nice to see that the training will be opened up for existing teacher preparation, as it was stated by Bybee when he envisioned a 10-year plan for integrated science, technology, engineering and mathematics: "I am referring to a perspective and education programs larger than Information Communication Technology (ICT)" (Bybee, 2010, p.30).

TECHNOLOGIES TO SUPPORT INTERDISCIPLINARY TEACHING

The participatory nature of Web 2.0 tools allows users to participate in various activities focusing on sharing (John, 2013), critiquing, collaborating and creating content on web-supported platforms, enabling almost spontaneous communication, instant feedback and collective work space if embedded into teaching with pedagogical design. The researcher of this study argues that incorporating Web 2.0 tools into teaching planning, and instructing, would benefit teachers or teacher candidates to work with one another. Teachers would be able to share information with one another, and use the tools to provide feedback or reviews to each other in a collaborative nature. Co-constructing the content on the website is another feature that teachers would benefit from if designed correctly, which will allow the highest order thinking, creating, according to Bloom's taxonomy (Bloom, Engelhart, Furst, & Krathwohl, 1956; Anderson & Krathwohl, 2001) .

With the technology continue to advance, what it means to teacher as technology integration has many facets. Content wise, one layer is that there are more teaching or learning materials being developed in online or digital format. In pedagogical aspects, another layer is learning tools based on the internet, which provides more modality to deliver the instruction, as well as incorporating student-centered pedagogy with digital tools to allow students become more of a designer, team player, and etc. One challenge is to support collaborative cognitive activity. Having a platform to share cognitive concepts of teaching would be an advantage to ease the cognitive load shared among teachers. Thus, in the next section the researcher will discuss the use of collaborative cognitive tools and its applications in learning and interdisciplinary collaboration.

COLLABORATIVE CONCEPT MAP

In this section, the use of concept map in classrooms will be discussed in two aspects: first, the use of concept in supporting students learning; and secondly, the use of concept mapping from teachers' perspectives. Concept map is recognized as an effective mindtools that can assist learners in representing knowledge and experiences with visual cues and links (Schroeder, Nesbit, Anguiano & Adesope, 2018). Being a participatory online tool, concept map platform has features to support in-depth collaboration, by communicating different concepts from each discipline, marking the relations between major concepts, and inspiring collaborative innovation pedagogy with technology integration. On one hand, concept maps have been studied to support students in content learning at various levels. Hwang, Shi & Chu (2011) experimented the concept map approach to support students' group learning. They found that students' self-efficacy on group learning has been positively impacted and students felt more confident to learn in group setting thus leading to effective learning improvement. At the elementary education level, Cai, Lin and Gu (2016) examined the use of visualization-based diagram integrated in elementary classroom science classroom, and it is reported that the balance between the collaborative tool and the role of teacher are to be balanced, emphasizing the role of teacher to provide scaffolds while students constructing diagram among different concepts. Farrokhnia, Pijeira-Díaz, Noroozi, and Hatami (2019) conducted a study to examine computer-supported collaborative concept mapping on conceptual understanding and knowledge co-construction in 10th grade science classrooms. At the post-secondary level, Wang, Cheng, Chen, Mercer, & Kirschner (2017) studied students in an online class at college level and reported that collaborative concept mapping functioned effectively in facilitating group interactions in the concept-oriented task situation.

Given the proven effectiveness of concept map and its potential, another research area to look at is how concept map can be used in helping pre-service teachers in their training and practices to deliver effective classroom teaching. Schaal (2010) studied pre-service teachers' use of digital concept maps in science courses, and reported that pre-service teachers motivation was elevated after participating in digital concept map supported activities. Özçakır and Çalışıcı (2016) conducted a case study examining pre-service teachers' use of mind maps in science, technology, math and engineering education courses, and their interviews of 42 pre-service teachers revealed that using mind mapping tools enhanced their understanding of the intertwined knowledge connection among different subjects. Zell (2019) recently reviewed three forms of integration when teaching integrated curriculums: content integration, supporting content integration and context integration, and he highlighted the need to support teachers in co-designing lessons and learning activities that stemmed from two or more disciplinary knowledge bases. Researchers are called to examine ways to promote training for subject-specific teachers to design and carry out interdisciplinary lessons.

To echo the recommendations from previous research, this study aims to provide a demo for pre-service teachers to utilize collaborative concept mapping tool to support instructional design in an interdisciplinary team teaching environment. A project-based learning approach with focus on lesson planning practices was used to engage teacher candidates to work with members from different teaching concentrations. Teacher candidates in a northeast metropolitan university in the United States completed the projects. Participants work in teams of three, and each team was formed based on their teaching concentration/discipline. The design task for each team is to create a technology-integrated interdisciplinary thematic unit for middle school students, and the unit should cover each of the teaching concentration represented by each team member. Cloud-based tools (such as Google Drive, and collaborative concept mapping tools such as Lucidchart https://www.lucidchart.com/) were used to facilitate the interdisciplinary collaboration. Prior to the project starts, students registered to use the tools, and two training sessions on concept mapping and Lucidchart were provided to facilitate students' collaboration process. It is the researchers' hope to discover how pre-service teachers work in interdisciplinary teaching design practices.

SELF-EFFICACY OF INTERDISCIPLINARY TEAMS

One way to measure how individuals work is to look at their self-efficacy. Self-efficacy is a person's belief about how well they will perform a specific activity (e.g., teaching elementary math to 3rd graders) (Bandura, 1997). Research regarding teacher self-efficacy has continuously shown that teachers with high self-efficacy keep students engaged, encourage autonomy (Arslan, 2019; Chacon, 2005; Cousins & Walker, 1995; Podell & Soodak, 1993) and pay more attention to learners with special needs (Allinder, 1994). Moreover, high self-efficacy is thought to be an important factor and, in some cases, predictor, for student success in school (Woolfolk-Hoy & Davis, 2006).

There are four sources of self-efficacy: mastery experiences, social persuasion, physiological responses, and vicarious experiences (Bandura, 1997). Briefly, mastery experiences suggest that a person needs to be engaged in authentic practices in which self-efficacy is being measured (e.g., teaching). Social persuasion relates to the influence others give (e.g., feedback from a supervising teacher). Physiological responses seeks to understand how issues like stress impact self-efficacy. Finally, vicarious experience (e.g., modeling) promotes the idea that when someone observes another person succeed at a task, they too feel like they can succeed. Bleicher and Lindgren (2005) reported that both mastery experience and verbal persuasion played a very important role with success in science learning and pre-service science teaching self-efficacy.

Building on Bandura's four sources of self-efficacy change, in their studies of project design teams in service learning programs, Schaffer, Chen, Zhu & Oaks (2012) proposed a framework termed Cross-disciplinary Team Learning (CDTL) for assessing students' self-efficacy in multidisciplinary project teams. This framework, utilized in undergraduate project design teams, is intended to help students as they transcend their own disciplinary boundaries, learn to appreciate different frameworks, and broaden their perspectives to include those of other disciplines (Fruchter & Emery, 1999; O'Brien, Soibelman, & Elvin, 2003). In this framework, three major factors were testified to be important to undergraduate students' self-efficacy in working in cross-disciplinary teams: identification, recognition and integration.

With the interests in using interdisciplinary approach in teaching increased nationally and internationally, especially in STEM field (National Academy of Sciences, 2007; Hardre, Ling, Shehab, Nanny, Nollert, Refai, Ramseyer, Herron & Wollega, 2013; Sochacka, Guyotte & Walther, 2016; Weinberg & McMeeking, 2017), the gap is to be filled in how we can prepare pre-service teachers for such pedagogy.

Hence, understanding pre-service teachers' self-efficacy in multi-disciplinary teams would help researchers in the field to gain knowledge on how pre-service teachers perceive the interdisciplinary team function, so that teacher education programs can better prepare teacher candidates to integrate such approaches in their future teaching.

METHODS

PURPOSE AND RESEARCH QUESTIONS

The purpose of this study is to examine pre-service teachers' self-efficacy in participating in project-based learning teams. More specifically, this study focuses on student teachers working in interdisciplinary teams to design and teach lessons for K-12 students through collaborative cognitive tools for team learning. With the aim, this study addresses the following two research questions:

Research Question 1: Does pre-service teachers' self-efficacy change over the duration of the interdisciplinary design project?

Research Question 2: How participating in interdisciplinary design tasks using concept map impact pre-service teachers' understanding of interdisciplinary teaching and interdisciplinary collaboration?

CONTEXT OF THE STUDY

The population in this study was undergraduate pre-service teachers in a New York metropolitan private university. Specifically, students enrolled in an undergraduate pedagogy course focusing on instructional design and technology integration were participants in this study. This is a mandatory course for all pre-service teachers in School of Education and it opens to juniors and seniors. Students in the course were required to complete a 7-week-course project to work with members from different teaching concentrations to perform an instructional design task, i.e. to design an interdisciplinary lesson for K-12 students. Pre-service teachers worked in teams of three or four, and each team was formed based on their teaching concentrations/disciplines. The design task for each team was to create a technology-integrated interdisciplinary thematic unit for middle school students, and the unit should cover each of the teaching concentration represented by each team member. The design task for pre-service teachers is listed below:

" In echoing the recent major shifts that is happening in our city (state adoption of newly established learning standards and city emphasis on middle school education, as a pre-service teacher, you now have the opportunity to practice and refine your teaching skills in this team instructional design project towards middle school students. In this team project, you are working in a team of three (3) members and each team consists team members with different focus on their disciplines or teaching concentrations. The task for your team is to apply the knowledge you obtained this semester regarding technology integration and expertise from your teaching concentration to choose a topic to design and implement an interdisciplinary technology-integrate lesson for middle school students. Specify the learning standards achieved through your team lesson. "

This project was broken down to four phases: 1) defining a team topic and collectively constructing a concept map identifying the relationships between relevant concepts in this unit, 2) planning the lesson with at least two Web 2.0 tools, 3) completing the lesson, 4) peer-review and individual reflection, and 5) final team presentation. Pre-service teachers registered for Lucidchart and used the tools to create their concept map. In-class exercises were given to practice the connections among concepts before building the group map. As a group, the pre-service teachers teams can utilize all features provided in Lucidchart and construct the group concept map. Figure 1, 2 and 3 are exemplar completed group concept maps for this design task.

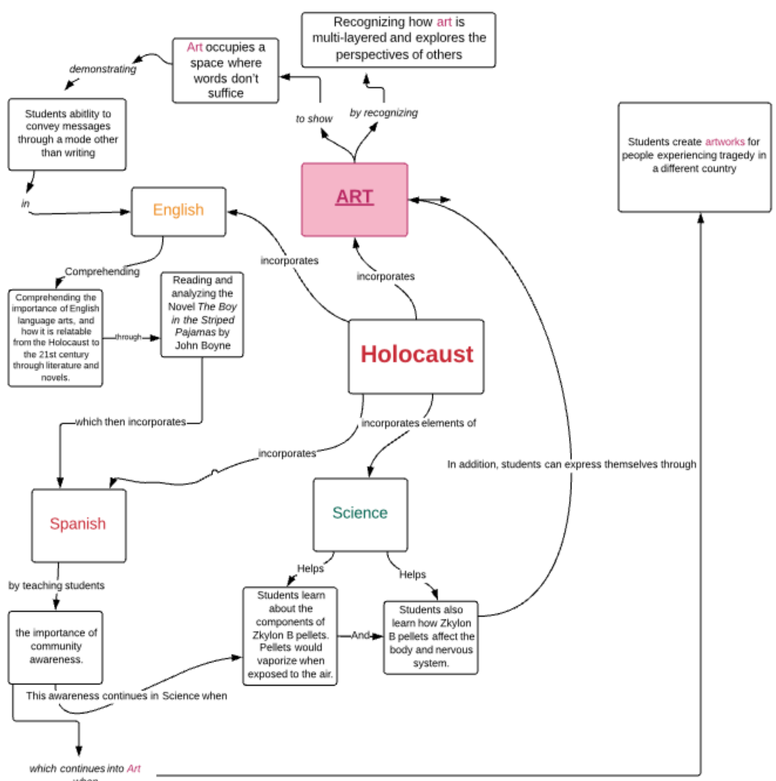

Figure 1. Collaborative Concept map for Holocaust Team

Figure 1 shows a collaborative concept map that was constructed by a team consists of three pre-service teachers whose teaching concentrations are English, science, Spanish, and this team chose the topic of holocaust and embedded Art, English Language Arts, Science and foreign language into this interdisciplinary lesson.

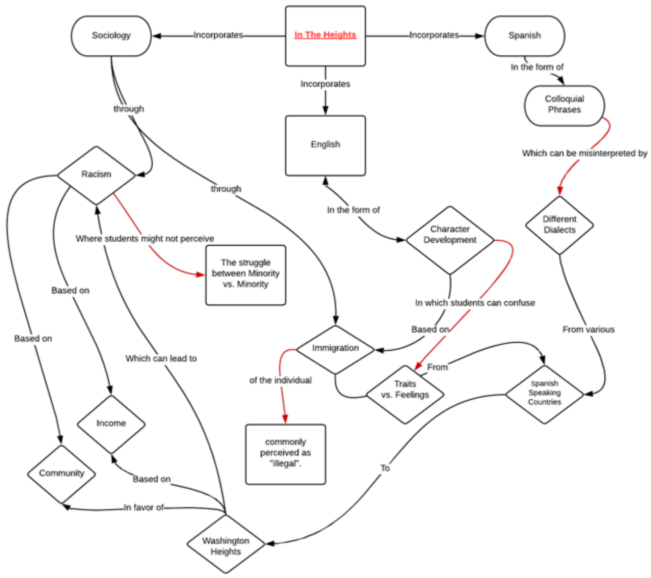

Figure 2. Collaborative concept map for In The Hights Team

Figure 2 is another example of collective concept map created by a team working on the lesson based on the book "In the Heights", and the lesson consists of English, sociology and Spanish lessons into one integrated lesson. Figure 3 is the concept map from the team "Ancient Egypt" which focuses in bringing math, English and social studies together through the interdisciplinary connections.

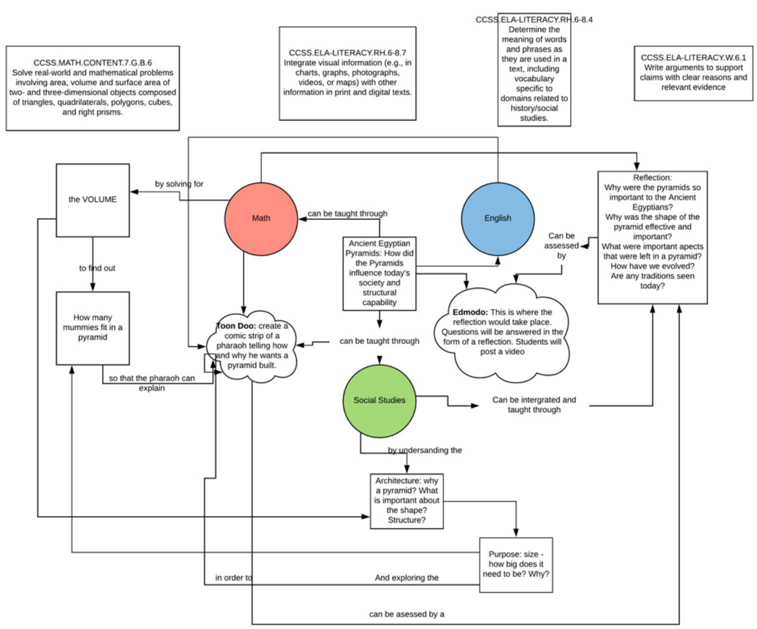

Figure 3. Collaborative Concept map for Ancient Egyptian Pyramids Team

PARTICIPANTS AND PROCEDURES

Before the study took place, an approval was obtained from the Institutional Review Board. Participants of this study consists of 49 students responded to both pre and post survey. There were 10 male students and 39 female students in the total of 49 responses, with 5 students had no prior interdisciplinary team experiences, 34 students had some prior interdisciplinary team experiences, and 10 students had a lot of prior interdisciplinary team experiences.

For the purpose of the study, the self-efficacy surveys were administered. A pre-project self-efficacy survey was given on Week 8 of the semester right before participants started the interdisciplinary team project (T1). This survey included questions about students' educational and demographic background (e.g. gender, age, major), prior experience with teams, and efficacy ratings related interdisciplinary team work. A post-project self-efficacy survey was given on Week 14 (T2) when students completed the interdisciplinary team project. The post-survey included the same set of efficacy ratings that appeared on the pre-survey. Both surveys were administered online. Participants rate each item on a 0-100 scale. Individual artifacts documents and reflections were also collected throughout the project process.

DATA SOURCES AND DATA ANALYSIS

Measurement and Instruments for Research Question 1

In order to measure pre-service teachers' self-efficacy and to address Research Question 1, survey instrument was administered. The survey based on three factors of inter-disciplinary team learning identified by Schaffer, Chen, Zhu, and Oaks (2012). The three factors include: 1) ***identification*** on one's skills, knowledge, and potential project contributions, 2) ***recognition*** of other team members' skills, knowledge and potential project contributions, and 3) ***integration*** on individual's own and other team members' skills, knowledge towards the project. This revised self-efficacy for cross-disciplinary team learning scale (Schaffer, et al, 2012) was administered with twelve (12) items in three (3) sub-scales. The identification subscale consisted of 4 items (α =.89), the recognition subscale consisted of 4 items (α =.9), and the integration subscale consisted of 4 items (α = .89). Participants were asked to rate their confidence in their abilities to carry out actions described in each item on a 0 to 100 scale, with larger numbers indicating greater confidence. The same instrument was administered for pre-test at Week 8 (T1) and post-test at Week 14 (T2). The mean score from each individual participant's rating on the four items in each sub-scale is calculated and recorded as the participants' pre-test score at T1 and post-test score at T2. Then, the average score on the subscales from all participants was calculated and recorded as the pre-score and post-score for each factor.

Sample items of the survey are: I can clearly identify the type of knowledge and skills I have brought to the project; I can accurately assess the extent to which my mastery of these knowledge and skills was adequate for the project; I can discuss the contributions other disciplines have made to this project; I can talk about the lesson design using other discipline language; I can examine a lesson design issue from my teammates perspective, and etc. The complete 12 items can be found in Table 1.

Table 1. *Pre and Post Interdisciplinary Team Self-efficacy Survey Items*

Factor	Items
Identification	1. I can clearly identify the type of knowledge and skills I have brought to the lesson design team project. 2. I can appropriately assess the relevance of my knowledge and skills to the lesson design team project. 3. I can accurately evaluate how much my knowledge and skills contributed to the lesson design team project. 4. I can accurately assess the extent to which my mastery of these knowledge and skills was adequate for the lesson design team project.
Recognition	5. I can clearly identify the type of knowledge and skills possessed by teammates from other teaching concentrations. 6. I can accurately recognize goals that reflect the disciplinary backgrounds of other team members. 7. I can discuss the contributions other disciplines have made to this lesson design team project. 8. I can think of ways other members have influenced the project in a way that represents their teaching concentrations.
Integration	9. I can talk about the lesson design using other teaching concentration language. 10. I can provide input to others from different teaching concentrations. 11. I can be proactive in working on design problems with those from different teaching concentrations. 12. I can examine a lesson design issue from my teammates perspective.

Data Sources and Analysis for Research Question 2

In order to address research question 2, the researcher collected qualitative data including artifacts participants at various stages of the team project, including group notes, completed concept maps, completed team lesson plan, peer-review, and individual reflection, and etc. Other data sources include researcher's observations and field notes. The data were inductively coded (Saldana, 2016), and, across multiple iterations, themes emerged related to pre-service teachers' use and understanding of collaborative concept map towards interdisciplinary teaching and collaboration.

RESULTS

RESULTS TO RESESRCH QUESTIONS ONE

To address research question 1, the methods of repeated t test was used on the 49 participants who filled out the survey at both the beginning of the project (T1) and the end of the project (T2) was conducted to determine if there was significant change in the students' pre and post ratings. Results are presented in Table 2.

Table 2. *Repeated Measure t-test for Differences in Self-efficacy for CDTL at T1 and T2 (N=49)*

Factor	Mean at T1	Mean at T2	T2-T1	*t* value	*p* value
Identification	69.08	83.85	14.77	6.68	<0.001
Recognition	68.06	83.85	15.79	6.89	<0.001
Integration	69.48	83.55	14.07	5.68	<0.001

The mean score for all three factors at T2 were significantly higher than the mean score at T1, suggesting significant overall increases in levels of efficacy for working in interdisciplinary teams. The differences between the score at T1 and T2 (T2 T1, p .01) for all three factors were then computed. For identification, the change scores ranged from -30 to 50, with 16% of the participants reporting no change (three participants) or a decrease (five participants) in their efficacy level. The change scores for recognition ranged from -15 to 46.25, with 18.37% of the participants reporting no change (three participants) or a decrease (six participants). Finally, the change score for integration ranged from to -17.5 to 53.75, with 20% reporting no change (four participants) or a decrease (six participants). The effect sizes for the analysis on identification (d = 1.20), recognition (d = 1.09) and integration (d = .95) were found to exceed Cohen's (1988) convention for a large effect (d = .80). The results echo the finding from Mills (2009) and Schaffer, et al (2012) study, that some students might have expressed an over-estimation of their abilities at the beginning of the project. To understand how students actually felt about this experience research question two was addressed.

RESULTS TO RESEARCH QUESTION TWO

Multiple data sources were collected and analyzed to address Research Question 2, including teamwork log, teamwork notes, and individual reflections. All names are pseudonym shown in the results sections. Four assertions were summarized from the data and presented as the results to Research Question 2.

Assertion 1: Collaborative concept map assists pre-service teachers to identify concepts from each discipline and find connections among different disciplines to integrate towards an interdisciplinary lesson.

Pre-service teachers acknowledged that making connections among different subjects in the lesson planning practices were challenging, however, they found the use of concept map was helpful to see the connections among different teaching subjects. Some pre-service teachers shared that they often did not realize the links between different teaching subjects until they were asked to lay out the concepts from each discipline and make relationship links among them towards the central theme. Having an established team goal and using concept map to work around the relationships facilitated the team design process.

Pre-service teachers were able to see the similarities and differences of different disciplines towards the central theme. Betty, worked in a team with other three pre-service teachers said concept map allowed her to look at the patterns in common among different subjects: "*The concept map played an important role within our interdisciplinary collaboration because it allowed us to see how much we have in common when it comes to our content and we were able to show how it works within the classroom."* Seeing the connections among concepts allowed pre-service teachers to think deeper in the lesson planning practices, as Betty continued to express: *"Concept mapping influenced our collaboration because we were able to see the ideas and concepts of our peers, which allowed us to see what we needed to improve and what should be influenced throughout the classroom.* "

Being able to identify and recognize that each other's teaching subjects can connect with one another allowed pre-service teacher teams to collaboration effectively. One pre-service teacher described her experience in the team, Aria shared that*, "concept mapping assisted the three of us with creating* ***cross-links to connect to different areas of the map to illustrate the relationship between the three concentrations****, which ultimately served to enhance the sixth grade students understanding and knowledge of probability, pronouns, and the different social groups within the Indian Caste System (the team's central topic)* ". Working in the same team with Arua, Emma mentioned that "*The concept map helped us to connect each of the disciplines that we were going to teach together. The map really made us think about the ways that we wanted to plan the unit and what concepts we were going to teach across the unit as well as in the individual subject areas.*" She continued to elaborate that concept map is supporting interdisciplinary connections "*The map influences the collaboration because you want everything to make sense together, and have goals and objectives that can build off one another and make sense and have cohesion when looking at the unit as a whole. When we thought of an idea that would work in Social Studies or English, we would see how that concept could work in Math, and in what ways can we connect standards together and create goals and objectives that work together nicely.*"

Bill, a junior in English major also reflected that "*as we added the actions that would lead from one topic into a new topic from a different discipline really allowed us to find our groove. It was definitely not until we created a good lesson plan that we were able to really see our project start moving towards finality.*" Jay, a math major worked in the same team as Bill mentioned that *"I think it (the concept map) also helped in conjunction with interdisciplinary lesson planning because as a group we had to come up with a way to incorporate all of our different concentrations or even majors into the lesson and teach them effectively and correctly.*"

Another student, Katie echoed the idea of seeing the connections among different subjects through the process of constructing collaborative concept map: *"The concept map was helpful to my group because it spelled out the connections for us. We knew that there were probably a lot of things that connected us for the lesson, but using a concept map really helped us to be able to see it all together in an organized way."* Beth said that *"The concept map helps the teacher of each respective discipline to make connections between what they are teaching and what the other teacher is teaching."*

In summary, working collectively towards a central idea using the concept map helps pre-service teachers to identify, recognize and integrate knowledge in the interdisciplinary lesson planning exercises. Participating in interdisciplinary design teams strengthened pre-service teachers' understanding of student success and broadened their pedagogical awareness for future teaching.

Assertion 2: Constructing collaborative concept maps is a process, with team communication taking place.

Like any cognitive activities, constructing a concept map requires students to think deeper about the connections among concepts. It is normally not a linear process that students can complete in one try. Students discovered that to create an effective concept map requires them to communicate with their team members back and forth, sharing ideas and providing feedback while working on connecting the concepts together. This process is often messy and challenging, yet it is a fruitful process.

Cathy, whose team decided on a topic to teach Anne Frank's diary from the aspect of social studies, English and psychology, reflected that constructing a collaborative concept map not only allowed the team to make concept connections but also facilitated team discussion on lesson. "*The concept map was the first step towards our goal of creating an interdisciplinary lesson. The map was a constant reminder of the goals that we had laid out for the lesson and help me and my collaborators stay true to our learning objectives.* ***I think that concept mapping heavily influenced my group's interdisciplinary communication.*** *After completing the final draft of the concept map, it was much easier to see what we wanted to achieve in the lesson and how each of our disciplines would contribute.*" Alfred, who commented that constructing collaborative concept map helps organize the collaboration process and facilitates team communication: *"Concept mapping influenced our interdisciplinary collaboration by making it meaningful, organized, and allowing the connections to be made, not just to us, but also whoever viewed it. It made the whole project work, without it miscommunication and chaos would have transpired."*

Keith, a pre-service teacher whose teaching concentration is adolescent English said that "*The way concept maps work seemed almost natural for our project's brainstorming, as it allowed us all to see just how we connected our different thoughts and made it easy to connect them to the work of our group members. I feel like our concept map really helped bring everything together when we were ready to actually begin our research, and our concept map also made it easy to show others just where we were looking to go with our project, without having to read through a large script of paper.* " A social study pre-service teacher in the same team, Jerry, said that "*the role of the concept map is to draw a connection with interdisciplinary teaching. The impact that concept mapping had through my group work collaboration is that it made* ***communication*** *rather easier when trying to* ***draw a connection*** *with ideas. Through concept mapping you are able to grasp a vivid view of the ideas being put down on paper and in fact by doing so; drawing connections with* ***different branches of knowledge will be easier to manage.***"

Based on the pre-service teachers' accounts, it is clear that pre-service teachers found the value of concept map in facilitating team process and team communication, which was key to effective team collaborations.

Assertions 3: Cloud-based collaborative tool visualizes interdisciplinary connections and it allows collaboration happen anywhere anytime.

One major advantage of collaborative concept map tools is that the Web 2.0 nature of cloud-based tool allows visualization, instant access and immediate feedback, which helps pre-service teachers to work towards the interdisciplinary lesson planning.

First, collaborative concept map assists the lesson planning flow and process, especially it helps pre-service teachers to visualize the connections among different subjects. Visualizing ideas is helpful for pre-service teachers in planning and connecting the concepts.

Some pre-service teachers sees the concept map as a team design organizer. One pre-service teacher reflected: "*We are visually able to see how the lesson connects to the main topic, and able to thread the end of one lesson into another lesson. I felt that this was helpful because I am very much a visual learner, and I thought it helped a lot to see all of our ideas play out onto the screen.*" Nan, Adam and Nancy worked in the same team that chose to develop the lesson around French revolution from English, math and social studies perspectives. Nan, with English teaching concentration, said that "*the role of the concept map was to demonstrate how each discipline connects to the other disciplines. This was also an efficient way to organize our thoughts and ideas about the project. We were able to record what our main idea was and then branch that, the French Revolution, into the content areas.*" Adam said that "*the role of the concept map was to get our ideas flowing, to see where this project could take us, and to get all our ideas out of our heads to be turned* *into reality for others to see to help us.* Nancy mentioned that "*Prior to doing the concept map we knew we had our topic, which was the French revolution, but didn't know how to incorporate all of our disciplines into it. However, while doing the concept map we were able to find ways to incorporate each discipline into the lesson. It became easier when we were able to see visually how the disciplines were going to be embedded into the concept*."

Another pre-service teacher reflected that the visualization of the concepts and the map enhances the team to carry out cross-disciplinary collaborations: "*we were able to draw arrows and cross lines across the content areas, further solidifying how these subjects clearly connect to each other. Once we were able to tangibly see those connections, we were able to fully work together as a cross-disciplinary team.* "

Secondly, collaborative concept map tool allows team members to work on the document at the same time or at a later time, logging in at different devices, computer, tablet or smartphones. The collaboration was not confined by the physical meeting place and time.

Kaia, commented on the participatory nature of the tool by saying that "*since we used Google Docs and Lucidchart to complete our concept map, each member of the group was able to add their ideas at the same time. This was a convenient way for everyone to stay on the same page. "* Julie said that "*The importance of have a concept map is so that it is easier to relate the topic and content areas to each other. It is also important for interdisciplinary work because everyone in the group is able to collaborate and is able to work on it at the same time."*

Barbara, echoed the idea of collectively constructing the map "*we used a Google doc and would get on at the same time and help each other with what activities to put assessments and how to connect everything, it worked out much better than I think it would have been if we done it separately.* " Debra wrote that "*We were able to work on the map at the same time, which fully allowed us to collaborate freely and expand upon each other's ideas. It was fascinating to watch the map grow*."

In addition to the benefit of having multiple users editing the document at the same time, some pre-service teachers also liked the fact that they can save the work and go back to the ideas at a later time. One pre-service teacher expressed that *"concept mapping is a strategy that organizes any collection of ideas which can be looked back on during anytime."* While another team member echoed "*we were capable of utilizing Lucidchart to put our ideas and key concepts on display so that we could all refer back to it to add or remove information at a later time. This allowed us to communicate more effectively towards each other's ideas.* "

Furthermore, having the visual connections from different team members allows team members to communicate, think and plan at the same time, which sparks creativity. One pre-service teacher said that "*Concept mapping allows us to actually see the links we aim to create in interdisciplinary collaboration. This strategy influences teamwork and encourages us to think outside the box.*"

In summary, the Web 2.0 participatory nature of the collaborative concept map tools allows pre-service teachers to visually organize their ideas towards lesson design. The tools allowed multiple-users to edit the document at the same time or different times, which sparks creativity in the teaching practices.

Assertion 4: Pre-service teachers view concept map as a teaching strategy and future teaching tool.

Working within the team to construct a concept map opened pre-service teachers' eyes on collaborative concept maps and its potential as an effective teaching strategy and teaching tool. After completing the group designing and teaching project, pre-service teachers expressed their interests to adopt concept mapping strategy in their future teaching practices.

Aaliyah reflected the process as how she realized the importance of concept map and the collaboration throughout the team process. "*When I was first introduce to the idea of concept mapping I did not fully understand it, nor did I see myself wanting to use it when I was planning. As the project was being introduced I found myself being intimidated by the concept mapping experience and I really did not want to do it, however with the help of my team I found myself becoming more confident in mapping as a way to plan. I love using concept mapping now and I found it extremely useful to execute our thoughts into our lesson plan. I think that when I begin to teach I will be using this strategy even when I'm not teaching with others. I think that it made it so much easier to view where things had to go and what needed to be done.*" Another pre-service teacher echoed that "*the skill of learning how to concept map and plan and also building strong communication skills will help me in my future teaching practices*."

Pre-service teachers also viewed concept map as an individual skill that they can continue to grow and it's something they can help their students' to acquire. An early childhood major pre-service teacher shared his view on the importance of learning about concept map "*I feel like concept mapping is a technique that can and should be taught to students at an early age to help ease them into the brainstorming process, which can sometimes seem like a daunting task if not guided in helpful techniques.*"

In summary, pre-service teachers had enhanced understanding of concept map and would be willing to adopt it in their future teaching practices as well as being more efficient to use it as a teaching tool.

DISCUSSION: INCREASED CONFIDENCE AND ADVANCED PEDAOGY

In this study the researcher examined (1) does undergraduate pre-service teachers' self-efficacy change over the duration of the interdisciplinary design project, and (2) how participating in interdisciplinary design project using concept map impact their understanding of interdisciplinary teaching and collaboration. Results show that pre-service teachers had a positive experience which increases their self-efficacy in the three areas of CDTL outlined by Schaffer, et al (2012) while working in collaborative teams designing interdisciplinary lessons. Findings from this study demonstrated that engaging in a five-week cross-disciplinary instructional design project increased students' self-efficacy, confidence, as well as their understanding for using interdisciplinary teaching approach for their future teaching practices. Although students are unfamiliar with digital collaborative concept map tools when they began the project, they discovered the value of collaborative concept map as a way to organize cognitive concepts from different subjects, and a way to facilitate the communicate process among team members. The finding of this project echoes the findings of Zee and Koomen's (2016) review on teacher self-efficacy and its effects on classroom processes, student academic adjustment and teacher well-being, that pre-service teachers' increased self-efficacy in learning in teams would enhance their willingness to collaborate and co-design integrated lessons in their future classrooms.

This project opened pre-service teachers' eyes to explore cloud-based collaborative cognitive tools to develop deeper understanding and deeper learning opportunities for their students. More importantly, by using the cloud-based collaborative tools, pre-service teachers gained both confidence and knowledge needed to design future lessons with such tools. Pre-service teachers believed that collaborative concept map allows them to integrate concepts from different subjects and make connections among different disciplines when designing technology-integrated lessons. Qualitative data revealed that concept map helps pre-service teachers to identify their own knowledge and skills that they can bring to the interdisciplinary design team, to recognize other team members' knowledge and skills that they can bring to the team, and to further integrate the knowledge and skills towards the common team design goal. Pre-service teachers appreciate the use of concept mapping to mark connections among different subjects. This finding is supported by Sümen and Çalisici (2016), which suggested that pre-service teachers were able to use conceptual mind map to associate the fields of science, technology, engineering and mathematics with one another.

Pre-service teachers also expressed their appreciation of concept map tools for facilitating the teaming process and team communications. It allowed the ideas from each member to be visually displayed, which serves as the basis of team discussions and moves the team design process forward. Visualization of concepts allows pre-service teachers to think outside of the box and sparks creativity when designing interdisciplinary lesson. This finding echoes the findings of a recent systematic review on creative interdisciplinary collaboration (Moirano, Sanchez & Stepankek, 2020) that visualizing the unseen processes of interdisciplinary collaboration would enhance creativity. These results suggest that providing pre-service teachers opportunities to visually organize and collaborate on design activities would enhance their collaboration as well as creativity.

Using cloud-based tool, having multiple users editing and working on the design document, such as the concept map, is welcomed by pre-service teachers. This process made it easier to overcome the constraints of in-person meeting time or location. Pre-service teachers' attitudes and beliefs towards collaborative concept map is positive and they view it as a teaching strategy and future teaching tool.

This project engaged pre-service teachers co-design and co-development of an interdisciplinary teaching project. Currently educational reform (U.S. Department of Education, 2017; Householder & Hailey, 2012; Bybee, 2013; Singer, Ross, & Jackson-Lee, 2016) calls out practices to enhance K-12 teachers to engage in design activities to support interdisciplinary teaching thus leading to facilitate higher order of thinking, especially in the STEM fields. The collaborative concept map serves as the bridge to help pre-service teachers to exchange their ideas towards the lesson planning through laying out key concepts on the visual map. The collaborative concept map also serves as the platform or the medium to mediate the team communication around key cognitive ideas towards lesson planning.

When preparing pre-service teachers for future teaching practices, it is important to address the challenges and help preparing teacher candidates with pedagogical implications to their teaching practices. As Tondeur, van Braak, Sang, Voogt, Fisser & Ottenbreit-Leftwich (2012) suggested, after examining the curriculum of technology integration courses in teacher education programs across the United States, that one of the best practices is to model technology usage for students before they teach on their own. The results of this study shows a project-based learning model to integrate collaborative concept map through lesson planning practices can positively influence pre-service teachers' efficacy in designing interdisciplinary materials for K-12 classrooms. Providing pre-service teachers more opportunities to practice their skills on concept maps would enhance their ability to adopt such practice in their future classrooms.

CONCLUSION: IMPLICATIONS, LIMITATION AND FUTURE RESEARCH

CONCLUSIONT AND IMPLICATIONS

The current study examined pre-service teacher's self-efficacy in interdisciplinary teams, and it is discovered that pre-service teachers' confidence and self-efficacy were positively changed after participating in the interdisciplinary teams. The results of this study have implications for educators. First, the results from both quantitative and qualitative data show that pre-service teachers' self-efficacy is increased after several weeks of participating in such design exercise. Having pre-service teachers model and practice these design tasks would help them speed up understanding of interdisciplinary teaching. Second, this project demonstrated that cloud-based concept map would be helpful to enhance collaborations and communications among student-teachers.

LIMITATIONS AND FUTURE RESEARCH

There a few limitations on the study. First, the current study has a relatively small quantitative data sample size, so it is necessary to triangulate the qualitative data to understand how pre-service teachers' self-efficacy changes in interdisciplinary design teams. In the future, administering the survey to larger sample would be helpful. Secondly, the current study analyzed individual level quantitative data, such as individual self-efficacy, and in the future, it would be helpful to analyze team-level data, such as team composition, and gender, GPA of each team member, as well as team level teaching documents including team lesson, and team teaching documents to understand the relationships and connections among cognitive concepts developed through such collaboration. Another goal for future research is to follow pre-service teachers after they have entered the teaching profession to see if beliefs and attitudes change. This type of research can have an extremely positive impact on both student teachers and how we prepare our future teachers.

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