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Preservice Teachers' Pedagogical Use of "Gerrymandering" to Integrate Social Studies and Mathematics

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The current study examined four preservice teachers' instructional strategies for mathematics activities examining the concept of "gerrymandering" in order to facilitate elementary students' understanding of the mathematics behind politics. The instructional designs developed by these four preservice teachers indicated that the discipline of political science has pedagogical connections to the subject of mathematics. This study presented empirical evidence showing four preservice teachers' general capacity to develop mathematics lessons based on a particular social studies concept—gerrymandering. The research was undertaken s to demonstrate the potential of social studies topics to serve as educational resources for developing preservice teachers' interdisciplinary mathematics teaching methods.

***Keywords**:* social studies, mathematics education, interdisciplinary education, teacher education, pedagogical designs

Many of the topics taught in social studies lessons can also provide contexts for mathematics education, demonstrating the connections between logical thinking and the humanist spirit. Early scholarship about interdisciplinary pedagogy combining mathematics and social studies can be traced back to the 1890s, demonstrating that such teaching methods have a long history in modern education (Barwell, 1913; Heppel, 1893). However, mathematics education contextualized within social studies activities has not been as extensively adopted as some other types of interdisciplinary teaching strategies such as mathematics-science, mathematics-arts, and mathematics-literacy integrated education (Hinde, 2005). In particular, since at least the 1990s, researchers have been investigating the integration of mathematics with social studies and the impacts of such teaching strategies on students' disposition and achievement in mathematics (e.g., Fauvel, 1991; Lim & Chapman 2010; Otte, 2007; Slaten, 2013).

Although the benefits of teaching mathematics integrated with social studies have been theoretically discussed (e.g., Barnett, Lodder, & Pengelley, 2014; Jankvist, 2009) and empirically assessed (e.g., Farmaki & Paschos, 2007; Jankvist, 2010), the focus of such research has been primarily limited to social studies about the history of mathematics, and the participants were predominantly secondary students and their teachers. The beliefs and capacities of elementary preservice teachers to integrate mathematics with social studies topics from anthropology, geography, and political science, remain unknown. Therefore, the current study aimed to help fill the research gap by investigating preservice teachers' capacity for and perceptions toward developing mathematics instruction for elementary school using social studies activities. Specifically, the present study addressed the following research questions:

1. What types of strategies and implementation plans did preservice teachers use to integrate mathematics with political science?
2. How did the mathematical learning tasks vary across the different versions of activities?

Theoretical Framework

Impact of Interdisciplinary Education on Learning

The concept of interdisciplinary education has a long history that can be traced back to ancient Greece, but the modern renaissance for interdisciplinary instruction began in the early twentieth-century when Francis Parker and John Dewey initiated the progressive education movement by providing the theoretical and curricular supports for integrative teaching (Kridel, 2010). In progressive educational philosophy, the artificial separation between learning obtained from the school curriculum versus informal out-of-school experiences is recognized as counterproductive to students' natural development of knowledge. Instead, teaching based on interdisciplinary project-based curriculums that highlight problem-solving, cooperation, and inquiry have been shown to significantly advance students' learning (Bresler, 2006; Kilpatrick, 1941). Although a number of educators and theorists have proposed a variety of educational methods employing interdisciplinary approaches such as multiculturalism (e.g., Horwitz, 1979), existentialism (e.g., Greene, 1973), and postmodernism (e.g., Slattery, 1995), nevertheless, a rigid discipline-based approach remained the mainstream way for organizing K-12 education in North America during the twentieth-century (Barrow, 2006).

During the past two decades, the influence of constructivist learning theory upon classroom pedagogy has resulted in a revitalized wave of curriculum reform (Hinde, 2005). Interdisciplinary teaching methods as well as interdisciplinary curriculum have become key in helping establish connections to students' real-life interests and experiences, and this is supported by extensive adoption by national-level teacher associations. Specifically, the importance of highlighting connections across subjects was recognized in the standards that were developed by the National Arts Education Association (NAEA, 1994), the National Science Teachers' Association (NSTA, 2003), the

American Association for the Advancement of Science (AAAS, 1998), the National Research Council (NRC, 1996), and the National Council of Teachers of Mathematics (NCTM, 2000). These national-level curriculum standards are designed to encourage opportunities for students to pinpoint and apply knowledge across subjects via the examination of relevant contextualized experiences from their own lives.

A number of studies have shown the benefits from interdisciplinary pedagogy in K-12 schools: At the cognitive level, researchers identified that interdisciplinary learning can (a) engage students in investigating and reflecting through contextualized tasks by providing multiple avenues of entry into various subject areas (Cady & Rearden, 2007), and (b) increase achievement on the standardized reading, writing, science and mathematics tests (DeMoss & Morris, 2002). At the attitudinal level, the interdisciplinary learning approach can (a) enhance enjoyability of a learning environment and improve students' learning motivation and engagement (An, Tillman, Boren, & Wang, 2014; Guzey, Moore, Harwell, & Moreno, 2016), and (b) allow students to develop a broader and more connective view of school subjects (Parsons, 2004). At the pedagogical level, teaching interdisciplinary lessons can (a) reduce the redundancy and fragmentation that occurs across school subjects by better addressing issues and topics in a comprehensive manner (Hargreaves & Moore, 2000), (b) help facilitate communication among students and encourage parental involvement through personally and culturally relevant projects (Niess, 2005), and (c) provide adjustable difficulty levels for learning tasks to accommodate students with special needs and gifted students (Koirala & Bowman, 2003).

Teachers' Interdisciplinary Pedagogical Content Knowledge

Effective elementary generalists who teach multiple subjects are required to be competent at motivating students to learn, sustaining students' engagement, planning and implementing lessons with clear objectives, presenting content through multiple methods, and helping students make meaningful connections within and across subject areas. Shulman (1986) characterized teachers' knowledge by articulating the importance of pedagogical knowledge (PK), content knowledge (CK) and pedagogical content knowledge (PCK) respectively. By extending Shulman's (1987) model of PCK, An (2017) introduced an additional component of teachers' PCK across different disciplines—the interdisciplinary pedagogical content knowledge (IPCK).

The IPCK rationale (see Figure 1) suggests that elementary generalists not only need to develop a robust PCK within each individual discipline that they are responsible to teach in class, but they also need to have deep understandings of the connections among concepts between disciplinary boundaries and how to use these connections as resources for developing learning activities. During the past three decades, teachers' PCK, especially their PCK in mathematics, has been extensively investigated (e.g. Ball, Thames, & Phelps, 2008; Mishra & Koehler, 2006). However, there has only been limited empirical investigation and theoretical development conducted exploring teachers' PCK for connecting high-stakes testing subjects such as mathematics with non-testing subjects such as some of the social studies subjects.

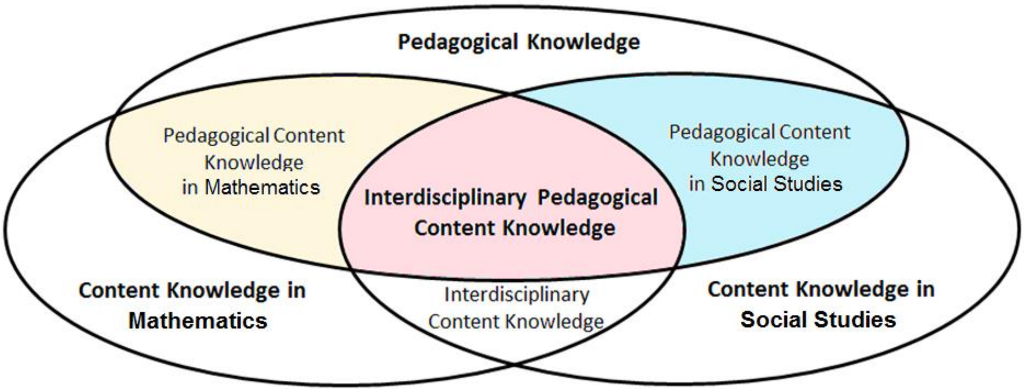


Figure 1. *Interdisciplinary pedagogical content knowledge (IPCK) framework employed in the current study to integrate mathematics and social studies.*

Based on empirical studies that examined preservice elementary generalists improving their PCK, researchers have proposed a number of recommendations for teacher education: (a) rigorous instruction of disciplinary content, (b) guided observation of experienced teachers' teaching, (c sufficient opportunity for teaching content to real students (Grossman, 1990; Magnusson, Krajcik, & Borko, 1999). However, generalist teaching practices are often interdisciplinary in nature, and the development of PCK within each individual subject boundaries is not sufficient to simultaneously improve teachers' IPCK (Park & Oliver, 2008). IPCK includes four additional categories of pedagogical capacity: (a) representing and demonstrating concepts based on themes from other subjects, (b) addressing content from multiple subjects simultaneously, (c) highlighting connections among different disciplines, and (d) assessing students' learning of content from multiple subjects (An, 2017).

Previous research has indicated that the development of teachers' IPCK requires specific training experiences focused on interdisciplinary pedagogy. Teachers' development of PCK for interdisciplinary education involves seeking, building, and evaluating pedagogical strategies that link disciplines in an adaptable manner (Park & Oliver, 2008). Teachers need to analyze educational resources in order to identify subject connections, while also intertwining common themes. The nature of IPCK determines that the teachers who have higher levels of CK and PCK in multiple subjects will be more effective, since they can better identify the integration opportunities in content to be taught to students. However, instead of facilitating preservice teachers' development of disposition and capacity for interdisciplinary education, traditional teacher education programs are accustomed to emphasizing mono-disciplinary instructional methods (Labaree, 2008).

Most disciplinary-based PCK taught to preservice teachers during their methods courses is presented in a subject-specific manner not transferable across disciplines such as from mathematics to science, nor within subject sub-areas such as from geometry to algebra, or from physics to chemistry (An, 2017; Darling-Hammond & Baratz-Snowden, 2007). The borders between school subjects become imprecise and faded with professional growth and experience, as preservice teachers gradually grow into more experienced veteran in-service teachers. Studies have found that interdisciplinary pedagogical ability is highly correlated with years of teaching experience (Archambault & Crippen, 2009; Niess, 2011), and therefore it can be recommended that earlier and more robust interdisciplinary teaching experiences should be provided for preservice teachers to better develop their IPCK earlier in their careers (An, 2017; Doering, Veletsianos, Scharber, & Miller, 2009).

Methods

Research Setting and Participants

The current study was conducted at a research university located in a metropolitan area of the southwestern United States. The university has an enrollment of over 23,000 students with more than 18,000 students self-identifying as Hispanic. The current study was part of a larger investigation focused upon developing preservice teachers' interdisciplinary pedagogical content knowledge, primarily for mathematics education. In total, the aggregate participants in the larger research project have included over 400 preservice teachers who were enrolled in either the elementary generalist certificate program, the elementary bilingual generalist certificate program, or the alternative teaching certificate program. For the current study, data was collected from four preservice teachers who were enrolled in a graduate-level mathematics teaching methods course. Each of the four participants had previous work experiences from outside of education and was currently enrolled in the alternative teaching certificate program to become a teacher.

Pedagogical Design of Task

The political concept of gerrymandering was presented as a pedagogical theme for study participants to use while designing mathematical learning tasks. Gerrymandering refers to an act of manipulating the boundaries of electoral districts to change the potential voting results in favor of one of the political parties (see Figure 2). The term "gerrymandering" originated in the early 1800s when the detractors of Massachusetts Governor Elbridge Gerry took offense at his blatant and self-serving stretching of the Essex County electoral boundaries. When Gerry's opponents noticed that his manipulations had caused the county's outline to morph into a shape similar to a salamander, the term "Gerrymander" was born.

Table 1
Profiles of Participants (all names are pseudonyms)

Name	Ethnicity	Highest Degree	Working Experiences
Carlos	Hispanic	Masters in Educational Administration	20 years in business
James	Caucasian	Bachelor in Engineering	12 years in military
Luisa	Hispanic	Bachelor in Business Administration	18 years in food service
Roberta	Caucasian	Bachelor in Engineering	15 years in engineering

As a widespread and effective technique for manipulating voting results, political gerrymandering was employed by both major parties in the United States throughout American history, at all levels of political voting including national, state and regional elections (Issacharoff, 2012; Kennedy, 2017). Noticing the harm from gerrymandering, some states such as Arizona, California, Iowa, and Florida approved laws to prohibit boundary drawers from re-drawing districts lines based on partisan data; however, many states still lack legislative control to prevent gerrymandering (Bernstein & Duchin, 2017).

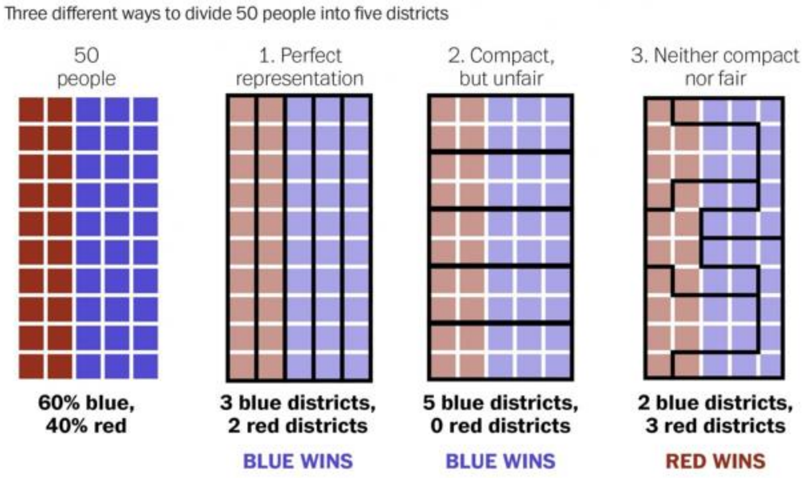


Figure 2. *Gerrymandering explained (Ingraham, 2015).*

Data Collection and Analysis

In this study, participants were assigned to do three tasks: (a) investigate cases of gerrymandering of voting throughout U.S. and world history, (b) identify mathematical patterns behind the gerrymandering cases, and (c) develop an interdisciplinary lesson to explain gerrymandering as well as the mathematics behind gerrymandering to elementary students. To facilitate the data collection, an online discussion forum was developed where the participants could introduce each of their instructional designs and make comments on the activities created by the other participants.

Following the participants' instructional design task, data analysis employed a grounded theory approach during which the current study could compare themes and generate patterns that were recurring across the data from four different participants (Corbin & Strauss, 2008). Specifically, we coded and compared the lesson theme, mathematics contents, as well as mathematics teaching methods among the four lesson plans the participants developed. In general, all the collected participants' instructional designs were analyzed based on a two-tiered process: (a) a macro-dimensional analysis focused on the theme of the lesson and the non-mathematics content integration described in the lessons, and (b) a micro-dimensional analysis focused on specific mathematics tasks and the methods for conceptualizing the included mathematics knowledge within concrete scenarios.

Results

The Case of Roberta: Distribution of VA Hospitals in District 4

Roberta was a preservice middle school mathematics teacher and she proposed her teaching plans based on a real region from her hometown, Illinois US District 4, where gerrymandering happens because of its unique geographical structure (see Figure 3). Two objectives in her lesson included the conceptual understanding of "compactness" as well as investigating the optimal way for locating Veterans Affairs (VA) hospitals in this region. Her lesson started with a background introduction about the gerrymandering of the target region:

> Since gerrymandering is so closely related to geometric concepts, this is a fantastic topic for geometry teachers to introduce. It would engage kids who may not normally be interested in math, as it is highly relevant to today's politically charged news events. To embark upon a geometry lesson that is related to gerrymandering, students should first understand what gerrymandering is, starting with an understanding of what redistricting involves. Students should learn about the basic constraints to redistricting, such as maintaining equal population and geometric contiguity. To illustrate contiguity, I like the example of a district within my once home state of Illinois: its Congressional District 4 includes a thin strip that is essentially a highway, connecting its northern and southern sections. Students will then be able to understand that gerrymandering happens due to the *absence* of a constraint that limits unfair partisan makeup. They should be able to look at a large variety of congressional district shapes, which are readily available, online.

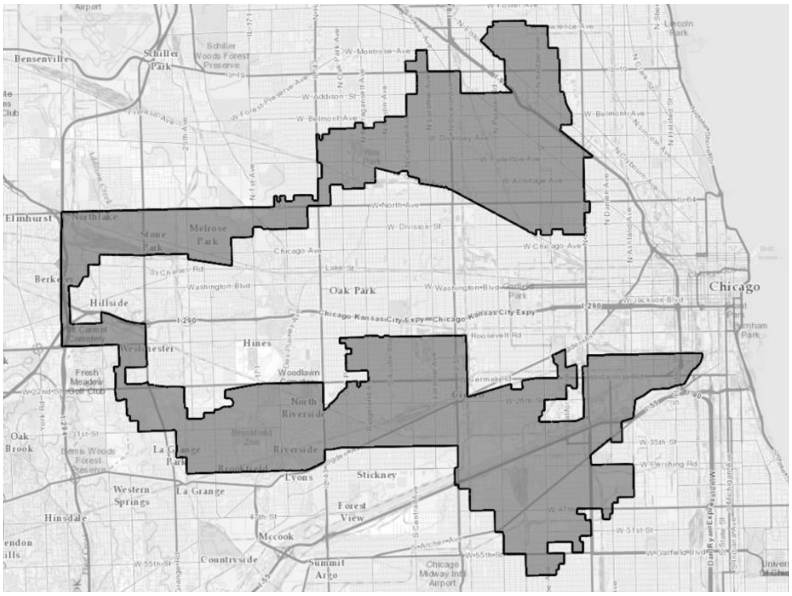


Figure 3. *Geographical boundary of the 4th congressional district of Illinois.*

Compactness is a complex concept in both mathematics and political science. Mathematically, compactness is a topology term, which refers to examining a Euclidean space that is closed (i.e., containing all its limit points) and bounded (i.e., all its points within a fixed distance from each other). Politically, compactness has been utilized as an indicator to geometrically evaluate a congressional district's boundaries based on ratio between perimeter and area (Polsby-Popper, 1991). In order to use this social studies context to teach mathematics, Roberta designed an opening activity for her lesson that introduced methods for evaluating compactness to determine whether Gerrymandering is present. As Roberta described, her plan and rationale for the warm-up activity were:

> Warm Up Activity: Ideate methods to determine a district's *compactness*. My mathematical activity related to gerrymandering is to consider the constraint of compactness. Interestingly, I found the Court has no precise definition of what constitutes compactness, though it considers this when judging if gerrymandering has occurred. I also found that scholars have proposed over 30 methods to judge compactness. I will ask my students to read Ingraham's article *America's Most Gerrymandered Congressional Districts*, and they will have a sense about how to quantify the compactness of districts by comparing its perimeter to the perimeter of a circle having the same area as the district. Since this is a 'real' problem that needs attention, my students could be challenged to come up with some ideas about how compactness could be defined in terms of geometric concepts such as area and perimeter. Subsequently, my students could be encouraged to incorporate circle(s) into their proposed measures of compactness, if they had not thought of that initially.

Within this context of examining gerrymandering by political parties, Roberta developed her main activity about locating Veterans Affairs hospitals. This open-ended task with a series of three questions required students to apply mathematical concepts from topics such as geometry (e.g., location and shape), measurement (e.g., distance and time) and data analysis (e.g., population), while also emphasizing social studies concepts from topics such as geography and social welfare. Roberta described her main activity as follows:

> Main Activity: Propose geographic regions and site locations for a fixed number of Veterans Affairs (VA) hospitals. This activity is building on my students' knowledge of how polygonal regions can be drawn on a map to capture certain populations of interest. My students would be given a problem to define geographic regions in the U.S. or perhaps within a single state, that would serve U.S. veterans. My students will also be tasked with locating one VA hospital within each region. Students could be given data regarding the populations of veterans within cities, districts or counties. This problem could be interpreted as a minimization problem, with the goal to minimize the total number of miles that veterans would collectively need to drive to their regional VA hospital. The project will allow students to consider questions such as: (1) Should the VA hospitals each be designed to accommodate the same number of veterans? (2) What might be the repercussions of locating the VA hospitals outside major cities? (3) What other factors, besides minimizing driving time, would be important to consider?

The Case of Luisa: Learning Compactness with Design Experiments

Luisa was a preservice elementary generalist, and she introduced an experiment that used a series of seven area comparison activities employing a variety of shapes with the same area. Luisa's learning activities encouraged students to measure and compare the areas of different shapes during two stages: (a) first measuring with non-standardized units, and then (b) measuring with standardized units. In the first part of the activity, Luisa's lesson had students use non-standardized unit—specifically, the students used coins to measure an area by putting the coins within the perimeter of the target shapes (see Figure 4). As she explained in her rationale for the activity:

> The focus of my activity is focused on shapes and their "compactness" and is designed for students at the elementary level. Through this activity, students will be able to understand the relationships between shapes, perimeter, area and the "compactness" of those shapes. Students are given individual printouts with the following seven shapes; a triangle, rectangle-A, rectangle-B, square, hexagon, and a circle. The students are asked to calculate the perimeter of each shape by measuring with the use of a ruler. (Note: I have pre-measured each shape and sides so that they have the same perimeter of 12 inches) In an effort to be precise, I have provided the radius of the circle to be 1.91 inches. After this, they are given several pennies and are asked to determine how many

they can fit within the boundaries of each shape. Next the students are asked to use the unit of square calculate the precise area for each object.

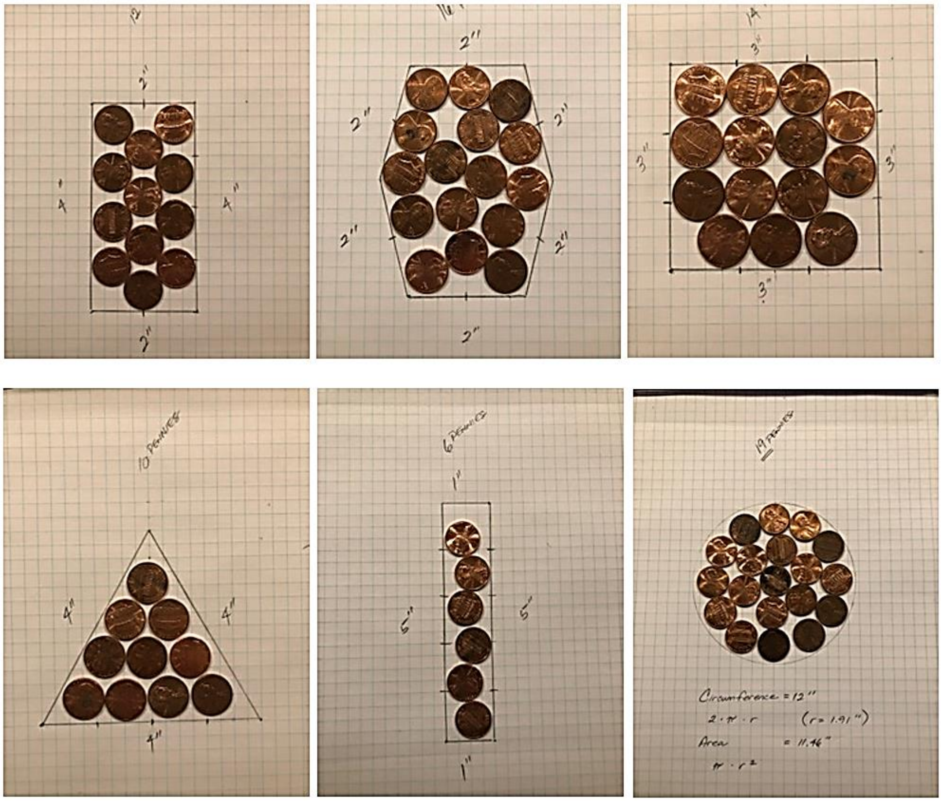


Figure 4. *Coin arrangements providing a visual proof of area for shapes.*

Luisa further specified that based on the results obtained from using the coins, students can learn to predict the number of coins that each type of shape will be able contain: (a) the slender rectangle can hold 6 coins, (b) the equilateral triangle can hold 10 coins, (c) the wide rectangle can hold 12 coins, (d) the square can hold 14 coins, (e) the hexagon can hold 16 coins, and (f) the circle can hold 19 coins. Luisa also offered a mathematical explanation behind the pattern between number of coins and types of shapes, while also discussing how this type of activity can be extended to examine three-dimensional objects:

> Through this experiment, students should be able to determine that the nearer that a given shape is to being circular, the higher its compactness measure will be. Although all shapes have the same perimeter, the areas determine the overall compactness and the [number] of pennies that they are able to fit inside of them. I will help my students conceptually understand that circles are the most compact shape because it "encloses the largest area for any given perimeter" (Gillman, 2002, p.11). The more elongated the shape the less compact it will be. Through this simple activity, I believe that the relationships I mentioned above will become clear for students. This activity can be

> performed and extended with various storage containers/boxes with different shapes. The objects can vary and can call for a combination of various shapes required to fill the various shaped containers/boxes. Students can be given minimum quantities of each object that must be used and determine which combination will yield the most quantity of objects being placed in each container/box.

The Case of Carlos: Gerrymandering as a Soccer Strategy

Carlos was a preservice middle school teacher, and he designed a mathematics activity to teach using gerrymandering in the setting of a soccer game. The task was about locating soccer players' positions during the match as well as investigating the "ball control" area and perimeter that the players each create. Carlos included a picture to illustrate the mathematical concepts in this activity (see Figure 5). Carlos's pedagogical design had two sections with progressively increasing difficulty levels about calculating areas encompassed by three variables and then four variables. His instructional direction for the first scenario was described as follows:

> Gerrymandering can help illustrate how manipulating boundaries can change measurements and shapes of figures. For this illustration, I used soccer positioning to review both perimeter and area. The activity could be either on paper, or to get slightly more interesting, on an actual field. For the first scenario, we have players #1, #2, and #3 (all from the same team, for now) covering a specific length and width. In this example, the three players will cover 24 feet in length and 5 feet in width. Students will calculate what the perimeter and area that three individuals can create on the field. The other students can also be grouped together to do the same. This will help the students understand how far they have to move from point A to point B as they get closer to the goal as well as how much area they have to cover to ensure they can get a goal or defend their goal. They can work together with their classmate to determine the best coverage or assigned boundaries for the best protection/advantage.

Similar to the perimeter and area exploration activities in the first scenario involving three players, Carlos also provided a follow-up task with a more complex setting by adding one more variable, a fourth player, in the new scenario. In the previous scenario, the three players created a triangle; in the new scenario, the four players formed into a quadrilateral, but also four different triangles. For example, in Figure 3, the four players #7, #8, #9, and #10 in the red team form into three triangles, including: (a) players #7, #8, #9, (b) players #7, #8, #10; (c) players #8, #9, #10, and (d) players #7, #9, #10. These four players can also each change their ball control areas by changing their individual field positions. Carlos detailed the mathematical tasks for this activity as follows:

> For the second scenario, my students will learn about gerrymandering and how it is used to establish an advantage for a particular group or party. By manipulating the participants or shapes, the pattern can change dramatically and can be an advantage or a disadvantage depending on the side. Students will be informed that although player #10 is currently on the other team, she will now join players #1, #2, and #3, adding an additional 12 feet in length and 5 feet in width. Students will calculate what the new perimeter and area will be for the four individuals. Students will be asked to provide a brief explanation of how this manipulation can positively or negatively affect each team. The students will not only learn to calculate perimeter and area, but also will also provide a brief explanation of how the manipulation can affect coverage or area of responsibility for each team.

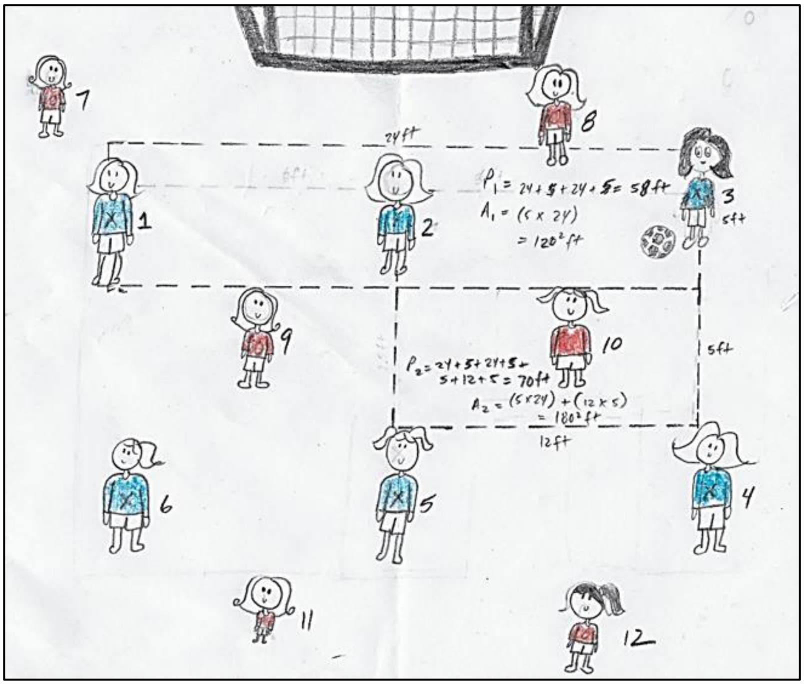


Figure 5. *Player positioning impacts the perimeter and area of ball control.*

The Case of James: Gerrymandering of Mock Voting

James was a preservice high school teacher. Different from the previous three cases of contextualizing gerrymandering within concrete scenarios, James proposed a mathematical task based on representing the population and party information abstractly with numbers and letters. To achieve this, James invented an imaginary state, named *Rectangula*, which contained 40 counties that are governed by two political parties. As he described in his background information about *Rectangula* (see Figure 6):

> After explaining the super simplified example of Gerrymandering from Wikipedia, I would show them a slightly less simplified example, like the diagram below [see table 6]. In this imaginary state, *Rectangula*, there are two

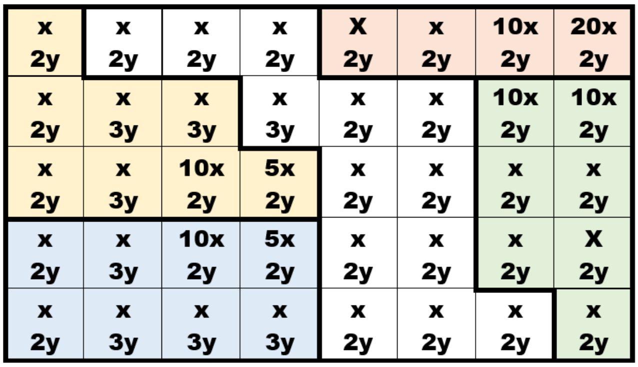
major parties: Party X and Party Y. It is divided into 40 counties of equal area, but very unequal population. There are two major urban centers, Central City near the center of the state, and Sister City in the Northeastern corner. There are 200,000 voters in the state, and 120 thousand of them vote for Party X while the remaining 80 thousand vote for Party Y. After the last census, the state is now entitled to send 5 Congress-people to Washington DC, and so the legislature must draw new boundaries dividing the state into 5 districts of approximately equal population, (39 or 41 thousand is close enough.)

x 2y	x 2y	x 2y	x 2y	x 2y	x 2y	10x 2y	20x 2y
x 2y	x 3y	x 3y	x 3y	x 2y	x 2y	10x 2y	10x 2y
x 2y	x 3y	10x 2y	5x 2y	x 2y	x 2y	x 2y	x 2y
x 2y	x 3y	10x 2y	5x 2y	x 2y	x 2y	x 2y	x 2y
x 2y	x 3y	x 3y	x 3y	x 2y	x 2y	x 2y	x 2y

Figure 6. *The imaginary map of the state of Rectangula.*

Using the state of *Rectangula* as a context, students tried different methods to divide the district boundaries for voting. James offered a series of questions to support the students' efforts to compare results from different divisions of the voting regions. This open-ended style of inquiry leads to multiple outcomes, and students need to apply algebraic thinking to determine the region boundaries in terms of such variables as population, party voters, and the shape of the region. This activity not only enabled students to solve mathematics problems employing connections among data analysis, probability, algebra and geometry, but also illustrated political concepts describing how voting works. James presented his guiding questions, together with an example of one possible solution, as follows:

> The exercise for the students (in small groups) is to try a few possible district maps and assess each: which map is fair? Which is to Party X's advantage? Or Party Y's? Which has more competitive districts? Or more safe ones? For example, here is a district map you might come up with [see Figure 7], the Northwest district has 21 thousand Party X voters and 19 thousand Party Y voters. The Southwest District also has 21 thousand for Party X, but 20 thousand for Party Y. The Northeast district has 32 thousand Party X voters and only 8 thousand favoring Y. The Southeast district has 25 thousand favoring X and 14 thousand for Y. Finally, the central district has 27 thousand for Y and 13 thousand for X. So, this map favors party X, since it would probably send 4 of them to congress, where representation would indicate it should be 3. On the other hand, the map is not ideal for X, because the western districts are both relatively competitive, especially the Southwest.



x 2y	x 2y	x 2y	x 2y	X 2y	x 2y	10x 2y	20x 2y
x 2y	x 3y	x 3y	x 3y	x 2y	x 2y	10x 2y	10x 2y
x 2y	x 3y	10x 2y	5x 2y	x 2y	x 2y	x 2y	x 2y
x 2y	x 3y	10x 2y	5x 2y	x 2y	x 2y	x 2y	X 2y
x 2y	x 3y	x 3y	x 3y	x 2y	x 2y	x 2y	x 2y

Figure 7. *An example of biased boundary setting within the state of Rectangula.*

Discussion

The current study examined four preservice teachers' instructional strategies for mathematics activities examining the concept of "gerrymandering" in order to facilitate elementary students' understanding of the mathematics behind politics. The instructional designs developed by these four preservice teachers indicated that the discipline of political science has pedagogical connections to the subject of mathematics. Topics from social studies, such as elections and voting processes, can be associated with mathematics content areas (NCTM, 2000) enabling an interdisciplinary perspective that can benefit both subjects, because (a) mathematics topics are meaningfully contextualized within political science scenarios, and (b) political science topics are conceptualized though mathematics (Farmaki & Paschos, 2007; Jankvist, 2009). The analysis of participants' instructional designs showed two common features emerged among the four cases: (a) each case described a scenario with hidden mathematical patterns, and (b) each case provided opportunities for students to enact individualized plans and analyze authentic data.

Pedagogical Coherence Across the Four Instructional Designs

Examining the four participants' instructional designs facilitated recognition of several similarities in their strategies and tactics for integrating mathematics and social studies. To explain the political concept of gerrymandering, all four participants employed a comparable constructivist learning procedure First, each of the four preservice teachers had the same chief purpose for their activities—to provide inquiry-based learning opportunities for students wherein examination and experimentation resulted in mathematical pattern recognition. Additionally, all four participants designed their mathematics tasks as a simplified simulation of real incidents of gerrymandering that had occurred during political voting. Further, all four tasks had minimal barriers to entry, allowing students to start at a wide range of levels in terms of their mathematics and social studies abilities.

The instructional designs presented by the four participants employed all five chief mathematical processes (NCTM, 2000) via interactions between the two traditionally separated subjects of mathematics and social studies. In particular, the instructional designs were designed to help students: (a) emphasize problem solving strategies including drawing pictures, making tables, and use intellectual guess-and-check/guesstimation; (b) create simulations of real-life scenarios that enable manipulation of key variables to investigate mathematical relationships; (c) make connections between topics within mathematics (e.g., geometry and statistics) and social studies content areas (e.g., geography and political science); and (d) represent mathematical ideas via multiple representations including pictures, charts, and manipulatives.

Pedagogical Variation Across the Four Instructional Designs

Several dissimilar pedagogical aspects were noticed among the four instructional designs created by the participating preservice teachers. First, the themes and types of contextualization among the four proposed activities were different. For example, Luisa's activity was based on informal measurement tasks of particular geometric figures (e.g., triangle, hexagon, and circle) via a non-standard unit of measurement—specifically, by using coins. In contrast, Carlos's activity was contextualized within a soccer match, wherein flexible player arrangement options were offered to students as a means to form various types of triangles and quadrilaterals (e.g., rectangle, parallelogram, and trapezoid). The identified differences between Luisa and Carlos's cases illustrated how the different themes and types of contextualization impact the learning tasks.

The instructional designs each presented different themes and types of complexity for contextualizing mathematics activities about gerrymandering. As an illustration, Roberta's lesson had a higher level of complexity than James's lesson. In James's lesson, an imaginary 40-county state was created as the background for the mathematics tasks. A state map in the format of an 8×5 matrix was presented for students to gerrymander the regional boundaries for voting according to provided population and political party information. In comparison to this simplified case, Roberta introduced students to a real region on the map from the District 4, Illinois. In her lesson, students needed to collect real data about veteran populations in each city and county of the district, and then go about "reversely gerrymandering" aspects of District 4, such as hospital distribution.

Social Studies -- A Hidden Teaching Resource for Mathematics

Numerous researchers have noticed the unbalanced educational focus within K-12 schools on high-stakes testing subjects such as mathematics and literacy, when compared to non-high-stakes testing subjects such as social studies, arts, and physical education (Fitchett, Heafner, & Lambert, 2014; Lucey & Meyer, 2013). Compared with mathematics and literacy, professional education has devoted limited time and resources to teaching those disciplines that do not easily lend themselves to standardized testing—social studies and the arts are some of these marginalized subjects (Passe, 2006; Rock, et al., (spell all names) 2006). Educational policy generally emphasizes literacy and mathematics as the only two foundational subjects, with science a close third, while the other components in the school curriculum become increasingly peripheral and thus treated less seriously (Kenna & Russell, 2014). Research also identified that among the teachers who were willing to devote more effort to social studies, their desired instructional time was often restricted and compromised by the pressure asserted from administrators and parents concerned about school subjects that were included in standardized testing (Good et al., spell all names 2010).

Social Studies enables students to learn how to utilize information to become responsible citizens who can make critical judgments and seek solutions for complex problems and conditions (Tarman, 2010). Unfortunately, curriculum narrowing continues as a predictable trend in the K-12 educational system because of the focus on assessment of literacy and mathematics (Leming, Ellington, & Schug, 2006). Based on this trend, social studies, the arts, and other "non-essential" subjects are expected to be further marginalized in future school curriculums. As a counterweight to this trend, the current study demonstrated the pedagogical value of social studies as an innovative educational resource that can be implemented in mathematics classrooms.

Conclusion

This study presented empirical evidence showing four preservice teachers' general capacity to develop mathematics lessons based on a particular social studies concept—gerrymandering. The research was undertaken to demonstrate the potential of social studies topics to serve as educational resources for developing preservice teachers' interdisciplinary mathematics teaching methods. Findings from this study were consistent with previous research conducted on this topic. This study also provided additional empirical evidence to verify that many mathematics content areas can be associated with multiple social studies content areas (Kenna & Russell, 2014; Lim & Chapman 2010). Further, this study contributed to the literature by examining the pedagogical similarities and differences among participants' lesson plans in terms of both contextualization and conceptualization processes. Although the present study has not demonstrated the pedagogical effectiveness of mathematics-social studies lessons in class settings, the current examination nonetheless revealed the presence of educational opportunities for teachers to facilitate their students' understanding of mathematics via contextualization into different types of social studies topics.

Before the final remarks, a few limitations to the present research study should be clarified. First, as a multi-person case study, the number of participants was fairly small. Additionally, all of the participants were non-traditional preservice teachers who had extensive work experiences in their pre-education careers. The findings from the present research study, therefore, invite additional empirical investigation of methods for advancing teacher education programs via emphasis on interdisciplinary pedagogy. The study also invites research to more thoroughly assess the teaching effectiveness of interdisciplinary-themed activities in mathematics classrooms. Hence, there are several research avenues available for scholars wishing to contribute to the development of contextualized mathematics pedagogy that employs concepts from subject areas as rich as social studies, history, anthropology, political science, and economics. Within this setting, this research study was undertaken in an effort to contribute to our collective understanding of how to better engage students in learning mathematics via contextualization within topics from social studies.

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