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Selecting From Three Curricula For A Preservice Elementary Teacher Geometry Course

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Abstract

Faced with selecting a geometry curriculum for our preservice elementary teacher mathematics course, we used a mixed-methods study to investigate the effectiveness, with respect to student achievement and student perception, of three reform-oriented curricula. ANCOVA results indicate students using one of the curricula scored significantly higher than students using the other two. Qualitative results indicate students use and learn more from curricula with referencing material, explanations, examples, illustrations, practice opportunities, and exploratory activities. These results led to our curriculum selection and also suggest guidelines for textbook selection and provide a model of obtaining feedback from students on textbook use.

Introduction

The Conference Board of Mathematical Sciences (CBMS, 2001), in addition to other national organizations and councils (Leitzel, 1991; National Council of Teachers of Mathematics [NCTM], 1991; 2000; National Research Council [NRC], 2001), points to the importance of preservice teachers learning about geometry. A few years ago, we were faced with the issue of selecting a curriculum for our geometry course for preservice elementary teachers. To this end, we investigated three geometry curricula and their effectiveness with respect to student achievement and student perception. This article describes our findings and shares what we learned about the three curricula, including recommendations other teacher educators may want to consider in selecting curricula for mathematics courses for preservice elementary teachers.

At our mid-sized university in the Rocky Mountain region, the third mathematics course that prospective elementary teachers take is devoted to geometry. Historically, instructors used *Geometry: An Investigative Approach* (O'Daffer & Clemens, 1992) for the primary textbook. Some students did not respond favorably to this textbook, reporting that they found the textbook difficult to read and unsupportive of their learning of geometry. Thus, in 2003 we began using a packet we compiled of activities adapted from elementary mathematics methods books such as *Elementary and Middle School Mathematics: Teaching Developmentally* (Van de Walle, 2004), from the previous textbook, and from resources developed by the authors and other faculty. We used this packet for approximately six semesters, including summer sessions, when we learned of an additional geometry curriculum for prospective elementary teachers, *Geometric Structures for Elementary Teachers* (also known as GeoSET) (Aichele & Wolfe, 2005).

At about this time, faculty and instructors that taught our mathematics courses for elementary teachers (including the authors) decided to review curricula of the three courses. We found it especially challenging to locate appropriate curricula for the geometry course. First, we wanted a textbook with sufficient geometry content to support the semester-long course. Therefore, we decided not to consider some of the more common mathematics textbooks for elementary teachers which tend to contain only 3-4 chapters for geometry (e.g., Bennett &

Nelson, 2004; Billstein, Libeskind, & Lott, 2004; Long & DeTemple, 1995). Second, many of the textbooks we found focused on geometry content more appropriate for high school students or undergraduate mathematics majors. Thus, we were left with our three choices mentioned previously: *Geometry: An Investigative Approach* (hereafter referred to as the Geometry Textbook), our packet entitled *Topics of Fundamental Mathematics: Geometry for Elementary Teachers* (hereafter referred to as the University Packet) (Powers, 2004), and *GeoSET*.

The basic investigative philosophy of the Geometry Textbook is "to encourage you [the student] to become involved in exploring the ideas of geometry" (O'Daffer & Clemens, 1992, p. xi). The intent is to facilitate a student-centered course, where students are working together in groups, testing their ideas, and getting immediate feedback from each other. The authors provide multiple problem solving and/or application activities in which the students use constructions, laboratory materials, and technology to gain understandings of various patterns in geometry. The authors' aim is to provide the preservice teachers with many discovery experiences in the hope that the preservice teachers will then be better prepared to facilitate such discovery experiences on the part of their future elementary students. Much like the Geometry Textbook, the intent of the University Packet is to actively engage students in investigating geometrical concepts and to thereby foster a student-centered classroom. The activities require students to work collaboratively solving problems followed by whole-class discussion in which the central mathematical ideas are drawn out. The activities also aim to make connections between various geometrical ideas, and students are expected to explain their thinking and use informal reasoning to justify their conclusions. The goal of the GeoSET materials is to offer an inquiry-based and innovative experience that provides for "each student's growth toward being a confident, independent learner empowered to make sense of the geometric world" (Aichele & Wolfe, 2005, p. iii). The intended delivery of the materials involves students working independently (or together) on guided-discovery activities or text passages before coming to class. In class, the teacher facilitates whole-class discussion of student questions on these activities and readings. These interactions are designed to provide the kinds of insights and personal enlightenment that create the deeper understanding of the course materials. The treatment of the material is to be intertwined among topics in each part rather than a linear treatment.

Each of these three curricula align well with the CBMS (2001) and NCTM (1991, 2000) reform-oriented geometry recommendations for preservice elementary teachers and the philosophy of our course. Therefore, we decided to undertake this study in which we examined each curriculum for its impact on student achievement and student perception in order to assist us in selecting our curriculum. Our guiding research questions were:

1. Is there a significant difference among students who were taught using the three curricular materials on their achievement scores on a post-test statistically controlling for prior knowledge and instructor effect?
2. What are the students' perceptions about how well the curriculum materials helped them learn geometry?

Methodology

In the spring of 2005, six sections of the geometry course were offered for our preservice elementary teachers. These six sections were taught by four instructors and each of the three curricula were used in two sections, as follows: Laura and Ben each taught one section and used the University Packet, Carl taught two sections and used the Geometry Textbook in both sections, and Robert taught two sections and used GeoSET in both sections (all names are pseudonyms, except for Robert, one of the authors). Carl, Laura, and Ben had used their respective curricula in previous offerings of the course and therefore decided to use their respective curricula again. Robert decided to use GeoSET after receiving information about it from a fellow faculty member that attended a professional development workshop on the materials. Information about these instructors can be found in Table 1. Each of the instructors used the curricula in a fashion respective of the student-centered philosophies of the curricula. Since each of the three curricula was used in two sections, we decided to compare results across the sections using the different curricula.

Table 1
Characteristics of instructors

Name	Gender	Number of Years Teaching Preservice Elementary Teachers	Number of Times Had Taught the Geometry Course	Terminal Degree
Laura	Female	1	0	M.S. in Applied Statistics
Ben	Male	15	3	Ph.D. in Mathematics Education
Carl	Male	31	0	Ph.D. in Mathematics Education
Robert	Male	4	5	Ed.D. in Curriculum and Instruction (Mathematics Education)

To address the research questions, we used a mixed methods design and relied upon three data sources. The data sources for research question #1 were quantitative and included pre- and post-tests (See Appendix A) administered near the beginning and the end of the semester, respectively, and a Perceptions of Instructor Survey (See Appendix B.) administered at the end of the semester. The pre- and post-tests were designed by the authors and one additional colleague, while the Perceptions of Instructor Survey was designed by the university's Institutional Research and Planning. The pre- and post-tests were used to determine students' knowledge of geometry and measured the dependent variable of the study. The Perceptions of Instructor Survey was used to determine students' perceptions of the course and of the instructor and was used to control for the different effects of the instructors as perceived by the students.

Validity of the pre- and post-test was determined through content and factor analyses. The pre- and post-tests were constructed to assess typical objectives of a geometry course for elementary teachers. The tests were examined, edited, and approved in their final form by all instructors of the course. In addition to its content validity, the researchers analyzed the post-test for evidence of validity from its internal structure. Based on scree plot analysis, the post-test contained two factors associated with geometry knowledge. Using a Varimax rotation with Kaiser Normalization, items 1, 2, 3, 5, 7, and 8 loaded onto the first factor, while items 4 and 6 loaded onto the second factor. It is difficult to classify each of these factors based on the loaded items of the assessment. The two factors, however, accounted for 42% of the variance of students' responses. Additionally, a measure of internal reliability was determined. The Cronbach's alpha measure of reliability for all eight items was .59, indicating a low to moderate amount of internal reliability of the assessment. With respect to interrater reliability of test scores, each item was graded by at least two mathematics educators, and any disagreements between scores on any of the items were then resolved between the two graders.

Reliability and validity of the Perceptions of Instructor Survey was determined through the university's Institutional Research and Planning. The Perceptions of Instructor Survey originally contained 26 items and had an internal reliability measure of .95 to .97 (D. Suhr, personal communication, February 24, 2005). Through factor analysis, these items were reduced to 11 items: four measuring aspects of the course and seven measuring the instructor effects on the course. Cronbach's alpha measure for the present study was .95.

The data source for research question #2 was the Curriculum Preference Survey (see Appendix B), which gathered demographic data and quantitative and qualitative information about the students' perceptions of their use of the curriculum and the effectiveness of the curriculum. It consisted of Likert-type items and three open-ended items. The open-ended items were intended to elicit the students' perceptions of how each of the curricula was and was not supportive of their learning of geometry and also to inquire about whether they would recommend their curriculum in future offerings of the course. The Curriculum Preference Survey was also administered at the end of the semester.

A similar study using the same population of students (i.e., preservice elementary education students taking the geometry course) was used to determine the reliability of the Likert items on the Curriculum Preference Survey. Because each item represents an individual construct, a test-retest measure of reliability was used to measure the coefficient of stability on each quantitative item (Gall, Gall, & Borg, 2003). With the exception of one item, the (Pearson) correlation coefficients ranged from .70 to .79. The anomalous item (Item 18) had a correlation of .60, which may be due to the inconsistent treatment of measurement in the course materials. All coefficients of stability were significant ($p < .0005$) using the validating sample ($N = 117$).

One hundred twenty-six students completed all three data sources, or 71% of the students enrolled that semester in the geometry course. Of the participants in the study, 119 were female (94%) and six were male (5%), while one participant declined to reveal his or her gender. The participants' ages ranged from 19 to 40, with a mean of 21.3 and a standard deviation of 3.3. The ethnicity of the majority of participants was reportedly White ($N = 86$ or 68%). However, some diversity was reported in the sample with participants identifying themselves as follows: two African Americans (2%), eight Asians (6%), 12 Hispanics (10%), three Pacific Islanders (2%), two identified as Other (2%), and 13 unidentified (10%). The typical participant was a junior ($N = 46$ or 37%); however one was a freshman (1%), 42 were sophomores (33%), 36 were seniors (29%), and one was a post-baccalaureate student (1%).

To answer the first research question, differences among students in each of the sections using the three curricula were determined statistically through an analysis of covariance. The independent variable was the curriculum group, and the dependent variable was student achievement scores. The anticipated covariate of the study was the students' perceptions of the teacher effect on the instructional process. Because intact groups were utilized in the study, any initial achievement differences were measured and accounted for using pre-test data.

To answer the second research question, item scales from the Curriculum Preference Survey were treated as Likert-type scores and mean scores were calculated to measure typical responses from each group. Analyses of variance were used to determine differences among the three groups. In addition, the students' comments on the open-ended items were analyzed qualitatively using the theoretical perspective of Grounded Theory, through which themes and patterns emerge from the data (Strauss & Corbin, 1998). The students' responses were combined for students using the same curriculum. Open coding, a process of naming concepts and developing them in terms of their properties and dimensions, was used to identify possible themes in the data. The responses were then sorted by these common codes and analytic memos were prepared about the common themes that emerged with respect to each curriculum. These analytic memos were then used to conduct a cross-case comparison of the students' perceptions of the effectiveness of the three curricula.

Results

Results for Research Question #1

This study examined two factors considered potential covariates to the post-test scores. In addition to pre-test scores, considered a likely covariate because of the use of intact groups, the teacher was thought to be a possible covariate. The correlations between pre-test and post-test as well as the students' perception of the teacher effect on the instructional process and post-test are presented in Table 2. Only pre-test scores were significantly correlated with the post-test scores ($r = .31$, $p < .01$).

Table 2
Correlation Coefficients between Variables and Post-test Scores (N = 126)

Variable	*R*
Pre-test	.312**
Students' Perception of Teacher Effect	-.046

** $p < .01$

Because students' pre-test scores were significantly correlated to their post-test scores, the researchers were interested in determining any initial achievement differences among the curriculum groups as measured by the pre-test. ANOVA results demonstrated that there were no significant difference, $F(2, 123) = 0.45$, $p > .05$, among the curriculum groups on pre-test scores.

Although pre-test scores were the only measured variable with a statistically significant correlation to post-test scores, both pre-test and students' perception of teacher effect on the instructional process were used as covariates in the analysis of covariance (ANCOVA). Based on this analysis, pre-test was indeed a significant variable in the model, $F(1,121) = 17.33$, $p < .0005$, while students' perception of teacher effect on the instruction process was not, $F(1,121) = 0.02$, $p = .972$. ANCOVA results also found that there was a significant difference among three curricula on post-test scores after statistically controlling for the covariate scores, $F(2,121) = 11.45$, $p < .0005$. Table 3 presents the results of the post hoc analysis; Table 4 presents the results of the Scheffe post hoc analyses.

Table 3
Adjusted Means and Standard Errors of the Post-test

	Geometry Text (*N* = 22)		University Packet (*N* = 58)		GeoSET (*N* = 47)	
	M	*SE*	*M*	*SE*	*M*	*SE*
Post-test	22.15	0.86	26.89	0.55	24.38	0.60

Note. Scores adjusted using pre-test = 17.01 and students' perception of teacher effect = 3.33

Table 4

Post Hoc, Pair-wise Comparisons of Estimated Marginal Means

	GeoSET	University Packet	Geometry Text
GeoSET	—	-2.51*	2.23
University Packet		—	4.74***

* $p < .05$; *** $p < .0005$

After adjusting the mean scores for pre-test and teacher effect scores, students who used the University Packet scored significantly higher than those students who used either the Geometry Textbook or the GeoSET materials. Additionally, the adjusted means scores of students who used the GeoSET materials were greater than those who used the Geometry Textbook, but not statistically different.

Results for Research Question #2

Analysis of variance was conducted on the 10 items from the Curriculum Preference Survey amenable to Likert-type scores to determine whether differences among students using the various curricula were apparent. Table 5 presents descriptive statistics as well as the ANOVA and post hoc analyses for these items.

Table 5
ANOVA Results of Survey Items

	Geometry Text			University Packet			GeoSET			
	N	*M*	*SD*	*N*	*M*	*SD*	*N*	*M*	*SD*	*F*
Item 9	22	2.91b	0.68	57	1.32a	0.47	47	1.34a	1.22	30.84***
Item 10	22	3.36b	1.05	57	3.32b	1.24	47	2.23a	1.03	13.78***
Item 11	22	2.27b	1.32	57	2.40b	1.22	47	1.49a	0.91	8.95***
Item 12	22	2.32b	1.25	57	2.47b	1.15	47	1.66a	0.82	8.00***
Item 13	22	3.05b	0.95	57	2.72ab	1.22	47	2.21a	0.91	5.35**
Item 14	22	2.86b	0.94	57	2.61ab	1.13	47	2.21a	0.83	3.79*
Item 15	22	3.14b	0.83	57	2.46a	1.05	47	2.32a	0.84	5.92***
Item 16	22	2.91b	0.97	57	2.54ab	1.17	47	2.09a	0.95	5.08**
Item 17	21	3.29b	0.96	57	2.61a	1.19	47	2.36a	0.92	5.55***
Item 18	21	3.10b	1.18	56	3.05b	1.23	47	2.36a	0.97	5.70***

* $p < .05$; ** $p < .01$; *** $p < .005$

There were significant differences among the curriculum groups on all items. Post hoc analyses of the items found to be significant were performed.

Four particular trends were observed in the results. First, students using the GeoSET materials had significantly higher mean scores than students using both the Geometry Textbook and the University Packet on the following items:

- Item 10: To what extent did you read the textbook or course packet outside of class;
- Item 11: How often did you use the textbook or course packet to assist you in completing homework; and
- Item 12: How often did you use the textbook or course packet to assist you in preparing for exams.

Second, students using the GeoSET materials and using the University Packet had significantly higher mean scores than students using the Geometry Textbook on the following items:

- Item 9: To what extent was the textbook or course packet used for in-class activities?
- Item 15: How helpful was the textbook or course packet in learning about three-dimensional solids; and
- Item 17: How helpful was the textbook or course packet in learning about motions in the plane, i.e. translations, rotations, reflections, and magnifications/dilations.

Third, students using the GeoSET materials had significantly higher mean scores compared to students using the Geometry Textbook on the following:

- Item 13: How helpful was the textbook or course packet in helping you learn geometry;
- Item 14: How helpful was the textbook or course packet in learning about two-dimensional shapes; and
- Item 16: How helpful was the textbook or course packet in learning about symmetry.

Fourth, there was no significant difference between students using the University Packet and students using either the GeoSET materials or the Geometry Textbook on Items 13, 14, and 16. The open-ended items were also included on the Curriculum Preference Survey to address research question #2. The following paragraphs describe features of the three curricula that students found supportive and not supportive as well as describe the students' recommendations for the curricula. In interpreting these results, one should note that the percentages below are based on responses to open-items. Thus, the percentages should be considered as a lower bound for the number of students that may agree with a particular type of comment, i.e., since these were open-ended items, students were free to comment on topics of their choosing and therefore may not have necessarily disagreed with comments by other students on other topics.

<u>The Geometry Textbook</u>

Twenty-seven students using the Geometry Textbook completed the Curriculum Preference Survey. This number is higher than the number of students included in the quantitative analysis, as the quantitative analysis did not include students that did not complete the pre- or the post-test. Overall, the students did not find the Geometry Textbook supportive of their learning, although some features were helpful. First, 44% of the students commented that the textbook did not include enough answers for the homework problems. These students explained that this prevented them from checking their answers on the homework and seeing how they were doing with understanding the material. As one student stated, "All of the answers were not in the book and therefore, I could not always check to see if I was correct in my way of thinking." Another common concern was that the textbook lacked and/or had poor explanations of the material (37%). Student comments included things such as "not enough explanations" and "didn't explain things well at all" to "there is too much broad information and not enough specific details" and "He [the author] also didn't explain geometry in simple terms". On a related note, 11% of the students commented that the textbook was difficult to understand. Finally, some students commented that the textbook seemed out of date (22%), contained some typos (15%), and lacked clear directions in the exercises (11%).

The students did remark that some aspects of the textbook were helpful for their learning. First, 22% of the students commented that the book contained several helpful pictures and illustrations. As one student commented, "The textbook was helpful because it had a lot of pictures." Another 22% of the students explained that the textbook contained helpful examples. Finally, 26% of the students found the reference material helpful, including the glossary, list of theorems, and index. As one student commented, "The definitions of geometrical shapes and the application of theorems were beneficial."

Not surprisingly, the majority of the students (63%) commented that they would not recommend the textbook for future course offerings, with only 15% of the students recommending it. Eleven percent of the students were unsure whether to recommend the textbook. They believed that better geometry books were available but were not familiar with these books so could not make an informed decision about whether to recommend the textbook.

The University Packet

The students found the University Packet more supportive of their learning. Sixty students using the University Packet completed the Curriculum Preference Survey. According to 32% of the students, the largest contributor to their learning was the convenience of having a packet as their primary textbook. The students explained that they liked having all of their activities and homework from the beginning of the semester. This allowed them to see what they would be studying next and/or what their homework would be for upcoming classes and also allowed the students to work at their own pace. Another benefit was that the packet kept all of their materials together – homework, worksheets, explanations, etc. Finally, the packet also allowed the students to take the pages out, to write in the packet, and to cut up various activities as needed. For example, one student commented, "It was nice to be able to take out pages to work on – especially when they needed to be rotated."

The students also mentioned other features that they appreciated about the packet. Some of the students were pleased with the affordability of the packet (22%) and that the packet provided multiple opportunities for valuable practice of the mathematical ideas (22%). Fifteen percent of the students commented that they enjoyed the activities. As one student commented, "I really enjoyed the activities. We were able to try things out and see for ourselves why formulas are true." Finally, some of the students commented that the packet directly contributed to their learning of geometry (10%) and that the packet was easy to follow and understand (8%).

The students did comment on some drawbacks of the packet. First, 45% of the students commented that the packet lacked explanations of the material and therefore it was difficult to use the packet for studying the material or for completing homework. One student wrote, "The course packet was not helpful because if there was anything I didn't understand in class or if I missed a day, I couldn't teach myself since it was only worksheets." Many of these same students commented that they wished there had been a textbook to supplement the packet. Another common concern was the lack of reference material such as a glossary and index (57%). For example, one student wrote, "There was no index or reference guide to help me locate specific information within the textbook." Another concern was the lack of examples found in the packet (22%). One student commented, "There were no instructions on how to do anything. If I was at home, I couldn't look at any examples because there were none." Finally, 18% of the students found the directions to be unclear.

Thirty-five percent of the students recommended using the packet for future offerings, while 37% percent of the students did not recommend the packet. Interestingly however, 28% of the students commented that they would recommend the packet if reference material, explanations, examples, and better directions were added.

The GeoSET Materials

Forty-eight students using the GeoSET packet completed the Curriculum Preference Survey. Many of the students' comments about GeoSET mirrored the students' comments about the University Packet. First, 33% of the GeoSET students commented for similar reasons that they appreciated the convenience of the curriculum being a packet. Second, 15% of the students stated that GeoSET directly contributed to their learning of geometry. One student commented, "I really enjoyed this packet. I felt as though it got the point across to me." Finally, the students appreciated that the packet was affordable (13%), was easy to read (10%), and allowed for multiple opportunities to practice using the various geometrical concepts (10%).

Forty percent of the GeoSET students commented that the packet contained too few explanations of the material or that the explanations were unclear. Thirty-one percent of the GeoSET students also commented that the directions for the various activities and exercises were unclear. Finally, 10% of the GeoSET students noted the lack of reference material.

Despite these similarities, there were two differences between the students' comments regarding the GeoSET packet and the University Packet. First, 23% of the GeoSET students liked the examples that were provided in the packet prior to the activities they were to complete. As one student commented, "Each section had instructions and problems worked out to help you understand them better." Second, 8% of the students commented that the GeoSET packet related to their future occupations as elementary teachers. One student wrote, "It made us think about how we would teach the material to elementary students."

Fifty percent of the students stated that they would recommend the GeoSET packet, while 25% of the students explained that they would recommend the packet if the directions for the activities were clarified, more explanations of the material were included, and/or the packet was paired with a textbook. Twenty-five of the students said they would not recommend the packet.

Discussion

Results from both research questions suggest that students using the University Packet or the GeoSET materials experienced the greatest learning gains, followed by students using the Geometry Textbook. On the post-test, students using the University Packet scored significantly higher than students using the Geometry Textbook or the GeoSET materials, and students using the GeoSET materials scored higher than students using the Geometry Textbook, although not significantly higher. This appears to imply that the University Packet contributed to more learning than the GeoSET materials; however, this result is tentative. Although the face validity of the post-test was ensured through agreement by each of the instructors, the specific objectives used to develop the test were taken from the University Packet, which was partially developed from the Geometry Text. That is, the content validity of the test was directly related to the University Packet, indirectly related to the Geometry Text, and related only through content to the GeoSET materials. This may explain the significantly higher scores from students who used the University Packet. Had the assessment been better aligned with the GeoSET materials, the results may have been more pronounced, and in fact, the results from the second research question allude to this possibility. On the Curriculum Preference Survey, the students reported that the University Packet and the GeoSET materials were more helpful in their learning of three-dimensional solids and of motions in the plane, while the GeoSET materials were more helpful than the Geometry Textbook in learning about geometry in general, about two-dimensional shapes, and about symmetry.

The most insightful information however appears to be evident in looking across the three curricula and noting the features of the curricula that supported the students' learning, as each curriculum did have at least some features that the students reported as beneficial and many features were common to two or more of the curricula. First, we note various features of the curricula that the students reported facilitated their use of the curricula. By use, we include reading the textbook, using the textbook to complete homework, and studying from the textbook for exams. Second, we note features of the curricula that supported the students' learning.

The most commonly cited aspect of the curricula that enhanced the students' use of the text was the availability of reference material, including an index, glossary, list of theorems, and table of contents. Without these items, students commented that they had difficulty locating information on a given topic in the text; thus making it difficult to use the text for studying outside of class. The second most common feature contributing to use was the convenience of having a packet versus a bound textbook. A packet allowed the students to take the pages out, to cut them up or rotate them as needed for the various activities, and to keep all aspects of the course in one central place. Some other features contributing to use included affordability, not being out of date, and being free of several typos and errors.

With respect to features that supported the students' learning of geometry, the most desired feature was helpful explanations of the material. The most common concern expressed by the students across the three curricula was a lack of explanation of the associated concepts. Without these explanations, students felt that their studying outside of class was limited as they had no written source they could consult for making further sense of the material. The second and third most common features that did support the students' learning included the inclusion of pictures and examples and of multiple opportunities to practice working with the various mathematical ideas. Many students commented that the illustrations and the examples included in the curricula assisted them with making sense of the mathematics, and many students commented on the value of being able to practice using such mathematical ideas. Another feature that the students found to be supportive of their learning was the various activities included in the curricula. These activities allowed the students to think about the geometry concepts in a fashion that built on their existing knowledge and that allowed them to make sense of the concepts rather than being "told" about the concepts. A final feature that many of the students mentioned was the readability of the text. Table 6 below provides a summary of the features that supported students' use of the curricula and that supported students' learning of geometry.

When selecting a geometry curriculum for preservice elementary teachers, ideally instructors should seek textbooks with the features identified in Table 6. Specifically, features that support the use of a textbook might be of paramount concern. If students are not using the textbook, no matter how nicely the curriculum supports the intent and objectives of a course, such benefits will not be realized. In addition, with respect to the features that support learning, these characteristics also would ideally be present in the curriculum, but if not, these features point to aspects that instructors can be sure to incorporate into their instruction. For example, the instructors might make explicit connections between the mathematics that the preservice teachers are learning and their future roles as mathematics teachers. This helps to meet one of the overarching goals of a mathematics course for preservice teachers, and as commented on by some of the students using the GeoSET curriculum, was highly valued by the students.

Table 6

Beneficial Features of the Mathematics Curricula

Features Supporting Use	Features Supporting Learning
Adequate reference material	Thorough and clear explanations
Bound as a packet with removable pages	Helpful illustrations and examples
Up to date formatting and presentation	Multiple opportunities for practice
Free of major typos and errors	Exploratory activities
Affordable	Readability

As a result of what we learned through this study, we selected GeoSET as the primary curriculum for our geometry course for prospective elementary teachers. It aligns with the CBMS (2001) and NCTM (1999; 2000) recommendations, approached significance with respect to student achievement, and received the most favorable reviews from students in terms of use and of supporting their learning. In particular, as a packet the curriculum was convenient and helpful, affordable, and allowed the students to work at their own pace and keep all of their materials together. Furthermore, it contributed to the students' learning of geometry, provided them with valuable practice, and related to their future occupations as elementary teachers. However, unlike the University Packet, it was not merely a compilation of activities but also included some explanations, examples, and reference materials.

We have noted that many of the students commented that GeoSET contained too few explanations and some unclear directions for the activities and have been working to supplement these weaknesses through classroom instruction For example, when the materials seem to lack explanations of the ideas, additional class time is devoted to collectively creating, recording, and providing such explanations. Similarly, the instructors sometimes supplement the materials with additional opportunities to practice the material, with helpful examples and illustrations, and/or with exploratory activities, depending on the students' interaction with the material.

In order to further verify and investigate these recommended features, we note two things in particular that might assist with future research. First, it would be interesting to draw upon Hill, Rowan, and Ball's (2005) conception of knowledge of mathematics for teaching and some of their associated assessments. Knowledge of mathematics for teaching includes content knowledge along with specialized knowledge for teaching, such as being able to analyze students' mathematical thinking. As such, it would serve as a more appropriate measure for the pre- and post-test of what preservice elementary teachers need to know and learn about mathematics in order to instruct elementary mathematics. Second, this study mainly focused on what students liked and disliked about the three curricula versus what aspects of the materials accounted for the differences in learning gains. Further investigation into this might suggest a synthesis of curricular approaches that might lead to more effective materials from which preservice teachers learn.

As we and other teacher educators continue such investigations, we feel that there are two lessons from this study. The first is to seek curricula that contain many of the beneficial features identified here, such as a sufficient number of explanations and examples and varied opportunities for students to engage in the mathematics. The second lesson learned is that even after the selection of a curriculum, information from the students about how the text is and is not assisting their learning should be gathered. In this way, the instructor can supplement the textbook as needed. Learning occurs best when there is a synthesis between curriculum and instruction. No curriculum is perfect, but well-informed instruction can improve any curriculum.

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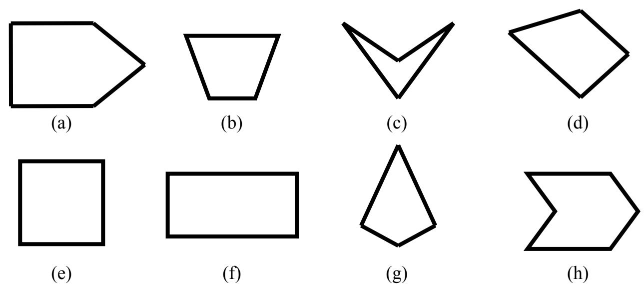
Appendix A: Objectives of the Pre- and Post-Tests and Actual Items from Post-Test

Objective 1: Given its definition, students will be able to identify two-dimensional shapes based on its properties.

Item 1: The UCSMP textbook *Geometry* defines a trapezoid as "a quadrilateral with at least one pair of parallel sides." Circle the letter of the following figures that would be classified as a trapezoid under this definition.



Objective 2: Students will be able to determine the measures of a central, vertex, or exterior angle of regular polygons, given the number of sides.

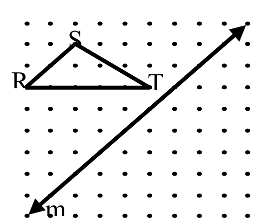
Item 2: A clock maker wishes to make a clock by inscribing a regular dodecagon (12-gon) in a circle. Determine the measure of a vertex angle of the polygon.

Objective 3: Students will be able to describe the rotational symmetries of two-dimensional figures.

Item 3: For the figures below, describe all rotational symmetries.

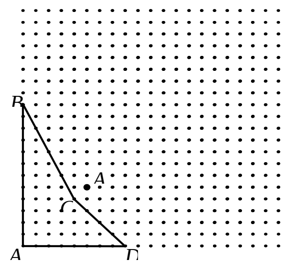
Objective 4: Given a line of symmetry, students will be able to draw the reflection of a two-dimensional figure defined by lattice points.

Item 4: On the dot paper below, draw the reflection image of the triangle *ABC* across the line *m*.



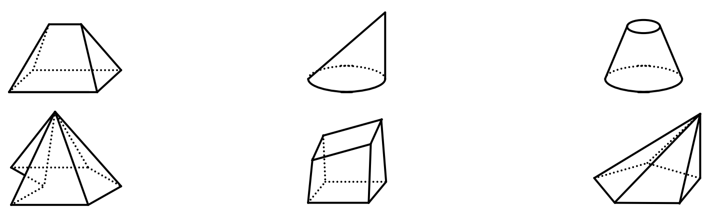
Objective 5: Given a figure defined by lattice points and a scale factor, students will be able to draw a similar figure at a given point.

Item 5: For the quadrilateral *ABCD* on the dot paper below, draw a similar figure magnified by a scale factor of $\frac{3}{4}$ and located so that *A′* is the image of *A*.



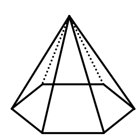
Objective 6: Given a perspective drawing of a three-dimensional solid, students will be able to identify a pyramid, cone, prism, or cylinder based on its properties.

Item 6: A *pyramid* is a three-dimensional solid with a polygon base that has straight-line elements joining every point of the base with a common point, the vertex. Next to each figure, write "yes" if it is a pyramid and "no" if it is not a pyramid.



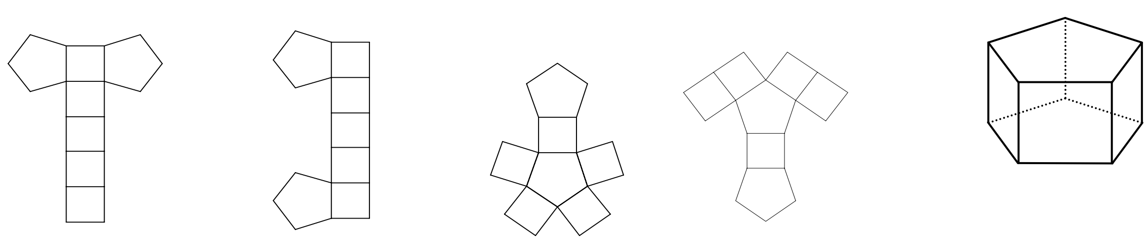
Objective 7: Given a perspective drawing of a three-dimensional polyhedron, students will be able to determine the number of faces, vertices, and edges.

Item 7: Determine the number of faces, vertices, and edges of the polyhedron on the right.



Objective 8: Given a perspective drawing of a three-dimensional polyhedron, students will be able to identify a corresponding net.

Item 8: Circle the shapes that could be folded to form the solid on the right.



Appendix B: Curriculum Preference Survey

Section I: Demographic Data
1. Gender: Female Male
2. Age: __________
3. Major: ____
4. Ethnicity: ____
5. Year in School: Freshman Sophomore Junior Senior Other

Section II: Impact of Textbook or Course Packet
For the following questions, refer to the textbook or course packet that you had to purchase for the course.
6. What was helpful about the textbook or course packet in your learning of geometry?
7. What was not helpful about the textbook or course packet in your learning of geometry?
8. Would you recommend that we use this textbook or course packet in future offerings of MATH 387? Why or why not?
9. To what extent was the textbook or course packet used for in-class activities?
Always Frequently Sometimes Infrequently Never
10. To what extent did you read the textbook or course packet outside of class:
Always Frequently Sometimes Infrequently Never
11. How often did you use the textbook or course packet to assist you in completing homework:
Always Frequently Sometimes Infrequently Never
12. How often did you use the textbook or course packet to assist you in preparing for exams:
Always Frequently Sometimes Infrequently Never

Section III: Assistance from the Textbook or Course Packet
13. How helpful was the textbook or course packet in helping you learn geometry:
Very Helpful Helpful Somewhat Helpful Rarely Helpful Not Helpful
14. How helpful was the textbook or course packet in learning about two-dimensional shapes:
Very Helpful Helpful Somewhat Helpful Rarely Helpful Not Helpful
15. How helpful was the textbook or course packet in learning about three-dimensional solids:
Very Helpful Helpful Somewhat Helpful Rarely Helpful Not Helpful
16. How helpful was the textbook or course packet in learning about symmetry:
Very Helpful Helpful Somewhat Helpful Rarely Helpful Not Helpful
17. How helpful was the textbook or course packet in learning about motions in the plane, i.e. translations, rotations, reflections, and magnifications/dilations:
Very Helpful Helpful Somewhat Helpful Rarely Helpful Not Helpful
18. How helpful was the textbook or course packet in learning about measuring length, area, and volume?
Very Helpful Helpful Somewhat Helpful Rarely Helpful Not Helpful