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ABSTRACT

This paper outlines the nexus between developing pedagogical content knowledge and the pressures for preparing pre-service teachers to be successful on high stakes testing. Increasing expectations about what students should know and be able to do, breakthroughs in research on how children learn, and the increasing diversity of the student population have significantly influenced the knowledge and skills teachers must have to meet educational goals for the 21st century. In mathematics undergraduate education, how pedagogical awareness is taught should relate to deeper and broader understandings of mathematical concepts for preservice teachers. A study was conducted with 193 students enrolled in their senior integrated methods block in the semester prior to beginning their student teaching. In an attempt to determine the effectiveness of the mathematics teacher preparation program, during the last week of their mathematics methods class, the students completed two assessment measures which examined their mathematics pedagogical content knowledge. Questions mirrored the pedagogical content questions on the state mandated teacher certification exam. Results indicated that previous mathematics ability was important to student success on all portions of the state mandated teacher certification exam. (Contains 30 references.) (SM)

Running head: TEACHERS ARE NOT BORN

Conventional Wisdom is Wrong: Anyone Cannot Teach and Teachers Are Not Born

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characterized as traditional teacher-education students. More specifically, they were mostly 20 – 22 year-old females in their senior year of undergraduate education. Ethnicity was predominately Caucasian, very few were Hispanic or African-American. Participants completed between 38 and 56 full days in elementary classrooms and had developed a weeklong integrated thematic unit and had written and taught a minimum of four constructivist lessons. Some students were enrolled in sections that included four days of field experience while others chose sections that included two-day field experiences each week. The students had also been involved in inquiry-type, hands-on, cooperative group activities involving the ten process and content strands of the *Principles and Standards for School Mathematics* (NCTM, 2000) during their mathematics block instruction. In addition, each participant maintained a reflective journal of classroom activities and field experiences. In one section, students were involved in working with math buddies.

Instrumentation

In an attempt to determine the effectiveness of the mathematics teacher preparation program, during the last week of mathematics methods class, (n=193) senior preservice teachers were administered two assessment measures. The first instrument was 15-item, multiple-choice mathematics pedagogical content knowledge instrument. Appendix A contains two sample items. This instrument was designed to mirror the pedagogical content questions contained on the ExCET test. Participants also completed a four item open-ended rubric-scored content and application instrument. Appendix B contains two sample questions. This instrument was adapted from the **PISA** International Test (www.pisa.oecd.org, 2000) and items were selected that covered the domains in

Appendix C, tested on the ECE 02 mathematics portion of the ExCET test. Because it is important to report the reliability coefficient for data in hand (Capraro, Capraro, Henson, 2001; Henson, Kogan, & Vacha-Haase 2001; Thompson, 1999) the Cronbach's alpha ($n = 193$) was .74 and .81 respectively for the two instruments.

In an attempt to achieve uniformity in administration, a test administration document was written and provided to all administrators of the instruments. Both instruments were considered for validity, content and construct validity were achieved by having four classroom teachers, and two mathematics teacher educators (not involved in the teacher preparation program) review the questions. After review, the original multiple-choice instrument was reduced from 20 items to the current 15 items. The open-ended instrument was shortened from the original six items to four items. Based on responses from the reviewers it was believed that the multiple-choice items sufficiently assess the understanding of pedagogical content knowledge, specifically to mathematics. The review of the second instrument was more varied. The majority of the reviewers believed that the instrument adequately assessed a narrow band of conceptual mathematics understanding. In subsequent semesters, an additional four questions were added to more adequately cover all of the domains tested on the ECE 02 portion of the ExCET test.

The test was administered during the last week of the spring 2001 semester across all sections of elementary and middle school methods blocks ($n=193$). Each mathematics methods instructor was responsible for administration of the instrument. Multiple choice answers were scored 1 correct and 0 incorrect. The rubric scoring guide is included in Appendix D for each item ranging from 0-4. Specific alignment was conducted then a

Abstract

This paper outlines the nexus between developing pedagogical content knowledge and the pressures for preparing preservice teachers to be successful on high stakes testing. Increasing expectations about what students should know and be able to do, breakthroughs in research on how children learn, and the increasing diversity of the student population have put significant pressure on the knowledge and skills teachers must have to meet educational goals set for the 21st century. Specifically, in mathematics undergraduate education, how pedagogical awareness is taught should relate to deeper and broader understandings of mathematical concepts for preservice teachers.

The participants (n = 193) were enrolled in their senior integrated methods block in the semester prior to beginning their student teaching. The results indicated that previous mathematics ability was important to student success on all portions of the state mandated teacher certification exam ExCET.

Conventional Wisdom is Wrong: Anyone Cannot Teach and Teachers Are Not Born

Various reform initiatives have produced documents calling for a new vision for the teaching and learning of mathematics (NCTM, 1989, 1991, 2000; National Research Council, 2001). These documents describe a very different role for the mathematics teacher compared to the more traditional one as described by other authors (Romberg & Carpenter, 1986). This change of role has led to the need for those responsible for the preparation of prospective mathematics teachers to examine their own roles and how these new teachers are being prepared. The responsibilities of institutions to preservice teachers revolve around providing access to appropriate mathematical preparation and creating a supportive learning environment. These opportunities maximize the chances that prospective teachers will have the solid mathematical preparation needed to teach mathematics to students successfully (Texas Statewide Systemic Initiative, 1998).

The Teaching Principle from the *Principles and Standards for School Mathematics* states that, "Effective mathematics teaching requires understanding what students know and need to learn and then challenging and supporting them to learn it well" (NCTM, 2000, p. 16). Effective teachers must have a profound understanding of mathematics (Ma, 1999). Profound, in Ma's description, has three related meanings: deep, vast, and thorough. A deep understanding is one that connects mathematics with ideas of greater conceptual power. Vast refers to connecting topics of similar conceptual power. Thoroughness is the capacity to weave all parts of the subject into a coherent whole. "Effective teachers are able to guide their students from their current understandings to further learning and prepare them for future travel" (National Research Council, 2001, p. 12).

Teaching and learning mathematics with understanding involves some fundamental forms of mental activity: (a) constructing relationships, (b) extending and applying knowledge, (c) reflecting about experiences, (d) articulating what one knows, and (e) making knowledge one's own (Carpenter & Lehrer, 1999). Some specific classroom activities and teaching strategies that support these mental activities, include appropriate tasks, representational tools, and normative practices that engage students in structuring and applying their knowledge. There may be differential effects of this type of instruction for some students (Secada & Berman, 1999). Classrooms that promote learning mathematics with understanding for all students involve a necessarily complex set of interactions and engagement of teacher and students with richly-situated mathematical content (Cobb, 1988). Within that richly situated learning environment, teachers must be able to build on students' prior ideas and promote student thinking and reasoning about mathematics concepts in order to build understanding (Kulm, Capraro, Capraro, Burghardt, & Ford, 2001).

Teaching mathematics effectively is a complex task. The National Commission on Teaching and America's Future (1996) stated that in order to teach mathematics effectively, one must combine a profound understanding of mathematics, with a knowledge of students as learners, and to skillfully pick from and use a variety of pedagogical strategies. To compliment this, The Texas Statewide Systemic Initiative (TSSI) in their document, *Guidelines for the Mathematical Preparation of Prospective Elementary Teacher* (1998) confirmed that the teaching of mathematics not only requires knowledge of content and pedagogy, but also requires an understanding of the "relationship and interdependence between the two" (p. 6). This was referred to as "pedagogical content knowledge" (Shulman, 1988) one of the seven domains of teachers' professional knowledge. Schulman defined this as "a knowledge of subject matter for teaching which consists of an understanding of how to represent specific subject matter topics and issues appropriate to the diverse abilities and interest of learners " (p. 9). This knowledge leads to the preparation of teachers who are capable of making instructional decisions that lead to meaningful activities and real-world experiences for the student in their future classrooms (TSSI, 1998).

Lloyd and Frykholm (1999) also found that future teachers need to develop both extensive subject matter background and pedagogical concepts and skills. In using middle-school reform-oriented teacher guides and student texts to work on activities, preservice teachers were able to recognize that "teaching demands extensive subject matter knowledge" (p. 578). These students found that even sixth grade activities posed significant mathematical difficulties for them. Capraro, Capraro, and Lamb (2001) found that having preservice teacher view an experienced teacher on videotape based on a lesson-planning document improved their ability to engage in self-reflection and to critically examine the educational practices of other teachers. As preservice teachers become aware of the intricacies of teaching they begin to exhibit a greater awareness of guiding students from current understanding to deeper conceptualization.

Unfortunately Ball and Wilson (1990) found that teachers are tied in general to procedural knowledge and are not "equipped to represent mathematical ideas to students in ways that will connect their prior knowledge with the mathematics they are expected to learn, a critical dimension of pedagogical content knowledge" (c.f. Fuller, 1997, p. 10). Fuller (1997) found that teachers with experience in the classroom had a better conceptual understanding of numbers and operations than did preservice teachers, however, both groups had mainly a procedural knowledge of fractions. Both groups of teachers felt that a good teacher was one who demonstrated to students exactly how to solve problems.

Often teachers who are stressed with all of the dilemmas of teaching are pressed for time and are consumed with pressures from administrators and parents. It is these teachers who revert to teaching the way they were taught, procedurally based. It is no surprise that these same teachers grapple with how to modify and present ideas to students that are meaningful (Ball & Wilson, 1990; Borko, Eisenhart, Brown, Underhill, Jones, & Agard, 1992; Onslow, Beynon, & Geddis, 1992).

Realizing the importance of conceptual understanding, Ginsburg, Lopez, Mukhopadhyay, Yamamoto, Willis, and Kelly (1992) suggest that mathematics should be taught as a thinking activity. Doing this requires that assessment methods provide ways of obtaining information concerning students' thinking, efforts at understanding, and procedural and conceptual difficulties. These assessments can provide those involved in preparing teachers with a richer level of understanding of what knowledge preservice teachers have as they move into their first years of teaching.

Preservice teachers must handle many different problems during their field experiences and ultimately future careers. "Because teaching and learning in increasingly diverse contexts are complex, prospective teachers cannot come to understand the dilemmas of teaching only through the presentation of techniques and methods"

(Harrington, 1995, p. 203). To be effective, preservice teachers must comprehend the awesome responsibilities and situations that lie ahead. Field-based assignments and clinical internships have provided students with limited opportunities due to their unique placements (Feiman, Nemser, & Buchmann, 1986). Therefore, to determine whether pedagogical content knowledge can be gained through experiences in a methods class or in a field-based classroom demands further study.

Statement of the Problem

Increasing expectations about what students should know and be able to do, breakthroughs in research on how children learn, and the increasing diversity of the student population have put significant pressure on the knowledge and skills teachers must have to meet educational goals set for the 21st century. Specifically, in mathematics undergraduate education, how pedagogical awareness is taught should relate to deeper and broader understandings of mathematical concepts for preservice teachers. Teacher preparation programs are often measured by state level teacher certification examinations. These examinations may or may not be correlated closely to specific grade bands or require content specific subtests for prospective elementary teachers. How do teacher preparation programs differentiate themselves from other institutions? An institution may prepare teachers with little consideration for their ability to actively inquire about the field they have chosen. While other institutions may embark on a path of professionalization that include but are not limited to participation in professional organizations, active use of practitioner journals, and explicitly teaching about curriculum awareness and its origins there is growing evidence that these practices positively influence pedagogical content knowledge. Teaching mathematics requires knowledge of content and pedagogy, and the understanding of the relationship between the two. How to assess understanding of the relationship of the two is one question facing one large university. This symposium will discuss attempts to determine appropriate ways to assess the effectiveness of the elementary/ middle school teacher preparation program in the areas of mathematics content and pedagogy.

Methodology

This study considers a quantitative analysis of the variables established as important to success in mathematics teaching as determined by high-stakes testing. A regression analysis was used in an attempt to identify variables useful in predicting student success on the ExCET test in general and specifically on the mathematics teaching subtest. A qualitative case study design was undertaken in an attempt to describe the phenomena present in a purposeful sample of undergraduate education majors. Three cases were studied for insights into the understanding of how preservice teachers with strong mathematics backgrounds develop pedagogical skills, how they plan for conceptual development, promoting student thinking and reflection, and building on student ideas in the development of mathematics conceptualization.

Participants

The study was conducted at a large southwestern state public university during the spring semester of 2001 and has also continued for three semesters with different students each semester enrolled in the senior methods block. The participants (n = 193) can be content analysis procedure was used to determine the content knowledge required for success on the item. An item analysis was conducted to assure that proper alignment was achieved between the NCTM standards and SBEC standards as tested on the ECE mathematics domains.

Results

Table 1 contains the results of the multiple linear regression with mathematics subtest **(ECE2)** as the dependent variable. The independent variables include: (a) the section in which the student was enrolled **(section)**, (b) success in previous mathematics courses **(math courses)**, (c) score on the post test pedagogical content knowledge test **(Ped. Cont.)**, (d) final **(grade)** in the mathematics methods course, and (e) the post test short version of the Open-Ended Contend Knowledge Test **(O-E Post Test S)**. In the regression model, of the 10.7% multiple R squared effect, the *B* weight of success in previous mathematics courses appears to be the most important predictor at $p = .024$. In examining the squared structure coefficients both the pedagogical content knowledge test and the open-ended content test are practically important predictors. The value of the predictors is not evidenced in the regression B weights because the variance accounted for is allocated by formula even though another variable may be equally important. For this reason it is important to compute and review squared structure coefficients to determine the practical importance of each variable in predicting the dependent variable. As Thompson and Borrello (1985) noted, "Logically, coefficients which are important in the canonical case may also be important in the case of multiple regression" (p. 208). These results seem to indicate that success in previous mathematics courses is strongly correlated to success on the ECE 2 portion of the ExCET exam. When considering the variable ***section*** there was no statistically significant effect. Therefore, the differentiated impact of a four-day versus a two-day field experience was not evidenced. In review of the B weight for section .256 weight was near last and when considering its square structure coefficient it is reveled that it accounts for only 3.9% of the variance accounted for in the model. This finding would indicate that the variable is neither statistically or practically important.

INSERT TABLE 1 ABOUT HERE

Several Pearson correlations indicate some interesting findings. First, in Table 2 the correlation between performance in prerequisite mathematics courses Math 365 and Math 366 and performance on subtests of the ExCET exam are statistically significant. The correlation between the performance in mathematics classes is strongly correlated to performance on the professional portion and more moderately correlated to the Elementary Comprehensive Examination (all six subtests). This suggests that students who do better in mathematics also do better on the yardstick by which the mathematics teacher preparation program is measured. The correlation between the previous mathematics performance is also strongly correlated to the pretest administered in the mathematics methods courses. This seems to match the results of the earlier finding that students who demonstrated lower performance levels in mathematics courses enter the mathematics methods course exhibiting many of the same strengths and deficiencies. However, when considering the correlation between previous mathematics courses and the posttest administered in the mathematics methods course, the correlation is almost zero. This finding seems to indicate that the previous student performance in mathematics was no longer important to performance on the posttest and that the methods courses improved mathematics content knowledge. A more disturbing correlation is between grade earned in mathematics methods and performance on various other measures. The grade earned in mathematics methods courses are negatively correlated to grades earned in mathematics courses and to the mathematics portion of the Elementary Comprehensive Exam (Mathematics). There is a relatively small (not statistically significant) correlation to both the pedagogy and open-ended tests administered in the methods block. As noted by other researchers grade inflation often accounts for such loss of predictability and indicates the uselessness of using grades earned in the regression equation. The shortened version of the Open-ended content instrument was correlated to the full length version with a result of r = .808 with a $p = .003$ which indicates the more parsimonious test adequately measures the trait of interest.

INSERT TABLE 2 ABOUT HERE

When considering a participant's section on student performance the only correlation was between previous mathematics course and the professional development portion of the ExCET test. The correlation was weak but indicated that students who had preformed better in previous mathematics classes had opted for sections offering four day field placements. Because of the strong correlation between previous mathematics courses and performance on the ExCET in general the effect was evidenced in the correlation with section as well.

Cases

As mentioned above, teaching and learning in increasingly diverse contexts is complex and prospective teachers cannot come to understand the dilemmas of teaching only through the presentation of techniques and methods. Preservice teachers require field experiences and clinical internships that provide for opportunities to work with and teach mathematics concepts to children to develop deep conceptual understanding of how to teach mathematics to children. To extend the study further--beyond test scores and course grades--individual cases were considered to describe the mathematics teaching performance of three senior interns in a classroom setting.

The interns were provided opportunities to teach mathematics concepts to fourth grade students during a one-hour session, for four weeks, as part of a mathematics methods course. A theme was provided for each week (i.e., computational fluency, problem solving, communication, estimation). Based on pre-assessment data from their mathematics buddy, interns designed mathematics lessons based on objectives related to the theme standards. After each session, interns reflected on their teaching performance in whole class format and in a written reflection submitted for evaluation.

Each of the three interns involved in this study took their mathematics courses through the university and received grades of either A or B. Scores on the mathematics portion of the SAT were 540 or better. Table 3 further describes their mathematics background and performance on the two instruments administered as part of this study.

Test scores, course grades and performance on the administered instruments indicated the interns had a mathematics background effective for the teaching of elementary school mathematics. However, their planning and teaching of lessons to their mathematics buddy showed some subtle differences.

INSERT TABLE 3 ABOUT HERE

Sally loved math and showed excitement for having the opportunity to design activities around a mathematics concept to teach to her buddy. Sally was confident in her ability to teach mathematics, designed meaningful learning opportunities each week, and her reflections consistently identified strengths and weaknesses of her teaching. She was able to identify and discuss effectively the strategies used by her buddy as she approached a learning task or solved a problem. During the third and fourth session, Sally was able to connect student learning to other content areas--specifically science and language arts.

Jane was the conscientious intern with good planning skills, a strong academic background, and experience with the use of technology. However, her confidence in her ability to teach mathematics effectively to elementary students was minimal at the beginning of the semester. She explained to me that she decided on a social studies emphasis because she felt she could not pass the additional required mathematics classes for a mathematics emphasis, and she preferred social studies to science. Jane was very capable of designing meaningful mathematics activities for her math buddy, but was always very critical of her teaching ability. During the four weeks of the math buddy sessions and throughout the methods semester, Jane gained confidence in her teaching abilities--especially in mathematics and science after experiencing positive reactions of students to activities she planned for her unit and taught during the math buddy sessions. Jane used resources to her benefit and had the necessary knowledge to be able to plan and teach lessons that were standards-based and encouraged students to be active learners. Jane commented at the end of the semester that she enjoyed teaching math and science and felt she might even be good at it with a little more experience.

Molly was an early childhood emphasis with much experience in working with and teaching elementary students. She had been a HOST volunteer and had been a substitute in a local district to gain experience in teaching children prior to the methods block semester. Molly was at the stage of "trying to put it all together" as she commented. A reflection, submitted by Molly of a math buddy session, illustrates this idea and indicated some conceptual misunderstandings during the session. To begin this session, Molly provided learning experiences for her math buddy focusing on equivalent fractions. Fraction squares and circles were used during the session to model the fractions. Molly wrote:

> After we had all the pieces out, I went back to try and assess his understanding of equivalent fractions. I asked him how many fourths make one half. He struggled with this and looked at me with a blank stare and then guessed four. I asked him why he thought four, and he couldn't given any explanation. So I had him show me one half of a circle, and then I had him cover it with fourths. He then realized that it only took two fourths to make one half. So I said, are the fractions 1/2 and 2/4 equivalent? He said yes and explained because they take up the same amount of area. I continued this with him for fourths, eighths, and sixteenths. He was able to do this by putting pieces on top of the others....After I felt he had a good grasp of equivalent fractions, I moved on to a game. The game required him to turn over two fraction cards and decide whether they were equivalent. When he turned over the

> first two cards, I realized that he did not have a good understanding of how to simplify fractions. So, I didn't get to play the game as planned. Instead, I decided to use the fraction cards to decide if two fractions were equal. The first two fractions he turned over were 1/8 and 3/24. He didn't know where to begin, so I asked him to show me 24 divided by 3....He already knew that eight divided by one was equal to eight because any number divided by one is the same number. I then explained that since these numbers are the same the fractions must be equal....

During the session, Molly moved away from her intended objective of equivalent fractions and introduced the idea of equal fractions. She used division as a strategy but in the development of the ideas, her explanation was conceptually incorrect.

Discussion

If indeed these are the qualities of successful teachers of mathematics, how do teacher preparation programs go about assessing preservice teachers' understanding in the areas of mathematics content and pedagogy? The results of this study will contribute to the literature in three ways: (a) by providing a forum for communities of stakeholders to interact and respond to the position of one university, (b) by developing two instruments intended to empower teacher educators in the decision making process, and (c) by exploring a process often reserved for states in the assessment of teachers leaving a teacher preparation program. If indeed it is important for preservice teachers to develop pedagogical content knowledge and it is possible to assess it then what is the appropriate tool? How should teacher preparation programs go about assessing preservice teachers' understanding in the areas of mathematics content and pedagogy?

It is evident from this study that preservice teachers learn and develop as teachers throughout their education. There is no silver bullet that takes place during the methods courses that either makes or breaks a future teacher. However, there are indications from this study about some important factors that lead to success as measured by state accountability instruments. First, it is impossible to divorce mathematics content from the teaching and learning process of mathematics methods. Students who have a better background in mathematics are more open and able to comprehend the conceptual development ideas contained in mathematics methods. Second, however important field experiences are, they are insufficient alone. This study clearly delineates the idea that simply being in a field-based assignment for a longer period of time has no measurable short-term effects. Long-term effects are yet to be determined. For instance, if a preservice teacher is placed in a prolonged field experience with a mentor who exhibits the qualities of a nationally recognized mathematics teacher, one would expect that the mentors ideas, beliefs, and interpersonal abilities would be learned by the impressionable mentee. In contrast, if the preservice teacher is placed in the classroom where the teacher lacks 'math power' and strongly believes in using worksheets and high-stakes test preparation materials over conceptually based activities and curricula, the methods instructor will find it almost impossible to convey the importance of teaching conceptually. It is reasonable to believe that in moderation there is a place for everything. By improving the quality of what preservice teachers' see and participate in and by limiting negative influences it is possible to convey the intrinsic value of 'math power' and help preservice teachers develop a mathematically inquiring mind with the tools to find the answers to teaching mathematics with understanding to their students.

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Appendix A

Use the student work sample below to answer the question that follows.

> Name: *Juanita*
>
> Problem: The sun is 785,354 miles away from the earth. If it takes a spaceship 4 days to go from the earth to the sun, how fast did the space ship travel? Use your calculator to solve the problem, and explain how you got your answer.
>
> Answer: *81.8077 miles per hour*
>
> How did you get your answer? *First I figured out how many hours there are in 4 days, which is 96 hours. Then I divided the distance to the sun by the time it took the spaceship to get there.*

Juanita, a sixth-grade student, used a calculator to solve the word problem above. When going over Juanita's work with her, the teacher should place the greatest importance on which of the following?

A. reminding Juanita that she should always do each calculation several times whenever she is using a calculator

B. asking Juanita to estimate the answer to the problem in order to assess the reasonableness of the answer on the calculator

C. reviewing with Juanita the rules for the conversion of units within the same system of measurement

D. asking Juanita to try to think of another method to use to solve the problem.

Students in a fourth-grade class are measuring the circumference and diameter of common objects to the nearest centimeter. Some of their data are displayed in the table below.

Object	Diameter	Circumference
Soup can	2cm	6cm
freesbee	4cm	12cm
dish	6cm	18cm

The teacher could best develop students' understanding of the concept of a function by posing which of the following questions about the data?

A. Do objects with larger diameters always have larger circumferences than objects with smaller diameters?

B. Do you think the data in your table would show a different trend if you were using more precise measurement tools?

C. How can you use the data in your table to calculate the area of the circles you have measured?

D. If you knew the diameter of a circle, how could you determine the circumference without measuring it?

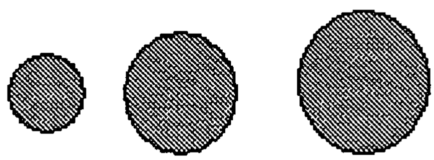
Appendix B

Question 1: Pizzas

A pizzeria serves two round pizzas of the same thickness in different sizes. The smaller one has a diameter of 30 cm and costs 30 zeds. The larger one has a diameter of 40 cm and costs 40 zeds. Which pizza is better value for money? Show your reasoning.

Question 2: Coins

You are asked to design a new set of coins. All coins will be circular and colored silver, but of different diameters.



Researchers have found out that an ideal coin system meets the following requirements: diameters of coins should not be smaller than 15 mm and not larger than 45 mm.
Given a coin, the diameter of the next coin must be at least 30% larger. The minting machinery can only produce coins with diameters of a whole number of mm (e.g. 17 mm is allowed, 17.3 mm is not).
You are asked to design a set of coins that satisfy the above requirements. You should start with a 15mm coin and your set should contain as many coins as possible.

Appendix C

ECE 02	**Domain Descriptions**
020	Higher-order Thinking and Questioning
021	Problem-Solving Strategies
022	Mathematical Communication
023	Mathematics in Various Contexts
024	Number and Numeration Concepts
025	Patterns and Relationships
026	Mathematical Operations
027	Geometry and Spatial Sense
028	Measurement
029	Statistics and Probability
030	Recent Devoplments and Issues in mathematics

Appendix D

Rubrics for International Test of Mathematics Skills (TEFB 412) based on Balanced Assessment Rubrics

Question 1 (Pizza)

Student A: Incomplete or no process without any demonstration of mathematical solution (intuitive solution)

Student B: Incomplete process. Demonstrates some mathematical understanding of the concept. No or partial incorrect solution. No or partial process or explanation.

Student C: Complete process. Proper application of mathematical relationships. Incorrect arithmetic or Incorrect interpretation of numerical results.

Student D: Complete process. Proper application of mathematics relationships. Correct solution and interpretation. Evidence of understanding that the comparison is based on cost per unit.

Question 2 (Coins)
Student A: Incomplete or no process shown whether answer is correct or not
Student B: Incorrect process shown such as 30% uniformly added to first coin and that amount added to all succeeding coins
Student C: Correct process shown, minor miscalculations; started correctly but did not complete all five coins
Student D: Logical correct process carried out, all steps shown, correct coins created
Student N: No response

Question 3 & 4 (Formula for Distance and Time)

Student A: Process not correct whether answer was correct or not
Student B: Process appears correct, however, miscalculations lead to incorrect responses
Student C: Shows correct process leading to correct answer; all steps shown or appropriate mental calculations
Student D: Process correct and answer correct; identified what answer represented
Student N: No response

Table 1
Summary of Regression Analysis for Variables Predicting a Passing Score on the Elementary Comprehensive (ECE2) Portion of ExCET Exam (n = 193)

Variable	B	Beta	R_s^2	t	Sig.
Constant	-57.101			-.374	.709
Section	.256	.003	.039	:840	.402
Math Courses	3.704	.191	.489	2.281	.024
Ped. Cont.	.611	.069	.387	1.644	.102
Grade	.037	.139	.024	.032	.975
O-E Post-test S	-1.022	.156	.415	1.809	.043

Note. R Square=.107; p= .008

Table 2

Correlation Matrix between, Previous Math Courses, Performance on the Professional and Elementary Comprehensive exams, Pedagogical Content Score, The Short and Long versions of the Content Test Score, Section, Grade in Mathematics Methods, and Performance on the Mathematics portion of the Elementary Comprehensive Exam.

	Math Courses	PD ExCET	ECE ExCET	Ped. Cont.	O-E Content S	O-E Content L	Section	Grade
Math Courses	1.000							
Math Courses	1.000							
PD ExCET	**.466	1.000						
PD ExCET	**.466	1.000						
ECE ExCET	**.442	**.733	1.000					
ECE ExCET	**.442	**.733	1.000					
Ped. Cont.	.097	.139	**.225	1.000				
Ped. Cont.	.097	.139	**.225	1.000				
O-E Content S	.140	.118	**.227	**.210	1.000			
O-E Content S	.140	.118	**.227	**.210	1.000			
O-E Content L	a	a	a	**.389	**.808	1.000		
O-E Content L	a	a	a	**.389	**.808	1.000		
Section	*.119	*.144	.109	.035	.025	-.027	1.000	
Section	*.119	*.144	.109	.035	.025	-.027	1.000	
Grade	**-.154	*.225	**.214	.041	.115	a	.085	1.000
Grade	**-.154	*.225	**.214	.041	.115	a	.085	1.000
ECE2	**.355	**.577	**.798	**.207	*.199	a	.082	*-.128
ECE2	**.355	**.577	**.798	**.207	*.199	a	.082	*-.128

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).
a Cannot be computed because at least one of the variables is constant.

Table 3
Summary of Mathematics Background and Scores on Instruments for Preservice Teacher Cases

	Certification	Math Courses	GPR	SAT (Math)	ExCet (Math)	Open-Ended Pre	Open-Ended Post	Mulitiple Choice Pre	Multiple Choice Post
Sally	4-yr INST Mathematics	18 hrs A-B	3.36	550	--	22	27	13	14
Jane	4-yr INST Social Studies	9 hrs B	3.43	540	85	19	20	11	12
Molly	Early Childhood	15 hrs A-B	3.84	550	--	7	17	13	14

Note. Mathematics Courses consistent among all interns: Math 365 and Math 366. Maximum score on open-ended instrument was 30. Maximum score on multiple choice instrument was 15.

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