IUMPST: The Journal. Vol 3 (Technology), August 2013 [www.k-12prep.math.ttu.edu]
ISSN 2165-7874

Pre-service Elementary Teachers' Perceptions of a Modified Peer Instruction Implementation of Clickers in their Mathematics Content Course

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Abstract

This article discusses pre-service elementary teachers' feedback regarding an implementation of a personal response system (clickers) in their mathematics course. A modified peer instruction model used clickers as a preliminary to class exploration of mathematical content. Classes of approximately 30 students included six lessons that were enhanced with clicker questions. Most students expressed favorable perceptions of the clickers and clicker lessons. Students felt that the inclusion of clickers helped them to better learn and understand course material, with most identifying a mathematical topic for which they attributed a better understanding to clicker lessons.

Introduction

Personal response systems, or clickers, are an increasingly common addition to both k-12 and higher education instruction. Clickers enable individual students to send their responses wirelessly to a classroom computer upon which the instructor presents questions and can display a graph detailing the students' answers. Pedagogically appropriate methods for implementing clickers continue to be developed through experimentation in the classroom. The body of research examining the impact of clicker use upon measured learning outcomes and identifying effective practices in consideration of predominant learning theories, while limited, continues to grow.

Clicker use can promote the development of active learning environments by requiring students to provide feedback during class time (Bruff, 2009). Studies have shown the inclusion of clickers to have positive effect upon student retention and upon measured academic outcomes in a variety of disciplines (Boatright-Horowitz, 2009; Liu & Stengel, 2009; Sevian & Robinson, 2011). A proper implementation model can provide immediate bi-directional feedback between the student and the instructor (Boatright-Horowitz, 2009; Bruff, 2009; Strasser, 2010) and can also promote class discussion and critical thinking (Lucas, 2009; Mollborn & Hoekstra, 2010).

Research further demonstrates that students generally express favorable attitudes toward clicker use in classes from a variety of disciplines, particularly when the class population is large (Duncan, 2005; Martyn, 2007; Milner-Bolotin, Antimirova & Petrov, 2010; Trees & Jackson, 2007; Wolter, Lundeberg, Kang & Herreid, 2011). A number of factors influence these perceptions, including an individual's gender and major, and the type of clicker used (Wolter, et al., 2011). Additionally, the cost of the clickers, inconsistent operation of the computer and clicker system, and the potential for incorrect responses to adversely affect one's course grade can negatively influence students' attitudes (Chessman, Winograd & Wehrman, 2010; Strasser, 2010).

The effectiveness of a clicker implementation, as with any teaching innovation, hinges upon a seamless introduction into the curriculum. The potential advantages of clicker use must align well with both the course content and course objectives. Factors that can potentially influence students' "buy in" with the technology must be addressed (Bruff, 2009), as students' perceptions of the task and intended outcomes will influence their motivation and participation and, in turn, realized learning outcomes (Crawford, Gordon, Nicholas & Prosser, 1994; Prosser & Trigwell, 1997). Additionally, the model for clicker use discussed here requires interaction with peers, which exposes learners to varied learning approaches and others' beliefs, perceptions, and existing knowledge, all of which directly influence how and what an individual learns (Vygotsky,1978). To develop effective and meaningful learning communities, the design of learning tasks must consider contextual factors, individuals' needs, and established learning goals (Ball,1996; Lave & Wenger,1991; Stemler, Elliott, Grigorenko & Sternberg, 2006). Understandings of individuals' needs and perspectives can ensure that refined teaching innovations allow for sufficient individual reflection upon mathematical content, and development of personally meaningful understandings of mathematics content by demonstrating understandings and abstractions via interaction with the technology, instructor, and peers (Bender, 2003; Cobb & Bowers, 1999; Mishra & Koehler, 2006; Zenios, Banks & Moon, 2004). Students' attitudes toward the technology implementation and perceptions of the intended associated learning goals are important aspects of students' experiences in such learning opportunities (Miller, 2012).

This study examines pre-service elementary teachers' perceptions of clicker use in their college-level mathematics content course. The decision to integrate clickers into the course was two-fold. The first objective was to expose future teachers to a technology that they will likely encounter in their future teaching careers. The need to model appropriate use of technology in the mathematics classroom for pre-service teachers is essential toward developing technological pedagogical content knowledge and promoting effective technology use in their future careers (Mishra & Koehler, 2006; Ronau, Rakes, Wagener, & Dougherty, 2009; Schneiter, 2010). Proper use of technology is an increasingly critical component of mathematics instruction that has long been encouraged by the National Council of Teachers of Mathematics (NCTM, 2000), and appropriate modeling for future teachers continues to be a goal of the Association of Mathematics Teacher Educators (AMTE, 2006).

Secondly, a technology was desired that would further promote course objectives: namely, communication about and with mathematics as well as development of deeper and personally meaningful understandings of mathematics content. These goals connect with the *NCTM Principals and Standards* (NCTM, 2000) and the newly developed *Common Core State Standards for Mathematics* (National Governors Association Center for Best Practices, 2010). The experiences of student teachers in the field, coupled with the experiences of colleagues who were already using the technology in their disciplines, led to the implementation of clickers. As research regarding clicker use in small, major-specific, and mathematics college courses classes is limited, the study detailed here aimed to develop an understanding of students' perceptions in these types of courses. Specifically, the study was designed to gain students' feedback regarding the specific structure of the implementation model, the appropriateness of the model for the course, as well as details concerning how students felt clicker lessons influenced their learning of mathematics content.

ISSN 2165-7874

Context

Participation via clickers was integrated into four sections of the first in a two-course sequence of mathematics for elementary teachers, initially in a spring semester and again in the subsequent fall semester. The course was three credits, with two sections meeting for three 50-minute periods per week and two meeting for two 75-minute periods each week. Mathematics topics included number systems and operations, inductive and deductive reasoning, sets and Venn diagrams, and algebraic representations. Instructors employed a constructivist approach to the course, modeling learning activities, manipulatives, and technology appropriate for the elementary grades but pushing to deeper levels of understanding necessary for a career as an elementary teacher. Collaborative activities in groups of two to three students were a regular component of class discourse. The study of teaching methods was reserved for a later education course. Although demographic data was not collected, the vast majority of these students were females in their freshman or sophomore year. Altogether, 122 students from the four class sections used clickers in this study, with 57.8% (n = 70) reporting that they had no previous experience using personal response systems.

Sections of the course were taught by two different professors as detailed in Table 1, and were included in the study due to the willingness of their instructors.

Table 1
Course Section Details

Instructor	Semester	Number of Students
A	Spring	31
A	Fall	32
B	Spring	32
B	Fall	27

Students did not know in advance that clickers would be used in the courses. Instructor A had one semester of experience in using the technology, but only for the purpose of giving occasional reading quizzes at the beginning of class. Instructor B had no previous experience in using the classroom technology. Clickers were not used daily; instead, clicker questions were incorporated throughout six distinct lessons spread throughout the semester, focusing upon the following topics: deductive reasoning, sets and Venn diagrams, numeration and base arithmetic, multiplication algorithms and models, divisibility, and applications of prime factorization. These topics were selected because their associated lessons had lacked interactive and collaborative components common to most course lessons. Questions were multiple choice, with occasional questions allowing for multiple correct answers or for “none of the above.” See Appendix A for the full set of questions used in each lesson. Seven to nine questions were interspersed throughout any given lesson. A classroom set of clickers was obtained using a university-awarded technology grant, with students assigned by number to a specific clicker. Students were not graded on their responses, although they were aware that the instructor could later access and examine their individual responses and that content covered by the questions would reappear in homework assignments, quizzes, and exams.

Although a common practice, clickers were not instituted as a means to take attendance or administer assessments. Instead, a model was sought that would promote development of meaningful understandings with an emphasis on communication of mathematical concepts. An answer-discuss-answer model was used, similar in nature to the modified peer instruction model (MPI) described by Milner-Bolotin et al. (2010). This approach also aligns with the common educational practice of think-pair-share, in which students examine a question or topic individually, next work with partners or a small group, and finally share their findings in groups with the entire class (Lyman, 1981). When using the clickers, students would first answer the question individually, after which a bar graph of all students' responses would be displayed. Students would then be directed to discuss their answers with the other one or two groupmates. During this discussion, students would argue their approaches and rationale to their peers. Next, the entire class would answer again, after which a bar graph with students' responses would be displayed that also indicated the correct answer. A full-class discussion of the concept then followed.

Methodology

To better understand students' perspectives of the clicker implementation, a one-page questionnaire was distributed in class near the conclusion of the semester. This survey is provided in Appendix B. Common questions were asked of all four sections, and Instructor A asked additional questions to further explore students' beliefs. Surveys were completed anonymously, and responses were triangulated with an instructor journal noting students' interactions with clicker technology and with additional items asked on end-of-the-semester course evaluations from the two sections taught by Instructor A.

As the gathered data set was small and varied with additional questions asked of select class sections, the opportunity for statistical analysis was limited. Resultantly, basic statistics were calculated for responses to survey and course evaluation items. An inductive approach was undertaken for the qualitative analysis of the free-response data. This analysis sought convergence of recurring themes, ensuring that similarly coded data meaningfully belong together within a category and verifying the clarity of differences between categories (Johansson, Marton & Svensson, 1985; Patton, 2002; Sandberg, 1996).

Students' Perceptions

On end-of-the-semester course evaluations, students in Instructor A's spring group reported a 9.1/10 mean to the statement "The use of PRS clickers was beneficial in this course." This over-arching result is indicative of students' feedback to specific survey questions. On the questionnaire, students were first asked to share their general impressions regarding how clickers were used in the course. The clicker lessons proved popular; of the 122 students from the four sections using clickers, 117 (95.9%), indicated that they generally liked the use of clickers in the course, with only three (2.4%) disliking the implementation and two (1.6%) unsure. A slightly smaller but still significant 109 students (89.3%) believed that the use of clickers had assisted them in learning and/or understanding course material. Four students (3.3%) did not believe this to be true for them, and nine students (7.4%) remained unsure. To compare students' responses across the two instructors Fisher's exact test was calculated, as a chisquare test would prove unreliable due to the low counts for students responding unfavorably or uncertain toward the implementation. The results revealed no significant differences at the 0.05 level for the proportions of students both liking the clicker implementation and viewing it as benefitting the learning process. Thus, instructor bias was not evident in terms of students liking the implementation or believing that clicker use was beneficial for learning.

ISSN 2165-7874

Of the 63 students in Instructor A's classes, 55 (87.3%) responded favorably when asked if the inclusion of clickers led to a better understanding of course content. When asked to describe how they believed that using clickers improved their understanding of course content, students provided four general perceptions as displayed in Table 2. Discussion of the mathematics content, resulting in additional thinking about the mathematics, was reported by a majority of the respondents. This feedback reveals that students did not attribute improved learning to the technology itself, but rather to the way in which it was implemented.

Table 2

Perceptions of Specific Potential Benefits of Using Clickers – Instructor A's Classes

Response	N	%
Discuss for understanding and think about content	36	57.1%
More accountability and involvement; fun	14	22.2%
Additional notes and examples for reinforcement	8	12.7%
No perceived positive effect	3	4.7%

Students for both instructors were also asked if they could identify or describe at least one specific topic or mathematical concept for which they gained a better understanding as a result of using clickers. The four leading results are provided in Table 3, and align with topics addressed by four of the six clicker lessons.

Table 3

Topics Identified as Better Understood Due to Clicker Use

Identified Topic	n	%
Sets & Venn Diagrams	69	56.6%
Numeration/Base Arithmetic	20	16.4%
Deductive Reasoning	17	13.9%
Divisibility	9	7.4%

Additionally, three students each (2.4%) indicated terminology or properties, two generic aspects that were included in all clicker lessons, as content that they better learned via clicker use. Seven students (5.7%) were unable to identify any specific topic or course concept, even though they continued to claim that the use of clickers in the class was beneficial to their learning of mathematics content. The recall of the Venn diagrams lesson, the second clicker lesson of the semester, was noted by a majority of the students surveyed. Comparisons of the proportions of responses across instructors were again examined via Fisher's exact test, as some students provided more than one topic in their response and were therefore double-counted in the sums by providing multiple topics and the counts for some items were low. For the seven categories evident in responses, there were no significant differences at the $0.05/7= 0.00714$ level. That is, no instructor bias was evident for the recalled topics that students provided or for students' inability to recall a specific topic addressed by one of the six clicker lessons.

While students claimed that clicker lessons assisted them in learning course content, this was not what they reported as the course aspect most influenced by the use of clickers. Table 4 presents Instructor A's students' perceptions concerning how their course experience was changed by the inclusion of clicker lessons. The influence of clicker use upon learning was perceived as a distant second behind providing a fun variation to lessons. In regard to the variation clickers introduced to the course, one student wrote, "I always looked forward to clicker days. It made me excited to learn the new material because it was like a competition!" This notion of "competition" is worthy of further discussion. Clickers were not implemented as part of a game or competition; that is, no points were awarded, no teams were formed, and those with successful responses were not recognized in class. Further, there was no direct grade motivation, as grades were not influenced by responses via the clickers. Despite this, instructors reported that the more competitive students in the classes seemed to view the answering of clicker questions as a competition. This was increasingly evident in their classroom demeanor as noted in the instructor's journal and in students' survey feedback. Meanwhile, this perception of the clicker implementation was not expressed by the less competitive students in the class and, based upon their classroom participation and survey feedback, the competitive nature their peers adopted did not negatively influence their overall perceptions of the clicker usage. In particular, one non-competitive student wrote that "the clickers changed my experience by allowing me to converse with my tablemates and feel more comfortable asking questions."

Table 4

Perceived Changes to the Course Experience Due to Clicker Use – Instructor A

Change to Course Experience	n	%
Variation in lessons/fun	34	54.0%
More thinking/better understanding	16	25.4%
More notes/reinforcement/review	8	12.7%
No change	4	6.3%

While the percentage (25.4%) of students reporting that the clicker implementation led to better understanding and more thinking about the course content was smaller than desired, it is encouraging that some students believed that the exercises influenced their learning process. One student provided a detailed description of how she believed the use of clickers affected her learning process. She stated, "That whole process facilitated (improved) my individual critical thinking as well as my ability to justify and explain my thinking to others. I do not believe that process would have been as effective without clickers." Others echoed this sentiment. One student noted the value of privately discovering a flaw in her thinking: "if I saw that the answer I chose was incorrect on the screen, I think I was more likely to remember the correct answer later. I certainly was careful not to make the same mistake again." Clearly these students believed that this implementation model provided them with valuable learning experiences that they could not attribute to other teaching methods employed in the course.

Discussion

The modified peer instruction model for clickers in these mathematics courses was perceived favorably by the pre-service elementary teachers enrolled in the courses. Students believed that the occasional use of clickers throughout the semester provided variety to the teaching and learning strategies employed in the course, and they felt that these lessons provided unique and beneficial learning opportunities. Most students who were questioned were able to identify a specific course topic that they felt a clicker lesson enabled them to better understand, with the answer-discuss-answer format leading them to think critically about the mathematics content. Positive views were expressed by students of varying learning styles, with both competitive and noncompetitive students viewing their use of the clickers differently but equally effective.

No evidence of instructor bias was found regarding students' perceptions of the implementation, their perceptions of its influence upon their learning, or the topics they identified as positively influenced by the learning experiences with clickers. This suggests that additional feedback gathered from Instructor A's students is likely generalizable to Instructor B's students, and that student feedback can be attributed to the implementation rather than a specific instructor. As noted by Instructor A, significantly greater levels of collaboration and active learning were apparent among students in the clicker-enhanced sections of the course. Students generally reported that they considered the clickers to be a novel, fun and interactive way of exploring course content, which aligns with the findings of other researchers such as Gachago, Morris, and Simon (2011).

The feedback that students provided emphasized the need for a thoughtful and meaningful implementation model. While many recalled specific learning that occurred in the clicker-enhanced lessons, students adeptly attributed learning to the *process* – that is, the modified peer instruction model facilitated by the clickers – rather than to the clicker technology itself. This points to the perceived effectiveness of the model – *how* clickers were implemented.

These clicker lessons hinged upon effective in-class participation. This was a norm further promoted in the course through frequent group activities using elementary-level manipulatives in addition to using clickers. In courses with less frequent use of hands-on or collaborative activities, specific attention may need to focus upon encouraging appropriate and sufficient discussion when using this format. Complementary collaborative learning opportunities may be needed that align with the modified peer instruction model. But as previous research has shown (Bruff, 2009; Martyn, 2007), the very nature of the clicker technology promotes a more active learning environment.

Students' answers to clicker questions in the study presented here had no direct impact on students' course grade, which may have allowed for the development of the positive viewpoints among students, as Chessman et al. (2010) found that a negative impact of clicker responses upon course grades can lead to negative perceptions of the clickers. Further, if clickers had been used more frequently, students may have developed more negative perceptions, believing that they should earn points for participation. Future research should explore the possibility of a "saturation point" with clicker use – the point beyond which students' buy-in wanes or at which other aspects of the implementation model must be modified to compensate – as well as the impact that different evaluation measures can have upon students' perceptions.

Additional questions remain, particularly whether or not students' perceived academic benefits actually materialized in terms of developed understandings of mathematics content, established learning goals, and eventual course grades. Subsequent analysis will examine these outcomes for the implementation described here. Clearly, if an innovation so positively received by future teachers can lead to greater achievement of measured learning outcomes, the technological model can have significant impact upon the preparation of future teachers. Also, the perspectives of those students who saw no value in the clicker innovation deserve more scrutiny. Can modifications to the model, particularly making connections between intended learning goals and the technology more apparent, help some students to better appreciate and recognize the benefits of clickers?

The effectiveness of specific types of clicker questions also demands further examination. Students viewed the visual Venn diagram questions more favorably and as more beneficial than the other questions that were presented. Had students previously struggled more with these concepts than other topics covered in clicker lessons, and therefore recognized greater gains as they progressed through the Venn diagrams lesson? Or was the visual nature of the Venn diagram questions, in comparison to other clicker questions, more effective, meaningful, and memorable?

Specific aspects of this implementation model had clear influence upon students' perceptions and, in turn, the success of the classroom innovation. First, the procurement of a classroom set of clickers avoided students' concerns regarding clicker cost, which could have led to initial negative attitudes toward the innovation. Conflicting results have been reported regarding the impact of clicker cost upon students' attitudes (Boatright-Horowitz, 2009; Greer & Heaney, 2004; Hall, Collier, Thomas & Hilgers, 2005; Strasser, 2010). Perhaps these differing results can be attributed to the different student populations of the studies, but the absence of this issue may have proved beneficial for the current implementation.

Second, the synergy of the peer instruction model with the constructivist approach to the course, along with the homogenous nature of a course designed specifically for future elementary teachers, allowed for a specific, pointed approach to using clickers. In teaching practice, the modified peer instruction model with clickers provides promise for engaging future teachers in a meaningful, well-received approach to learning mathematics while also scaffolding their development of technological pedagogical content knowledge for future mathematics instruction. Future research should explore how we can capitalize upon these considerations in mathematics courses geared toward students of other majors and toward pre-service secondary mathematics teachers enrolled in higher-level mathematics courses.

Acknowledgment

The author acknowledges Dr. Janet A. White and Dr. Michael Wismer, Millersville University of Pennsylvania, for the implementation of this study and data collection. The author also acknowledges Dr. Nadjib Bouzar, University of Indianapolis, for guidance with statistical analysis. This manuscript is based upon a paper presented at the Joint Mathematics Meetings of the MAA and AMS, January 2010, San Francisco.

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Appendix A: Clicker Questions

Lesson 1

Which of the following is the converse of the phrase "If I am hungry, then I will eat."

A. If I eat, then I am hungry.
B. If I am not hungry, then I will not eat.
C. If I do not eat, then I am not hungry.

Which of the following is the inverse of the phrase "If I am hungry, then I will eat."

A. If I eat, then I am hungry.
B. If I am not hungry, then I will not eat.
C. If I do not eat, then I am not hungry.

Which of the following is the contrapositive of the phrase "If I am hungry, then I will eat."

A. If I eat, then I am hungry.
B. If I am not hungry, then I will not eat.
C. If I do not eat, then I am not hungry.

Is the argument Valid or Invalid?

If my car starts, then it has gas in the tank.
My car does not start.
Therefore, my car does not have gas in the tank.

A. Valid
B. Not Valid

Is the argument Valid or Invalid?

If it barks, then it is a dog.
It is not a dog.
Therefore, it does not bark.

A. Valid
B. Not Valid

Is the argument Valid or Invalid?

If a person loves math, then he or she is an exciting person.
Janet loves math.
Therefore, Janet is an exciting person.

A. Valid
B. Not Valid

Is the argument Valid or Invalid?

If a person has good taste, then the person likes Coke.
Dr. Miller likes coke.
Therefore, Dr. Miller has good taste.

A. Valid
B. Not Valid

Lesson 2

1. Which of the following sets are ***equal*** to the set {2, 3, 4, 5} ?

A. {a, b, c, d}
B. {1, 3, 4, 6}
C. {5, 2, 4, 3}
D. All of the Above
E. None of the above

2. Which of the following sets are ***equivalent*** to the set {2, 3, 4, 5} ?

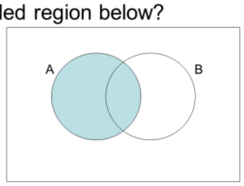
A. {a, b, c, d}
B. {1, 3, 4, 6}
C. {5, 2, 4, 3}
D. All of the Above
E. None of the above

3. How many proper subsets does the set {t, p, i, r} have?

- 6
- 8
- 15
- 16
- None of the above

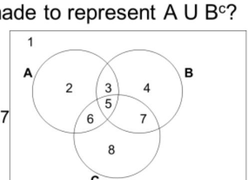
4. Which answer best describes the shaded region below?

A. $A \cap B$
B. $A \cup (A \cap B)$
C. $A \cup B$
D. A
E. None of the above



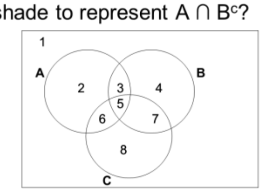
5.Which region(s) of the Venn Diagram would you shade to represent $A \cup B^c$?

A. 1 only
B. 2 & 6
C. 1,2,6 & 8
D. All but 4 & 7
E. None of the above combinations



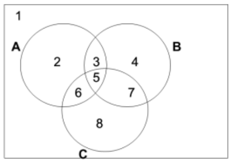
6.Which region(s) of the Venn Diagram would you shade to represent $A \cap B^c$?

A. 1 only
B. 2 & 6
C. 1,2,6 & 8
D. All but 4 & 7
E. None of the above combinations



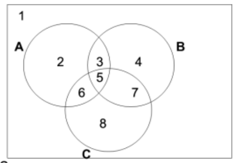
7.Which region(s) of the Venn Diagram would you shade to represent $(A \cap B)^c$?

A. 2 & 6
B. 2,6,4 & 7
C. All but 3 & 5
D. All but 3,5 & 1
E. None of the above combinations



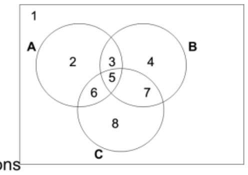
8.Which region(s) of the Venn Diagram would you shade to represent $(A \cup B)^c$?

A. 1 only
B. 8 only
C. 1 & 8
D. 1,2,3 & 4
E. None of the above combinations



9. Which region(s) would you shade to represent $(A \cup B^c) \cap C$?

A. 1 & 2
B. 2 & 6
C. 5 & 6
D. 6 only
E. None of the above combinations



Lesson 3

1. What numerals come before and after the numeral 144_{five}?

A. 143_{five}; 145_{five}
B. 142_{five}; 145_{five}
C. 143_{five}; 200_{five}
D. 143_{five}; 150_{five}

2. What numerals come before and after the numeral 420_{five}?

A. 419_{five}; 421_{five}
B. 414_{five}; 421_{five}
C. 418_{five}; 422_{five}
D. 414_{five}; 430_{five}

3. What value does the symbol "3" represent in the numeral 2311_{five}?

A. Seventy-five
B. Three hundred
C. Fifteen
D. Three hundred seventy-five

4. Convert the numeral 10442_{five} into a base ten numeral.

A. 3735_{ten}
B. 1235_{ten}
C. 82_{ten}
D. 747_{ten}

5. Write the number "one hundred thirty-two" as a base five numeral.

A. 107_{five}
B. 1012_{five}
C. 407_{five}
D. 512_{five}

6. Represent the number 23_{ten} in base eight.

A. 23_{eight}
B. 27_{eight}
C. 32_{eight}
D. 72_{eight}
E. None of the above

7. Convert 572_{eight} to base 10.

Lesson 4

1. In the multiplication problem n x a = b, the a value is called the…

A. Multiplier
B. Indicator
C. Multiplicand
D. Multiplicator
E. Product

2. The Identity Property is valid for whole numbers under multiplication.

A. True
B. False

3. The Commutative Property is valid for whole numbers under multiplication.

A. True
B. False

ISSN 2165-7874

4. The Associative Property is valid for whole numbers under multiplication.

A. True
B. False

5. The Closure Property is valid for whole numbers under multiplication.

A. True
B. False

6. What is the Zero Property for whole numbers under multiplication?

A. Division by zero is undefined
B. Zero is a whole number
C. a x 0 = 0 x a = a
D. a x 0 = 0 x a = 0

7. What is the Distributive Property of Multiplication over Subtraction?

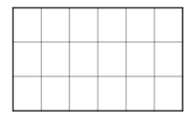
A. The rule that you must choose to do multiplication before subtraction
B. a(b – c) = ab – ac
C. a – (bc) = (a – b)(a – c)

8. Multiplication can be though of as…

A. Repeated subtraction
B. Repeated division
C. Repeated addition

9. In the multiplication problem modeled by the diagram below, the value of the multiplier is…

A. 6
B. 3
C. 18
D. None of the above



Lesson 5

The notation a | b means…

A. "a or b"
B. "a divided by b"
C. "b divided by a"
D. "a divides b"
E. "b divides a"

If "a" divides "b", then …

A. "a" is a factor of "b"
B. "a" is a multiple of "b"
C. "b" is a factor of "a"
D. "b" is a multiple of "a"

The number 39872503 is divisible by 2.

A. True
B. False

The number 39872503 is divisible by 3.

A. True
B. False

The number 39872502 is divisible by 6.

A. True
B. False

The number 39872502 is divisible by 9.

A. True
B. False

A proper divisor of a number…

A. is greater than the number
B. is equal to the number
C. is less than the number

If the sum of the proper divisors of a number "a" is more than "a", then…

A. "a" is called a *perfect* number
B. "a" is called an *amicable* number
C. "a" is called an *abundant* number
D. "a" is called a *deficient* number

Lesson 6

A prime number is best defined as:

A. A number with no divisors
B. A number with exactly one divisor
C. A number with exactly two divisors
D. A number with more than two divisors

A composite number is best defined as:

A. A number with no divisors
B. A number with exactly one divisor
C. A number with exactly two divisors
D. A number with more than two divisors
E. Any number that isn't a prime number

1 is…

A. A prime number
B. A composite number
C. Neither prime nor composite
D. Both prime and composite

The number 16 has ____ factors

A. 6
B. 5
C. 4
D. None of the above

The prime factorization of 36 is:

A. 4·9
B. 4, 9
C. $2^2 \cdot 3^2$
D. $2^2, 3^2$
E. None of the above

The greatest common factor of 36 and 48 is:

A. 6
B. 12
C. 24
D. 72
E. 144

The least common multiple of 36 and 48 is:

A. 6
B. 12
C. 24
D. 72
E. 144

ISSN 2165-7874

Appendix B: Student Survey

Clicker Evaluation Instructor: ____________________ Clicker ID#: __________

1. Did you like the use of PRS clickers in this class this semester?
   YES NO UNSURE

2. Do you believe that use of the clickers helped you to better learn and/or understand course material?

   YES NO UNSURE

   Please explain your answer.

   If you answered "YES" to #2, please identify or describe at least one specific topic or mathematical problem that you gained a better understanding of as a result of using clickers.

3. How do you believe that the use of clickers changed your experience in this class this semester?

4. Have you used clickers in other courses? YES NO UNSURE

   If "YES", please compare/contrast the use of clickers in this course to these other classes.

5. How could use of clickers be improved in this course?