

Observing the Effects of Activity Based Learning
On Math Comprehension in a High School Algebra Class

By:

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Abstract

As a third year high school math teacher, it can be difficult to engage all students with new math concepts. To address this problem, I compared a traditional lecture based class, to classes that emphasized group work, discussions, and demonstrations in front of peers. Activity based teaching methods were the variable used to impact the performance and engagement of participants in three ninth grade Algebra 1 classes. Throughout one ten day long math unit, assessment data was collected and analyzed, and observations of student engagement were documented. The primary emphasis was to identify whether activity based teaching has significant positive effects on students' level of interest, engagement and performance in a 9th grade Algebra 1 class.

Table of Contents

Introduction	4
Literature Review	7
Design	9
Results	12
Reflection	15
Resources	18
Appendix A (Math Stations)	19
Appendix B (Kahoot)	20
Appendix C (Bingo)	21
Appendix D (Chapter 7 Quiz/Test)	22

Introduction

During my interview prior to getting hired as a high school mathematics teacher, I described my passion for using activities and technology to excite students about learning. I believed activities make teaching fun. Studies have demonstrated that technology can heighten the level of engagement students feel, which improves comprehension and understanding (Blasco-Arcas 2013). Research also shows, specifically in math classes, that use of hands-on “manipulatives” and group work profoundly impacts student achievement (Wu-Yuin 2013). A few days after my interview, I was notified that I would finally have an opportunity to live my dream of teaching math.

As a first year teacher with two classes to prepare for, I discovered that my time was sufficient to create only the most basic lecture based lessons, and no opportunities remained to plan creative activities for students. To my surprise, students seemed to grasp the content as well as students of fellow teachers who were incorporating group activities regularly in their classes. Furthermore, I began experiencing the realities of a tightly packed high school math curriculum. Despite the absence of activities in my lessons, I discovered that I could rarely spare an extra day to incorporate activities even if I wanted to without falling behind the required curriculum requirements. Other obstacles to these teaching methods, based on research and personal experience, included effectively constructing groups, insufficient time and resources for the creation of activities, teaching students necessary social skills for group activities, and assessment of the learning that occurs in the group (Gillies, 2010).

An obvious problem became apparent, which caused me to call my teaching philosophy into question. Although I was excited to engage students using activities, I questioned whether activity based strategies were realistic in a math curriculum with such limited time. Even if sufficient time was available, did activities really help students comprehend math on a deeper level? After all, despite a lack of activities during my first year, my students had similar averages on the final exam to their peers who

experienced a variety of teaching styles from their respective teachers, and took the exact same final exam.

At Hudson High School, there is arguably just enough room for around 1,700 9th-12th grade teenagers to make their way to each class. Within this population, 11% have a disability, 12.6% are economically disadvantaged, and .8% classify as limited English proficient. On average, about 74.6% of Hudson High School Students will continue their education at a post-secondary institution. Students take a variety of standardized tests, including the ACT Aspire test (which is new for freshman in 2014-2015), Wisconsin Knowledge and Concepts Examination (WKCE) testing for freshman, and Pre-ACT and ACT testing. Based on the Wisconsin Department of Public Education 2013-2014 WKCE test results, Hudson High School “Exceeds Expectations” with an overall score of 77.2 out of 100. This score measures achievement, growth, and closure of achievement gaps in the areas of reading and mathematics. Hudson’s math achievement score was 41.1/50 vs. the statewide average of 35.8/50.

The research that I conducted in my high school Algebra 1 class was designed to determine whether an activity based teaching approach would yield assessment results superior to students who experienced mostly lecture based lessons in Algebra 1 during the prior year. I will define activity based teaching as any non-lecture teaching method that requires students to collaborate or work in groups of at least two. In this Algebra 1 course, a range of concepts are examined including order of operations, functions, equations, inequalities, systems of equations, properties of exponents, and quadratic equations. On average, a class of 25 students is comprised of mostly 9th graders, with the exception of roughly two non-freshman who may have failed algebra the previous year, or had difficulty transferring credits from another school.

This research was conducted throughout chapter seven of the McGraw-Hill Algebra 1 textbook, a unit about properties of exponents (MacGraw Hill, 2014). This unit included multiplication and division of integers and variables with exponents, and raising an exponent to another power. Negative and zero

exponents were also introduced. Common Core standards covered within this unit include A.SSE.2 (Seeing structure in Expressions part 2), N.RN.1, and N.RN.2 (The Real Number System part 1 and 2). While teaching this unit the previous 2 years, I relied almost entirely on lecture based teaching strategies. Each day, I allowed questions from the previous day's homework, covered new concepts for the current day, provided a couple of problems for students to try in pairs with my help, then provided students with 5-10 minutes at the end of class to start their new assignment. I used this method partly due to the rigor and limited time as a first year teacher, and partly because it seemed to work best for the most students. Despite my positive experiences with lecture, I was ready to engage students with lessons that included activities and peer-interaction, which aligned with my perception of a great classroom, and allowed me to pursue Hudson High School's goal of engaging students with.

During the exponents unit, I gave students the opportunity to demonstrate their abilities on the Smart-board in front of peers, work and collaborate with classmates regarding new content, rotate through math stations throughout the room with partners, use mini whiteboards to review content, and use their cell phones to play review trivia. Assessment of students' knowledge included homework, a mid-chapter quiz, and an exam to conclude the chapter, along with observation of student performance during activities. In my research, anonymous assessment data from a convenience sample of 150 Algebra 1 students was used to observe whether an activity based approach seemed superior to lecture. Overall assessment data from last year's 76 Algebra 1 students was compared with the respective data from 74 Algebra 1 students from this year's 2014-2015 class. The results of the data comparison showed no obvious difference between lecture driven teaching and activity based teaching. However, the level of student engagement and interest were perceived to be elevated by the used of new activities based strategies.

Literature Review

Gillies' research was conducted with 223 9th grade students from 6 different high school classes in Brisbane, Australia. Of the six classes, three were unstructured, meaning they did not incorporate cooperative learning. The other three classes did incorporate cooperative learning, which is defined as groups of 3 or more students working together on a common task. In Gillies' research, the structured classes had students engage in mixed-gender groups of 3-4 students, at least once per week across English, science, and math. Each group had specific expectations and roles to keep all students equally involved with the task at hand. After, math questionnaires based on Bloom's Taxonomy were used to measure the results. A multivariate analysis of variance (MANOVA) test was used to determine that cooperative learning did yield significant positive results regarding student interest and verbal interaction (Gillies, 2004).

In 2013, Blasco-Arcas also conducted research to observe the effects of interactivity and engagement on the performance of 198 undergraduate business students in Spain, ages 18-36. More specifically, groups of students used "clickers" to learn new content. Clickers are small remotes that allow students to answer questions presented in class. Throughout this business course, seven multiple choice tests were given using clickers. Each test was 10 questions long. Students worked in groups of 4-5 students, and only one clicker was assigned per group, so groups were required to thoughtfully discuss the answers before selecting their answer. After, questionnaires were given and confirmatory factor analysis (CFA) was used to determine the reliability and validity of the data. The study concluded that clickers had significant positive effects on collaborative learning and engagement. According to Blasco-Arcas, this interactive approach caused students to feel more socially connected to peers and teachers, which fostered a more engaging environment where students were more open to learning (Blasco-Arcas, 2013)

Also in 2013, Hwang showed that a variety of instructional strategies helped geometry students achieve more success in the classroom. Twenty-nine 5th grade students used virtual manipulative to discover concepts of surface area and volume, among others. Virtual manipulatives are computer-based programs and/or applets that allow students to turn and move 2D and 3D shapes with the click of a mouse. In Hwang's research, the control group of students explored geometric concepts using paper and pencil. The experimental group explored the same concepts using the virtual manipulatives, allowing them to experience the 3D concepts interactively. A five point Likert scale was used to measure the ease of use, usefulness, and playfulness of the experimental approach. Hwang used Cronbach's Alpha test to evaluate the consistency of the results of the survey. Also, pre-test and post-test data from the control group and experimental group were examined using a t-test. While the pre-test data from both groups showed no significant difference, the t-test determined with 95% confidence that there was a significant difference between the post-test data of the two groups. So, Hwang concluded that group interaction and 3-D manipulative helped to create a more socially and conceptually rich learning environment for the 5th graders. By engaging students with more interesting and engaging tasks, students were more motivated to learn, and struggling students were able to receive motivation and help from group-mates who excelled. (Wu-Yuin Hwang 2013).

Design

During the exponents unit, I supplemented the McGraw-Hill curriculum with several activities to engage students with a more interactive learning approach. Gillie's research reminded me that activity based learning does not need to be implemented daily to be significant. Gillies' research helped me design a more time sensitive approach for my research with 9th graders, where the fast paced curriculum does not allow me to incorporate group activities on a daily basis. Instead of daily activities, I strived to incorporate about one interactive strategy every 2-3 days throughout my unit. My research wasn't focused on increasing quiz and test scores, standardized test scores, or homework grades. Instead, like Gillies, the ultimate focus of my research was the response of students and their attitude toward learning.

Math stations were implemented on two different occasions during the unit (See appendix A). Before students entered the room, I posted a variety of types of math problems on the walls that were pertinent to the day's lesson. I allowed students to create their own groups of two or three as they navigated to each station to complete each challenge. Once each group finished, I required them to bring me their answers for critique. Each group was required to correct any mistakes and complete each problem correctly before beginning the assignment for that day. This method was effective for two reasons. First, it allowed students the opportunity to interact with peers and move around the classroom, which heightened engagement, and allowed them to give each other feedback. Also, as groups completed the stations, I was able to give specific feedback, followed by self-corrections by students.

Technology was a crucial aspect of the unit. I implemented a technology approach that was unfamiliar to me, which forced me outside my comfort zone. Blasco-Arcas' work with clickers significantly impacted my decision to use Kahoot, a cell phone based trivia game, which was recommended to me by a student (See appendix B). In a high school math class, keeping students interested is sometimes the teacher's most difficult task. In my experience, if students at this level aren't engaged, they are less likely to understand and retain information. Blasco-Arcas' research reminded me

that promoting an engaging and socially connected classroom could be the keystone to improving the performance of my 9th grade Algebra 1 students. Since this was a student recommended activity, I was confident that students would be excited and interested in this approach. I provided laptops for students who lacked sufficient cell phone technology. A 30 second timer forced students to be both quick and accurate while solving each problem. Once a solution was obtained, students used their phones to select the correct answer from four possible options. If students answer correctly, they receive points based on how quickly they answered. Following each question, Kahoot displays the number of students who chose each of the four possible answers, which allowed me to quickly and accurately assess students' strengths and weaknesses. In many cases, a single wrong answer would be selected by a high number of students. This provided a great opportunity for discussing that common mistake, and how students could avoid that mistake in the future. The top 5 students on the 'leader-board' were given extra credit equivalent to one homework assignment. Students showed excitement and interest as they worked and competed with their peers.

The third new activity used was a math review game similar to bingo for students to study prior to a quiz (See appendix C). I learned this approach from a fellow math teacher. I gave students sixteen answers to upcoming questions. Students each made their own 4x4 Bingo card, but worked in pairs, and used the sixteen given answers to randomly fill in each space on their card. Once students' cards were completed, they solved one math problem at a time. If they solved the problem correctly, students could find and mark the corresponding answer space on their bingo card. If students could not find their solution on their card it meant they made an error, and I encouraged them to ask for help from a peer or myself to obtain a correct solution. I allowed students to get a maximum of two bingos, and continued playing until five different students obtained a BINGO. Students received extra credit equivalent to half of a homework assignment for each bingo they achieved.

The fourth and final strategy involved using mini-whiteboards. Mini-whiteboards allowed me to quickly assess student understanding of content in a manner that seemed fun and engaging for students. I

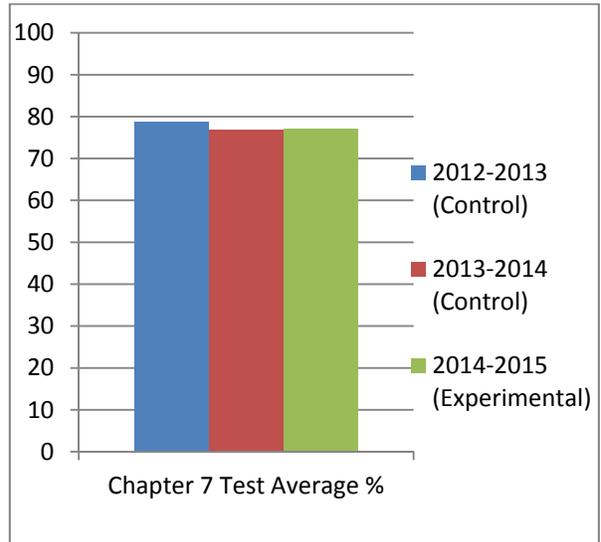
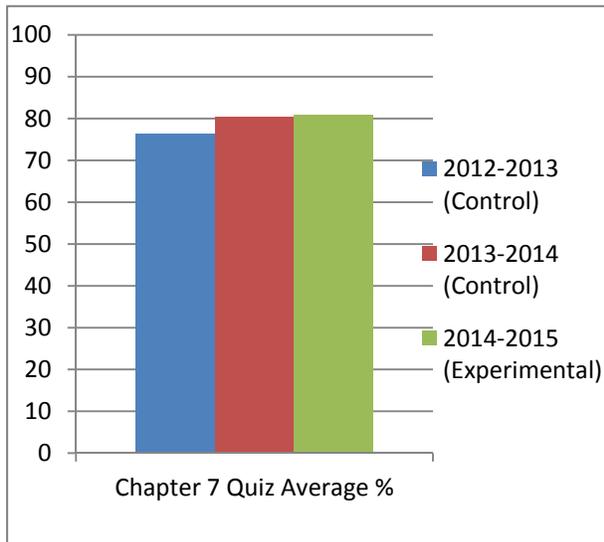
learned this strategy while earning my degree in education at the University of Wisconsin River Falls. After lecturing a new lesson, I distributed whiteboards, erasers, and markers to each student. Next, I displayed one problem at a time on my Smart-board while students showed work and reached a solution independently on their whiteboard. Once finished, students compared with a partner, then held up the whiteboard and received a “Got it”, “Close” or “try again” from me. I typically gave more specific feedback to students who tended to struggle most. Once a student achieved a correct answer, they were expected to help someone near them. Students always have an observable positive, motivated response to the use of mini whiteboards. While students were busy having fun, I was able to quickly assess how well they understood new concepts and what common mistakes and misperceptions needed to be re-addressed.

Following this unit, assessment scores on a quiz and unit test were compared with corresponding scores from the same unit from two previous years, which were taught almost entirely by lecture. Additionally, I made informal observations regarding students’ interest levels. Comparing assessment data and observing student reactions helped me reflect on the pros and cons of activity based strategies, which I will elaborate on in the results and reflection portion of this paper. By weighing the perceived pros and cons, I determined whether activities based learning seems to have a significant impact on high school algebra achievement in my classroom.

Results

Results from this study were mixed. During this ten day unit, the quiz was given on day five and the test on day ten. Assessment data showed that quiz and test scores of students from the 2014-2015 experimental groups had actually dropped slightly in some cases compared to control group students from the two years prior. In 2013, students earned 76.32% of possible points on quizzes, and 78.65% of possible points on tests. In 2014, students earned 80.32% of possible points on quizzes, and 76.79% on Tests. In 2015, using new interactive strategies, students earned 80.92% of possible points on quizzes, and 77.06% of points on tests. Chapter 7 quizzes and tests data is shown in the table below.

Due to such a small sample size, small differences in scores, and the inevitability of fluctuations in student averages from year to year, the slight variations in scores don't seem to be significant. Therefore, this research cannot determine that an activity based teaching approach neither helps nor hurts student performance on assessments in a high school Algebra 1 setting.



Despite inconclusive results of assessment scores, I was able to identify several positive aspects of technology and interactive learning throughout this unit. My energy level was noticeable higher during this unit as I anticipated how students would react to each day's activity. Students seemed to feed off my energy and displayed an increased attention levels. While playing Kahoot, students showed a competitive nature and levels of engagement I hadn't witnessed before in my classroom. On several occasions, students excitedly challenged their friends with comments like "I just moved up to second place!" In later chapters, some students rushed in prior to class on review days asking "Are we playing Kahoot today, Mr. Bock?!" Observations like these gave me clear indication that students were excited to come to class in anticipation of math activities.

During Bingo, students helped their group-mates, and self-critiqued their work if they were unable to find an answer on their bingo card. As pairs of students worked their way through math stations, peer-to-peer interactions took place as students discussed each problem and critiqued each other. I ended the game once 5 students had completed a bingo. I regularly observed excited students making comments like "Can we try just one more problem, Mr. Bock?!" Also, using mini-whiteboards rather than paper and pencil seemed to create a new fascination with math for many students as they solved problems and received instant feedback. A positive attitude can have a profound impact on how students view math throughout the year, and in the future. In my experience, many students perceive math as a difficult subject and a source of ongoing frustration in school. By shifting the focus from lecture and homework to peer interaction, technology, and fun, students' attitude began to change, and I observed students arriving to class excited as they inquired about which activity we would take part in that day.

The pros of this approach outweigh the cons, I did find drawbacks to the new methods described. Although Kahoot was exciting and engaging for students, I noticed it wasn't effective for everyone. Because it's a speed-based competitive trivia game, several students rushed their answers and took shortcuts that caused them to make errors. So, rather than writing the problem on notebook paper and solving step-by-step, students would say, "I can just do it in my head" and hurry so they could be quicker

than classmates and potentially earn more points. While I encourage mental math in my classes, Kahoot reinforced some students' habits of being sloppy and careless with their work.

Another difficulty with using an interactive approach is time. High school math curriculums are often designed with little spare time. Bingo, math stations, Kahoot, and mini whiteboard lesson often require an abundance of time, which required me to shorten or eliminate student work time to compensate. During my first 3 years of teaching, I have observed the importance of allowing students to have in-class work time to begin assignments, ask questions, and develop confidence before finishing the assignment at home. The reduction of in-class work time greatly reduced students' opportunities to receive help from me and their peers. Therefore, I have to spend more time at the beginning of class the following day addressing questions that would typically be addressed during work time the day before.

After observing students throughout this unit, I firmly believe that activity based teaching strategies are an essential part of a high school math classroom. Regardless of whether test scores improved, I found that teaching with activities was far more rewarding, and students demonstrated higher levels of interest, excitement, and engagement in math.

Reflection

Throughout my research, and during the units that followed, I was reminded that engaging students with fun and meaningful lessons helps to make the education process more meaningful to me as a teacher, and more engaging to students. I am grateful to the University of Wisconsin River Falls, for the opportunities I've had to learn new techniques and improve as a professional educator. Going forward, I will continue to implement the activities based techniques I incorporated in my research, due to many observations of student excitement, engagement, and eagerness to learn. However, I will also consider modifications in the implementation of those techniques.

Math stations were valuable to encourage peer interactions, while allowing students an opportunity to leave their desk and move around the classroom. This activity was typically used on day 2 of a sub-section from the unit, and provided a method for me to engage students with several types of math problems. Math stations allowed me to check student errors and give feedback on an individual basis as I checked their work. Going forward I'll use this strategy as a means to assess student progress in a more active manner than before.

However, I would make some changes in the future. Since each group was only required to turn in one set of answers, I occasionally noticed that just one of the team-members was engaged, making the activity less beneficial for both students. Also, students were simply doing 'mental math' and writing down their answer. While I do encourage mental math in my classes, it made it difficult for me to assess where the students had made mistakes, making my feedback less valuable. Next time, I'll create a template and require each individual student to re-write the problem, show their work, and display their final answer, making the activity impactful for more students, while maintaining the positive aspects from my research.

Kahoot, a recommendation from a student, proved to be a valuable tool I will continue to use in the future. Kahoot provides a rare opportunity for students to use cell phones in an environment where

they are typically asked to put them away. The competitive nature of working against a clock and moving up the 'leader-board' offered students a way to have fun, review math content, and earn extra credit points. Kahoot offers a powerful assessment tool, as quick effortless data following each question allowed me to dissect commonly selected wrong answers and address misconceptions. On many occasions, I heard students' excited comments as they entered class, and saw increased engagement from students, which solidifies Kahoot as a go-to tool in my math class.

But, some aspects of Kahoot will be adjusted for next year. First, I will have pre-made worksheets for each student. The worksheet will have a space for students to re-write each question, and show their work before selecting an answer using their phones. Worksheets will be collected, and thorough completion of the worksheet will be a requirement to earn extra credit points. Next, I'll increase the allowed time for many of the questions. Kahoot is designed to give students more points based on quickness, so there will still be an incentive for students to be quick, while allowing them sufficient time to write the problem and show their work without feeling rushed. Lastly, I will ask students to get out their phones and log on to Kahoot at the start of class as we go over homework questions from the previous day. Kahoot was usually used near the middle of class, but we sometimes wasted minutes as students took time access the internet and log in. By giving students the access code and instructing them to log in at the start of class, I'll eliminate wasted time.

Bingo is unique because students know immediately whether they answered a question incorrectly, if they don't find their answer on the bingo card. In the future, I will require students to thoroughly show their work and turn it in to receive credit. Showing work will make bingo a more useful experience as students create a habit of being complete with their work, and will allow me to more easily identify weaknesses in students' problem solving skills.

If I were to re-create this experiment, I would consider some more general modifications. First, I would keep a journal of specific comments, concerns, and actions of students as they engage in the

various activities of my research, enabling me to display a more detailed account of the quantity and varieties of comments I heard from students during each lesson. Next, I would create a Likert scale for each student to complete following the unit to gauge students' perceptions of the usefulness of activities, student attitude, and student engagement. Initially, I did not create a Likert scale because I doubted whether it could be used to determine the significance of my teaching methods. In hindsight, I wish I had, not to gauge the significance of the research, but simply to gain an understanding of how students perceive the activities. I would be intrigued to see how the results of a survey would compare to the impressions I received based on students comments during class.

To conclude, I firmly believe I have expanded my abilities and techniques, so I can maximize my teaching ability, and engage more students on a regular basis. I am excited to improve my existing techniques and to continue finding new approaches. I'm convinced that other teachers will see the benefit of trying similar activities in their own classroom. This research has inspired me to continuously improve and create the interactive and engaging math classroom that I always imagined.

Resources

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Common Core Standards - <http://www.corestandards.org/Math/>

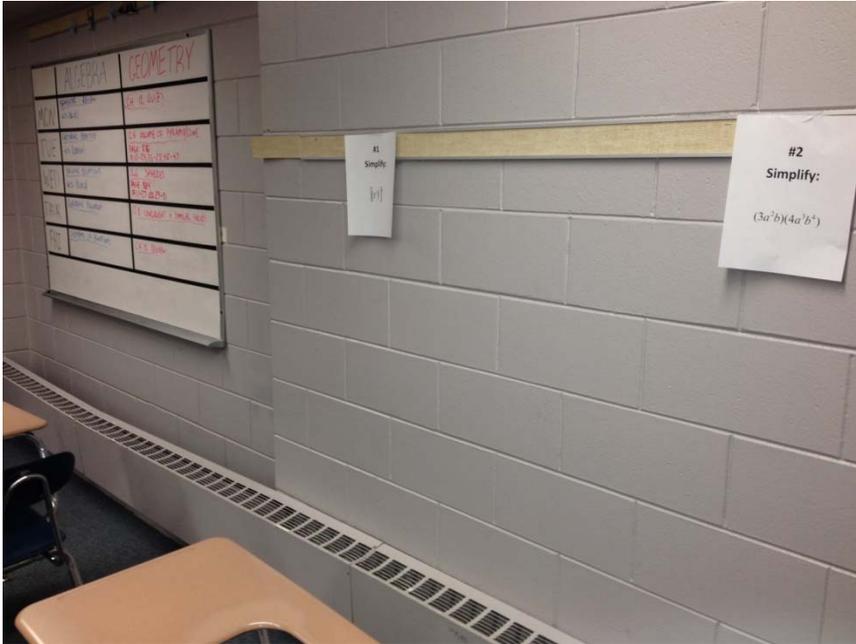
MacGraw Hill, 2014 - <https://www.mhonline.com/programMHID/view/0076639231>

Appendix A (Math Stations)

A variety of 4-6 math problems ranging from solving to word problems are placed around the room.

Students are asked to find one or two partners to work with. Each group makes their way to each station.

When finished, I check their work and give critique. Students are expected to fix any mistakes and show me again. Once finished, students are allowed to begin their assignment.



Appendix B (Kahoot)

Students log on to the Kahoot website using their cell phone or a laptop I provide. Students get 30 seconds to answer. Once 30 seconds expires, or all students answer, Kahoot shows how many students answered each of the four possible answers. Also, Kahoot shows a 'leader-board' ranking students by their total points following each question.



Appendix C (Bingo)

First, students are asked to create a 4x4 bingo card grid. Then, I give students 16 answers to upcoming math problems. Students use these 16 answers to fill their Bingo card spaces. Then, I show students one question at a time and allow them to solve. Once students find the answer to the current problem, they cover/mark the corresponding answer space on their Bingo card. Extra credit is given to the first specified amount of winners

BINGO CARDS!!!

- x^4
- $\frac{a}{b}$
- $4a$
- xyz^2
- $\frac{1ab}{5c^2}$
- 1
- m^6n^9
- d^{-2}
- $\frac{1}{cd^2}$
- $16x^5$
- 32
- f^{10}
- $\frac{a}{3b}$
- b^0
- m^8
- $\frac{k}{2}$

Simplify:

$$\left[\frac{4x^2y^{-4}z}{13x^{-5}} \right]^0$$

Appendix D (Chapter 7 Quiz on exponents)

Name _____

Algebra – Chapter 7 Mini-Quiz – Show all work for full credit

Simplify each expression:

1. $a(a^2)$ 2. $(10x^3y^2z)(-2xy^3z^3)$ 3. $(xy^2)^3$ 4. $(3ab^2)(-2a^3)^0$

5. $\frac{x^3y^2}{x^2y}$ 6. $\left(\frac{rs^{-1}t^2}{s^2t}\right)^3$ 7. $\frac{(a^3b^2)^{-1}}{a^5b^{-3}}$ 8. $\frac{(mn^2)^2}{4mn^4}$

Solve the following systems of equations by substitution OR elimination:

9. $4x + y = 9$ 10. $-3x + 5y = 8$ 11. $3x - 3y = -6$
 $y = 3x - 5$ $4x - 5y = -14$ $y = 3x - 2$

Solve the following inequalities:

12. $x - 4 < 1$ 13. $2x - 5 > 5 + 2(x + 3)$ 14. $3 - x \geq 7$

Appendix D (Chapter 7 Test on exponents):

Name _____

Chapter 7 Test

Fill in the blank. Write a number anywhere you see a “___”. (Numbers 5 & 8 have 2 blanks!)

1. $(x^2)^4 = x^{-}$ 2. $5 \cdot 3^0 = \underline{\hspace{2cm}}$ 3. $\frac{1}{4^{-2}} = \underline{\hspace{2cm}}$ 4. $2a^3 \cdot 4a^7 = 8a^{-}$

5. $(2y^2)^3 = \underline{\hspace{1cm}} y^{-}$ 6. $\frac{3^5}{3^3} = \underline{\hspace{2cm}}$ 7. $\frac{9x^5}{3x^2} = 3x^{-}$ 8. $\frac{14x^3y^{-3}}{2xy^2} = \frac{7x^{-}}{y^{-}}$

Simplify as completely as possible. Always rewrite with positive exponents. Circle your final answer!

9. $2^5 \cdot 2^{-8}$

10. $(3x)^2 \cdot 2x$

11. $3m^3n \cdot 4m^2n^6$

12. $3ab^2 \cdot (2a^3b)^2$

13. $(4x^3y^{-2})^{-2}$

14. $\frac{14x^2y^{-7}}{2z^{-3}}$

15. $x^{-8}y \cdot 0^{-2}$

16. $\frac{x^{-3}x^8}{x^2}$

17. $\left(\frac{-4m^3n^{-5}}{mn}\right)^{-1}$

18. $\frac{3x^3y}{4x} \cdot \frac{12x^2y^2}{y^3}$

19. $\frac{5m}{n^3} \cdot \frac{3mn^6}{m^5n}$

20. $\frac{(m^2)^3}{(m^4)^2}$

21. $\frac{-24x^{-3}y^5}{(2x^2y^{-1})^3}$

22. $(7x)^0 \cdot 2x^{-2}$

23. $\frac{(3m^2n^{-3})^2}{(2mn^4)^3}$

Throwbacks.

24. Solve $\frac{3x}{5} - 2 < 4$

25. Use substitution to solve the system of equations:

$$y = x - 3$$

$$2y - 3x = -14$$

BONUS: Simplify the expression

$$\frac{3m^4n^{-2}}{mn^2} \cdot \left(\frac{3mn^2}{m^{-2}n^7} \right)^{-2} \cdot 27(m^3n^{-2})^2$$