Activity-Based Curriculum for the Discrete Mathematics Classroom

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Abstract

Traditional lecture and drill mathematics classrooms have been shown to be not only ineffective but detrimental to student achievement. Classrooms must engage students with diverse learning styles, attitudes, and backgrounds. Activities can be used to enliven the classroom and make learning more engaging and meaningful. One of the questions this study attempts to answer is: Were the activities used enjoyable, effective, and worthwhile? After introducing each activity, students were given the opportunity to give free-response feedback regarding the activity and its impact on their learning. Analysis of each activity showed that while they enjoyed all three, only two were educationally worthwhile, and only one was completely successful. The other question this study attempts to answer is: How do interactive activities in the classroom affect students’ perceptions of mathematics and mathematics education? To establish baselines, students were given a survey early in the study regarding their opinions of mathematics in general. This same survey was administered after several weeks. Analysis of the changes in students’ opinions indicates that they found mathematics to be more enjoyable, important, and relevant after the use of the activities. The dramatic increase in my students’ enjoyment of mathematics, their higher regards for the importance and relevance of mathematics, and their improved perception of communication as a mathematical skill lend themselves to the need for further study on the use of activities in the mathematics classroom.
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Methodology

Population and Sample:

During the course of this study, I was a full-time classroom teacher at Reagan High School in Pfafftown, NC. As a fairly new, suburban high school in the Winston-Salem/Forsyth County Schools system, Reagan draws students from diverse socio-economic, ethnic, and educational backgrounds. My sample consisted of those students who agreed to participate from my three Discrete Mathematics Honors classes during the first semester of the 2009/10 school year. The majority of these students are college-bound seniors fulfilling their fourth mathematics credit required for graduation.

Research Questions:

As my journey through my Master’s coursework led me, I found myself becoming less algorithmic in my teaching and more exploratory. I saw the benefits of problem-solving and student interactions. I believe that teaching the Discrete Mathematics curriculum via interactive activities will create a more engaging, creative, and enjoyable environment. Furthermore, I believe the enjoyment will raise student’s perceptions of mathematics courses and increase their perceptions of their own abilities. I hope this will translate into wanting to take more mathematics beyond this course.

My study attempts to answer two questions. First, are the activities I’ve designed enjoyable, effective, and worthwhile? And second, how do interactive activities in the classroom affect students’ perceptions of mathematics and mathematics education?
Product Administration and Completion:

The activities I designed came from various resources. I was first introduced and encouraged by attending a MELT workshop at Appalachian State University in July 2008. In the workshop, Department Chair Dr. Mark Ginn and ASU Alumnus Heather Freeman introduced several ideas for lessons and activities. During the 2008/09 school year, I used many of these and began designing some of my own. I particularly needed resources for the unit on population growth, which is the unit I chose to study. Some of the activities tested were based on ideas I gathered from various internet sites. Others stem solely from my own creativity. All activities were based on the North Carolina Standard Course of Study (NCSCOS) and were meant to either (a) introduce a concept before, or (b) reinforce a concept after, formal instruction. Secondary goals included increased student engagement, interest, and understanding. Collaboration, Cooperation, Communication became key words in this new mathematics environment, along with Extend, and Explain. I even had these terms laminated and posted on the walls.

For each activity, students received an evaluation instrument so that they could provide feedback. Students were also given a mathematics survey early in the study and then again at the end of the study.

To encourage honest commentary, and ensure anonymity, students used a Participation Code for identification on each of their evaluation and survey documents. The code was created using the last four digits of the student’s school ID number, the first letter of his/her last name, and his/her six-digit (MMDDYY) birthdate. While this code could be deciphered, I assured students that these were for tracking purposes only; none of their responses would affect their grade in any way. While I needed a way to bundle subsequent documents together as coming from the same source, I wanted them to have a code that would be easy to remember throughout
the quarter, but one that could not be immediately deciphered. This identification procedure was used on all activity evaluation and survey documents and all students in attendance were expected to participate. As I sincerely told them, I valued all of their opinions as my students regardless of their participation in the study, and hoped to gain valuable feedback so that I could improve the activities for next year’s students. However, as participation in my study was voluntary, not all students’ data would be included in the analysis. Both Parental Consent and Student Assent forms were necessary for inclusion as a voluntary participant.

To further ensure that no student felt coerced into participating in my study, I was not permitted to know who was and was not agreeing to participate. This was achieved by placing a large, sealed box with an opening in the top on a table near the door of my classroom. Students were instructed to turn in forms over several days at any time of the school day, with or without signatures, and I did not keep track of whether students had submitted anything. From my 3 classes of students, I hoped to have 15 – 30 participants, so while I reminded them and encouraged them to turn in their forms – with or without signatures – I did not keep track of which students had done so. Participant or not, I did not want to know what their decision had been. As such, I was virtually unaware of which students had submitted forms, and completely unaware of which students had submitted signed forms agreeing to participate in the study.

After the forms had been collected, I gave the sealed box to a teacher who had agreed to assist me. I also gave her the evaluation and survey documents I had collected from all my students, sorted and grouped by Participation Code, and a Participation Code master list. From the sealed box she gathered all the forms that had signatures and highlighted on the master list those students who had submitted both Student Assent and Parent Consent forms. She later reported to me that she had 28 students who had submitted both signed forms and two others
who had returned one form, but not the other. I instructed her to not include the two who did not have both forms submitted and was pleased that I had 28 voluntary participants. On the master list, she numbered the highlighted participants from 1 through 28 so that I could later analyze the documents without knowing which student had provided them while maintaining the connection between documents from the same student.

She parsed out from the documents I had given her the ones from those students who were participating and labeled them in the corner opposite their Participation Codes with their numerical identifier. She then cut off the corner of the page in which the student had written his/her Participation Code. She bundled the remaining (non-participants’) documents with the master list and stored them in a box for her to keep then destroy after 6 months. She gave to me the numbered documents for analysis.

After implementing each activity, I also completed an evaluation. It was interesting to compare my impressions with those of my students.

Conclusions:

My study attempts to answer two questions. First, are the activities I’ve designed enjoyable, effective, and worthwhile? And second, how do interactive activities in the classroom affect students’ perceptions of mathematics and mathematics education? Although the activities were interrelated in the “Math in Nature” unit, they were each independent. As such, I have chosen to answer the first question about each activity individually.

Activity 1: Phi on You

The first activity that was done was “Phi on You.” The goal of this activity was to show students that the Golden Ratio was present in the ratios of measurements on the human body. Students were divided into groups with each group starting at one of five stations. Each station
had a data recording sheet identifying the measurements to be taken and metric measuring tapes. Students were instructed to measure as accurately in centimeters as possible and to record each person’s data on the station record sheet. They were also instructed to record their own measurements at each station on their worksheet in the “Phi on Me” chart.

After each group was finished measuring at its station, I instructed the groups to rotate stations. Students would thus be visiting all five stations during the activity. At the final station, each student copied the class data for that station onto his/her worksheet. The measuring portion of the activity took the entire class period and students were then instructed to complete the worksheet as homework. The worksheet guided the students through calculating the regression line for the class data from that station. They were also guided through calculating the regression line for their own set of data. Thus, for each class, five different regression lines based on the five different stations and up to 30 different regression lines based on each person’s individual data would be generated.

Theoretically, each of these regression lines should have a slope of approximately 1.61803, the Golden Ratio, Phi. This would amazingly show that whether looking at specific measurement ratios (Hip to Floor over Hip to Bottom of Knee, etc.) or the five different measurement ratios on a specific person, the Golden Ratio is present, which is part of the reason it is also called the Divine Proportion.

However, our results did not show this. The regression lines did not produce equal slopes, nor did they produce slopes of 1.61803. Of the 15 station regression lines found in my three classes, none produced the expected outcome and of the almost 90 student regression lines, only 1 student reported a slope near 1.62. (Note: Many students did not get this far. They reported being confused on how to find the regression line and tired of entering the data from the
class, so they did not find their personal regression line. Perhaps more students did have a slope of phi, but the activity did not keep them engaged enough to lead them to this discovery.)

My initial reactions to this activity were very negative. While the students were fully engaged in the measuring and generally positive in their verbal feedback, I knew the mathematics curriculum goal was not achieved. I felt as though I had wasted my valuable instructional time, confused my students, and set a bad preview for the year. It wasn’t until I reviewed their actual evaluations did I find value in what we had done, albeit not the value I had intended.

I first analyzed their responses to the question: “What did you learn about this topic from the activity?” I was disappointed to find that 10 of my 24 students had learned exactly what I had told them the goal of the lab was. This was disappointing because our lab did not show the expected results. The students who reported learning “The golden ratio is on our bodies and in our everyday life.”, or “The body has phi for a ratio.” were simply giving what they hoped was the correct answer. My goal in these activities has not been to have students tell me what they think I want to hear, but rather to encourage them to think for themselves. I want them to become curious, lifelong learners, not just all-A students. But I was a little relieved to find that six of my students had replies of ranging from “I didn’t learn anything.” to “Nothing really. I’m not sure how phi is associated with measuring our bodies.” showing they truly had thought through the question and had answered honestly. So while I had a long way to go with 42% of my students, I was pleased to see that 25% were already confident enough to give an honest answer, regardless of what I had told them they were supposed to learn.

Next, I looked at their responses to the question “How did the activity affect your learning?” Six of twenty-four students responded negatively with responses such as “It was kind
of boring because it was the same thing repeatedly.”, “It confused me because I did not see any comparison between class results and my own results.”, and “It was entertaining but I didn’t learn much. My slope ended up being 1 so I don’t know, maybe I just measured wrong.” The last response especially intrigued me. Are students so accustomed to using problems from textbooks in which the answers come out clean and neat that if they end up with messy, real-world data, they assume they’ve done something wrong? However, as stated above, this activity was flawed in that the data not only produced messy data, but there was no discernable pattern so a fear that something had gone wrong was not unreasonable. Neutral responses were given by five of the twenty-four students and the rest, 13 of 24 or 54.2%, were positive. Comments such as “It was nice to get up and move around.”, “I enjoyed doing all of the measurements.”, and “It was entertaining and fun.” validated the mode of instruction as one that the students were pleased with even without a valuable learning outcome. However, a few students were able to articulate some of the incidental learning that had taken place. Review of measuring, graphing, and lines of best fit, as well as getting to know other students, were reported as important learning that had indeed taken place. My goal, then, must be to maintain the action of the activity while ensuring that the learning goal specific to the curriculum is actually met.

When examining the responses to the questions “What were the best/worst parts of the activity and why?” I found that almost one-half of the students felt that working in groups was the best part. Comments such as “It helped me learn by working in a group.” and “It helped being able to ask group members for help about stuff I didn’t completely understand.” were common. The students’ most common complaint, coming from 62.5% of the students, was the actual measuring, recording of the data, and graphing. This seems very contradictory and somewhat disheartening. While more than one-half felt group work was the best part, even more
felt that actually doing the work was the worst! Do they view group work as a way to just have fun and not have to do the work themselves, knowing that one in the group will inevitably do it and they can take credit for the group work without contributing as much? This to me is and has been one of the biggest dilemmas in using graded group work in the classroom. I worry that the best students will do the work, the worst will do nothing, and both get credit. As such, I have purposefully designed the activities to be more like “experiences” rather than graded assessments, giving grades based on completeness and participation rather than accuracy.

The final question for each activity evaluation was “What advice would you give Mrs. Rodden in using this activity in the future?” The students gave insightful feedback with 33% encouraging a change in procedures such as “Make groups smaller.” and “Measure different things.” An additional 29% felt the instructions were not clear enough. While time in class allowed for the data collection, there was not enough time to do the graphing and analyzing in class. Allowing for more time so that students can work through this part in class with me available to facilitate should alleviate that problem. Another 29% suggested either completely eliminating the activity or rigging it so that the outcome is as desired. Next time, I will use static photographs that actually have dimensions that work out to Phi.

Overall, I believe this activity was successful. Specifically, it was perceived by most students to be enjoyable. They liked the physical nature of moving around and the collaborative nature of working in a group. This activity was also worthwhile in that it gave my students a sense of what would be expected of them in this non-traditional math classroom environment and helped introduce them to one another. However, this activity was not at all effective in illustrating the Divine Proportion. I will not use this activity in the future without drastic
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modifications as my curriculum instructional time is too valuable to spend on an ineffective activity, even if it provides other important but peripheral learning outcomes.

Activity 2: The Trouble with Tribbles

The second activity was based on the Star Trek episode, “The Trouble with Tribbles.” The goal of this activity was to show students the effects of exponential growth. Students were given a brief introduction to the Star Trek characters since so few of them had ever seen Star Trek. They were also given the accompanying worksheet. They were then instructed that they could simply watch the episode, work on the worksheet, or do both. The worksheet, and activity evaluation, would be due on Monday. Unfortunately, this resulted in only 13 of my subjects submitting evaluations to analyze as most of them forgot to bring them back.

During the playing of the episode, I was pleasantly surprised at my students’ reactions. I was afraid that my technologically savvy students would be disinterested in this classic episode from 1967 which lacked the computer-generated special effects to which they were accustomed. However, they were entertained not only by the poorly staged fight scene, the costuming and make-up, and the over-acting, they also found the actual dialogue to be humorous. To my delight, they were able to look beyond the lack of sophisticated visual effects and find entertainment in the characters’ personalities, their interactions, and the predicament the ever-loveable Tribbles had caused. As one student revealed on his activity evaluation, “It was definitely entertaining! I didn't look at the activity as an assignment because it was actually very fun.” However, I had hoped that they were not simply entertained, but also learned a bit about exponential growth.

I first analyzed their responses to the question: “What did you learn about this topic from the activity?” Nine out of thirteen, or 69.2%, of the responders reported learning something
mathematically meaningful in regards to exponential growth ranging from literal “I learned that the prediction of the Tribbles was correct.” to review “It helped to remind me of how to complete certain things on the calculator.” to general “I learned how to write a growth model formula and become faster at working through the problems.” to philosophical “It also opened my mind to think of things differently (graphically, in charts, etc.)” Another three responders answered the question with frivolous answers pertaining to the Tribbles or Star Trek rather than the topic of population growth. Only one responder felt “I didn't learn much.” However, this same student later commented on his evaluation in response to another question “It amazed me at the sum of Tribbles.” revealing that he had indeed learned something very important about exponential growth – the population can increase very quickly!

Next, I looked at their responses to the question “How did the activity affect your learning?” Only two of the responders reported being confused about the worksheet. As this part of the activity was done either individually during the episode or outside of class, this could be alleviated by allotting class time for the worksheet. However, this small percentage, 15.4%, may be better served by coming in after school for individual assistance since, for the overwhelming majority of students, the worksheet was self-explanatory. Of the remaining eleven responders reporting a positive effect, three simply thought it was fun while the others found it to be intellectually stimulating in some way. “The movie bored me. The work was very interesting and it made me think. I liked it.” was one response. This student apparently didn’t value the film aspect of the activity, but felt the worksheet was formatted in such a way that he was interested and engaged. Other students reported “I liked the movie with it and it helped (me) pay attention.”, and “It entertained me because I thought the whole Tribble idea was interesting. Also, I got a better understanding of exponential graphs/equations.”, and “This
activity entertained me and enhanced my learning. It was fun to watch a movie in class, and
listening to the characters explain the process helped me understand.”

When examining my students responses to the question “What was the best part of the
activity and why?” most felt the video was the best part. All students reported favorably toward
the episode with comments such as “I liked watching the movie because it explained the idea and
was still entertaining.” and “Watching the video. I enjoyed that and it helps when you add
something fun to learning.” Of these unanimous positive responses, 38.5% actually commented
favorably toward the use of the worksheet with the video. “The best parts were using charts and
relating the math to an imaginative scenario. Both parts helped to keep me intrigued.” reported
one student. Another found that, “watching the movie helped show what the generations mean
and the table helped explain and organize the information.”

I was once again a bit disheartened when evaluating the responses to the question “What
was the worst part of the activity and why?” as 53.8% complained about doing the work. “It was
a long sheet and I could not finish in class so I had to finish for homework.” and “The worst part
was completing the charts.” I wondered if my students – upper-middle-class suburban Honors
level students – were really that lazy! One could certainly make a case based on this statistic.
However, when analyzing the response to this question along with the response to the previous
question, I’m more inclined to believe that the students actually found the worksheet to be
acceptable, but of the two distinct parts of the activity, the worksheet was less enjoyable than the
video. Furthermore, an additional 38.5% stated there was no worst part as conveyed by one
student, “There were no bad parts; it was a very fun and beneficial activity.”

The final question for each activity evaluation was “What advice would you give Mrs.
Rodden in using this activity in the future?” Two responses were contradictory in regards to the
multi-tasking option. “Watch the movie first then do the activity.” and “Use it again, and continue to allow student to work on the assignment during the movie.” However, 61.5% of the responders had no suggestions for improvement. “None. I really liked everything about this activity.”, “Continue to incorporate the imagination and calculator aspects.”, and “Definitely do it again!” conveyed that the majority of students felt the activity was worth doing again without any changes.

In my overall analysis of this activity it is worth noting that there were two very distinct parts to this activity – the Star Trek episode and the worksheet. It was clear that the majority of students found the movie to be enjoyable. It was further clear that the many found the worksheet to be worthwhile. However, I found that the effectiveness of this activity was due to both parts interdependently. Just showing the movie or doing the worksheet would not have had the same effect or resulted in the same responses. This activity, while consisting of distinctly different parts, cannot effectively be dissected. The strength of this learning activity was based fully on both parts used together. I plan to use this activity in its entirety in the future without any modifications.

Activity 3: Squirrels

The last activity was used after the students had mastered linear and exponential growth. We began the activity in the classroom by discussing how quickly the Tribbles had multiplied and why this occurred. Students recalled Spock explaining that Cyrano Jones had removed the Tribbles from their natural habitat which included predators and introduced them into an environment that had virtually unending resources. Thus, their population was unchecked by any outside forces and allowed to grow exponentially.
Students were asked if this was realistic. Would a park ranger be able to use the exponential model to predict his park’s populations? If not, was there a better model to use? Students agreed that exponential growth might be a valid model during periods of abundant resources, but that the model could probably not illustrate the full picture.

I then explained our game of Squirrels before we went outside to play it. I would start the game by choosing two students to be the Squirrels. The rest of the class would be the Environment. Each student in the Environment would choose to be an available resource and depict their choice using hand gestures. Students would show that they were Shelter by placing both of their hands in a roof shape above their heads, Food by rubbing their abdomens, and Water by pretending to raise a glass of water to their mouths.

I explained that each round would begin with the Squirrels and Environment standing about 20 yards apart facing away from one another. While their backs were turned, each Environment would individually decide what resource he/she would portray and each Squirrel would draw a card from a basket to identify the resource he/she was in need of. Once both sides were ready, I would blow the whistle and each group would quickly turn around. The Environments were to quickly show their hand gestures and the Squirrels were to quickly gather one instance of their needed resource. If the resource was found, that Environment became a Squirrel for the next round. If the resource was not found, the Squirrel would “die” and become a Decomposer for the next round. Decomposers would sit out one round and then become Environment in the next round. At the beginning of each round, we would record the number of Squirrels and the number of Environments.

This activity was done very informally with no worksheet or graphing involved. My initial goal was to illustrate to students how populations are dependent upon resources and that
while exponential growth was a realistic model for unlimited resources, exponential decay was just as realistic when resources were scarce. The activity should show the up and down pattern of populations and give the students a tangible example to which they could associate their subsequent study of logistic growth.

“What did you learn about this topic from the activity?” had varying responses. While two students gave frivolous replies such as “There are a lot of squirrels.”, thankfully 90.9% gave answers pertaining less to the game and more to the concepts behind it. Of those, 22.7% were very literal in their conceptualization stating comments such as “I learned about how life cycles can be in the real world.” The majority of students, 68.2% conveyed learning about population growth. “It gave me a better understanding of logistic growth.”, and “That it can be sporadic growth; it was a good intro into the concept.”, “That logistic growth can grow, level off, or descend.”, and “I learned more about population and growth.”

In response to the question “How did the activity affect your learning?” only one student claimed “It didn't.” Upon further inspection of this participant’s replies on this activity, it seems he did not put much effort into answering the questions. His answer to the “What did you learn?” question above, “There are a lot of squirrels.” was one of the two frivolous replies and not at all up to what would be expected of someone putting forth a good faith effort to provide feedback. The remainder of the respondents found the activity to be fun, interactive, or interesting (68.2%) or the results surprisingly helpful in the student’s ability to understand the concept (27.3%). Sample feedback included “It was a good way to learn without really knowing it.”, “It was an interesting way to learn math.”, and “It helped me understand it better.”

The students’ responses to the question “What was the best part of the activity and why?” revealed much of the same thoughts as the previous activity evaluations. Students enjoy
opportunities to learn in environments that are varied, interactive, and collaborative as illustrated by 81.8% of their comments such as “Going outside changed (the) day to day routine and kept my attention.”, “We were outside engaging in the learning instead of just sitting in a classroom.”, “Interaction. Incorporation of a game and keeping results. It helps to keep my attention!”, “Going outside and getting to have fun while learning. It helped me be more motivated to learn.”, “I like learning from example.”, and “‘Working’ as a class together.” The remaining 18.2% gave trivial responses such as “Going outside.” and “Me not dying.” It would seem that the lack of a summary worksheet may have left some students enjoying the game but not linking it to the mathematics. This should be addressed in the future.

What could be bad about playing a game outside in math class? As there was no worksheet involved with this activity, I was expecting there to be no worst parts. This was true for 40.9% of the students who commented things such as “There were none.”, “No bad/worst parts.”, and “None!” Another 31.8% expressed minor complaints such as “Falling down.”, “Being a decomposer.”, and “It was a little chilly outside.” Some students felt the activity was confusing or difficult at times with three students, or 13.6%, stating “The worst part was having to record the info while we were playing the game. I couldn't concentrate well with both things going on at once.”, “Sometimes it got confusing to understand the main idea of the game.”, and “The transition phase (decomposing) was confusing because (I was) unaware of (its) purpose.” The final 13.6% observantly reported issues that I had also noticed during the game and planned to address in the future. As one student put it, “Some people just grabbed whatever they could. Could've affected our data.” while another stated, “You can't guarantee that the squirrels will go for what environment they drew.” I had also noticed this occurring with some of the students getting more interested in the chase for resources than the rules of the game. I did not address
the issue at the time because I felt this would not significantly affect the data such that students would be unable to see the logistic growth patterns. However, I have already planned to change the Squirrel’s assignment. Rather than choosing their resource by drawing a card, they will also display the Shelter, Food, or Water gesture as they race over to the Environment to capture their needed resource. This should cut down on the Squirrels just grabbing any Environment as his targeted resource will be visible to all at the whistle blow.

In response to the final question, “What advice would you give Mrs. Rodden in using this activity in the future?”, the overwhelming majority of the students, 81.8%, had no suggestions for change, but rather suggestions such as “Keep doing it! It was so much fun and a great intro to logistic growth.”, “None. I think this was a great activity.”, and “Keep doing it by incorporating the game! It was very fun, and I like all of our activities. It helped me to notice the prevalence of math in our everyday lives!” One responder advised, “Make sure squirrels actually follow the card they pick.” and another suggested, “Explain purpose of activity better before going outside.” All of these suggestions are very valuable as I look to improve this activity for future use.

In my overall analysis of this activity, I cannot disagree with the evaluations given by the majority of my students. This activity was a lot of fun for me as well as the students! It was informal, loud, active, different, and comical. To watch these uber-cool seniors act out Shelter, Food, and Water, and to watch others act like Squirrels as they scrambled to find their needed resources was priceless. We were all very entertained and enjoyed the activity quite a bit.

The activity also provided students with a meaningful, memorable experience to reference the following week as we learned about the Logistic Growth Model. Questions such as “Why did the Squirrel population double each round early on?”,” Why did the Squirrel
population decline then rebound?”, and in one class, “Why did the Squirrels become extinct?” were not just hypothetical lead-ins for a classroom lecture. They were real situations they had experienced and the students were eager and well-equipped to render their opinions. The activity was an exciting, 

*worthwhile* way to introduce and engage students in the study of the Logistic Growth Model.

While most students claimed to have “learned” about logistic growth during this activity, was I certain the activity truly met my educational goals? Should there have been a worksheet in which they graphed the data and tried to develop a regression curve? Would that have better illustrated how different, yet similar, logistic growth curves can be to linear and exponential growth curves? Would a worksheet have helped formalize the activity and eliminated the frivolous nature of some students’ perceptions of what we had done? These are all questions I will ponder as I determine how to use this activity in the future. While I definitely believe it sparked students’ interest in the topic, I will need to decide if that is a sufficient goal. At this point, I tend to think that it is. Laying the foundation for a more meaningful, engaging classroom lecture experience is indeed a valid educational goal. And this activity was certainly *effective* in doing that.
Mathematics Survey Outcomes:

Two identical surveys were given during the course of this project to collect information as to how each of my students felt about mathematics and mathematics instructional methods. One survey was conducted early in the course (the “Pre-Survey”) and the other at the end of the unit (the “Post-Survey”). The statements on the survey were presented in various and opposing manners. For example, “Mathematics is enjoyable to me.” versus “Mathematics is boring and old.” This was done so that a student would not be able to simply answer “Strongly Agree” for all statements in hopes of answering “correctly”. While it is apparent from reviewing individual surveys that some students cared more than others to respond thoughtfully and honestly, the varied presentations of the statements did seem to encourage students to think before responding.
Pre-Survey Analysis: Responses as a Whole

As a group, how did my subjects feel about mathematics before their participation in the activity-rich classroom?

Only 4 of the 27 students responded “Agree” to Statement 1: “Mathematics is enjoyable to me.” Furthermore, none responded “Strongly Agree.” In contrast, nearly one-half of the students either “Disagreed” or “Strongly Disagreed” to this Statement and 37% were “Neutral”.

I was surprised at the high number of students who “Disagreed” with Statement 2: “Mathematics is boring and old. There is nothing new to be discovered or learned.” I had expected many to agree with that statement as it seems to be the stereotypical description of mathematics. One student who “Disagreed” commented on his Pre-Survey, “There are always harder levels of math.” It seems that students may have placed more emphasis on the second sentence in the statement than I had intended. They realize that there is more to learn, but may
still feel it is boring and old. In retrospect, I should have simply stated “Mathematics is boring and old.” Unfortunately, because of this ill-worded survey question and its apparent misinterpretation, the data from this statement was misinforming. Therefore, Statement 2 will not be included in the outcomes or conclusions from this project and is not analyzed hereafter.

Statement 3: “Problem solving is a formal step-by-step process that requires little creativity.” and Statement 5: “Math is something you’re just good at or not. This cannot be changed.” did not illicit strong majority feeling in either direction with only 22% feeling “Strongly Agree” or “Strongly Disagree” and 30% feeling “Neutral”. The remaining respondents were nearly evenly split between “Agree” and “Disagree”. The shape of this distribution looks almost normal indicating almost random responses to these statements.

Responses to Statement 4: “Mathematics is best learned from lectures given by the teacher.” were about what I had expected. Overall, 74% of my respondents “Disagreed” with that statement, and half of those “Strongly Disagreed.” One of the most adamant responders commented, “Activities and interactive lessons are very helpful!”

“Neutral”, “Disagree”, and a couple of “Strongly Disagree” were the responses for 89% of the students in regard to Statement 6: “Communication is a mathematical skill.” Only three of the students “Agreed” with Statement 6, and none “Strongly Agreed.”

The responses to Statement 7: “The skills I learn in math class will help me in other classes.” and Statement 8: “Mathematical thinking is used in everyday life.” revealed that the majority of students “Agreed” or “Strongly Agreed.” in both cases. However, some students did not agree with 22% and 19% responding “Disagreed” and “Strongly Disagreed”, respectively.
Comparative Post-Survey Analysis: Responses as a Whole

As a group, how did my subjects feel about mathematics after, compared to their feelings before, their participation in the activity-rich classroom?

Responses to Statement 1: “Mathematics is enjoyable to me.” were much more positive in the Post-Survey. “Strongly Disagree” and “Disagree” showed decreases of 67% and 50% respectively, “Neutral” showed no change, and “Agree” showed an increase of 75%. The most exciting change was in the “Strongly Agree” response. While there had been no students to “Strongly Agree” that “Mathematics is enjoyable to me.” on the Pre-Survey, I had four students – almost 15% – stating that they “Strongly Agreed” to this statement on the Post-Survey!

The change in responses for Statement 3: “Problem solving is a formal step-by-step process that requires little creativity.” were in the undesired direction, but only slightly. Fewer
students chose the desired “Disagree” response on the Post-Survey and more chose the non-descript “Neutral” showing a somewhat “move to the middle” result.

The trend in the responses to Statement 4: “Mathematics is best learned from lectures given by the teacher.” was also not in the desired direction. On the Pre-Survey, 20 students either “Disagreed” or “Strongly Disagreed” while on the Post-Survey only 19 students felt this way.

The trend in responses to Statement 5: “Math is something you’re just good at or not. This cannot be changed.” was in the desired direction. Overall, one fewer student “Strongly Agreed” with this statement and five additional students “Disagreed.”

Statement 6: “Communication is a mathematical skill.” also showed change in the desired direction but at a much higher rate. “Strongly Agree” and “Agree” responses tripled, “Disagree” responses declined by 55%, and “Strongly Disagree” responses fell by 100% with no students “Strongly Disagreeing” on the Post-Survey.

Both Statement 7: “The skills I learn in math class will help me in other classes.” and Statement 8: “Mathematical thinking is used in everyday life.” showed very positive trends. The percentage of students responding “Strongly Agree” or “Agree” rose from 67% to 78% on Statement 7 and from 59% to 67% on Statement 8. On both Statements, the “Neutral” percentage rose 11 percentage points and the “Disagree” or “Strongly Disagree” responses were completely eliminated! No students responded “Strongly Disagree” or “Disagree” on either statement!
Directional Change Analysis: Individual Subject Responses

While looking at the subject group in its entirety revealed general trends, what changes were occurring at the individual level? How were individual students’ opinions changed and in what direction? In examining the aggregated data, a student whose opinion changed from “Strongly Disagree” to “Disagree” may not be included in the directional trend as he is still being counted in the contradictory category. But at the individual level, he has indeed seen a change in opinion which may or may not be in the desired direction.

To analyze the individual directional changes, each student’s responses on the Post-Survey were compared to his responses on the Pre-Survey. The desired change in student’s opinion on Statements 1, 6, 7, and 8 was in the direction of “Strongly Agree” and for Statements 3, 4, and 5, the desired change was in the direction of “Strongly Disagree”. Each student’s response for each statement was thus given a code of “Good Direction” or “Bad Direction”. If a student’s opinion had not changed, regardless of what end of the spectrum it was on, he received a code of “No Change”. A summary of the Individual Changes in Opinion (Pre- to Post-Survey) is given in the stacked bar graph below.
This graphical representation of the directional change data illustrates that the changes in students’ opinions were in the desired direction for a majority of the students on Statements 1 and 6 and almost half the students on Statement 5. A majority of students’ opinions had not changed on Statements 4, 7, and 8. Statement 3 showed the largest percentage of students with changed opinions in the undesired direction. However, the changes were virtually evenly spread on this statement with nine students changing opinion in the desired direction, eight showing no change, and ten in the undesired direction.
Magnitude of Directional Change Analysis: Individual Subject Responses

To analyze the magnitude of the individual directional changes, I calculated a “Change Number” for each subject and each question. This number was found by counting how many steps a student’s response had changed in the desired direction. For example, a Change Number of +4 indicated a change in student’s opinion from the undesired “Strong” opinion to the desired “Strong” opinion while a -4 indicated the opposite directional change of same magnitude. A Change Number of 0 indicated that a student had not changed his opinion at all. However, this should not be interpreted to imply neutrality. A student who had remained “Neutral” in his opinions would receive the same Change Number as a student who had remained “Strongly” opinioned on the undesired (or desired) end of the response spectrum.

Statements 1, 3, and 7 each had one student whose opinion had gone from the undesired extreme to the desired extreme (Good 4). There were no students on any Statement with an
opinion that shifted from the desired extreme to the undesired extreme (Bad 4). On all Statements but Statement 4, over 25% of students changed their opinions in the desired direction (Good 1-4) with Statement 6 showing nearly 60% change. Statements 4, 7, and 8 showed high percentages of students having no change in opinion with 59%, 67%, and 59%, respectively. On Statement 3, 37% of students changed opinions in the undesired direction (Bad 1-4) and 26% changed on Statement 4. All other Statements showed less than 20% of students had changed their opinions in the undesired direction. Furthermore, Statements 7 and 8 showed only two students with undesired directional change in opinion and Statement 1 with none!

Because of the high percentage of students with no change in opinion, I next analyzed the magnitude of directional change amongst only those with a change.

Of those who changed their opinions, at least 75% changed in the desired direction on all Statements but Statement 3 and 4. Statements 1, 6, and 7 each showed over one-third of the
students with changed opinions had moved at least two steps in the desired direction. In contrast, Statements 3, 4, and 5 each showed under one-fifth of the students with changed opinions had moved at least two steps in the undesired direction. Statements 1, 6, 7, and 8 each had no changes of at least two steps in the undesired direction. There were no students with change in the undesired direction of any magnitude for Statement 1.
Mathematics Survey Conclusions:

As I review the summaries of the surveys, from various perspectives, I am surprised, amazed, affirmed, and cautious. How did my students’ participation in my activity-infused classroom affect their feelings about mathematics and mathematics education?

Analysis of Statement 1: “Mathematics is enjoyable to me.” affirmed my belief that student’s enjoyment of math would be increased. Initially, I was surprised at the low number of students who “Agreed” on the Pre-Survey and that none had “Strongly Agreed”. This surprised me because each of my subjects was enrolled in my Honors-level classes, which would indicate past success in math. However, success did not equate to enjoyment for these students. While my students were good at math, over 85% did not agree that math was enjoyable. However, after participation in my course, 41% “Agreed” or “Strongly Agreed” that “Mathematics is enjoyable to me.” Even more exciting, while there had been no students to “Strongly Agree” on the Pre-Survey, I had four students – almost 15% – stating that they “Strongly Agreed” to this statement on the Post-Survey! Furthermore, in terms of individual changes in opinion, the majority changed in the affirmative direction while none of the students had changed their opinion in the undesired direction. So while there was positive change for over 50% of my students, there was negative change for none. In terms of making mathematics more enjoyable, the activities seem to have been an overwhelming success for both the group as a whole and for many individuals.

For both the Pre- and Post-Survey on Statement 3: “Problem solving is a formal step-by-step process that requires little creativity.”, the bell-shaped data distribution looks almost normal indicating nearly random responses to these statements. While the responses were not random, they did indicate the opinions of my students were highly concentrated on “Neutral” and virtually evenly spread in each direction across the response spectrum. On the Post Survey,
fewer students chose the desired “Disagree” response and more chose the non-descript “Neutral” showing a somewhat “move to the middle” result. This shift toward “Neutral” could’ve been perceived as negative in that my students had not seen their activities as requiring creativity, but rather a formal, algorithmic process. However, I believe this shift toward “Neutral” was a good first step. My students weren’t sure how to react to the Statement. While they had been given the latitude to use their creativity on the activities, they had also been given instruction on new concepts, models, and procedures as available tools to use in their search for solutions. I found myself pleased with the “Neutral” stance my students took on this statement as it reflected my own view. Problem-solving involves both creativity and the use of algorithms; students should be utilizing both interchangeably.

The trend in the responses to Statement 4: “Mathematics is best learned from lectures given by the teacher.” was also not in the desired direction. On the Pre-Survey, 20 students either “Disagreed” or “Strongly Disagreed” while on the Post-Survey only 19 students felt this way. Why would fewer students disagree to lecture learning after the activities than before? Had the activities in the classroom not been effective such that students felt lectures produced better learning? Or perhaps the distaste for lecture learning had decreased during the study. In this activity-rich classroom, lectures were no longer based on hypothetical situations or procedural memorizations. Lectures were more discussion-based and often prefaced by, “What happened to the squirrels when …” or “Why did the Tribbles …” In my classroom, lectures had become viewed as time for summary or clarification of a past activity or as learning a new technique that might be used in a future one. As such, students realized that they learned from both methods of learning, especially when used interdependently.
The trend in responses to Statement 5: “Math is something you’re just good at or not. This cannot be changed.” was in the desired direction. Overall, one fewer student “Strongly Agreed” with this statement and five additional students “Disagreed.” Coupled with the results from Statement 1’s analysis, it seemed that increased student enjoyment might be associated with increased hopefulness and increased motivation. Perhaps “I like to do math.” may be turned into “I think I can learn math.”

Statement 6: “Communication is a mathematical skill.” showed the greatest change in students’ opinions. While over 48% responded contrary to the statement on the Pre-Survey, under 19% responded such on the Post-Survey. In terms of individual respondents, nearly 60% of students changed their opinions toward “Strongly Agree” and less than 19% toward “Strongly Disagree”. Furthermore, nearly half of those students who changed opinion in the desired direction had moved two or more steps in the desired direction; no students moved more than one step in the undesired direction. This change was most likely in response to the nature of the activity-filled classroom. I had been caught off guard on the Pre-Survey when almost one-half of the students did not believe that “Communication is a mathematical skill.” While I understood where students might get this notion – the traditional classroom in which listening is strongly emphasized – I was surprised at how prevalent it was. After experiencing an interactive mathematics classroom environment, most students clearly understood the need to speak as well as listen in mathematics.

Analysis of the Pre-Survey data for both Statement 7: “The skills I learn in math class will help me in other classes.” and Statement 8: “Mathematical thinking is used in everyday life.” perplexed me. On each Statement, a majority of students “Agreed” or “Strongly Agreed”. However, I was amazed that not only were some students “Neutral” on this, but some students
did not agree. While only a minority (22% and 19%) actually “Disagreed” or “Strongly Disagreed”, I wondered why students would feel that way. Was my class simply another math class they had to endure for graduation? Did they really see no connection to their other classes, future studies, or everyday lives? Furthermore, would the activities utilized throughout my class, with their obvious applications in other disciplines such as art, business, science, etc., result in a change of opinion for those students? Analysis of the Post-Survey group data showed very desirable changes in opinion. For each of these Statements, there were no students responding “Disagree” or “Strongly Disagree” after participation in this project. In looking at individuals’ change direction, there were only two students on each Statement with undesired directional change, but these students’ changes were only of magnitude one and did not result in a contradictory response to the Statements. Furthermore, in examining each student’s data responses, of these four instances of undesired directional change, three were from “Agree” on the Pre-Survey to “Neutral” on the Post-Survey and one was from “Strongly Agree” to “Agree”. Additionally, of the six students who responded “Disagreed” or “Strongly Disagreed” on the Pre-Survey for Statement 7, three moved to “Neutral”, two to “Agree”, and one to “Strongly Agree”. Of the five for Statement 8, three moved to “Neutral”, one to “Agree”, and one to “Strongly Agree”. The use of activities in the classroom did seem to enlighten students to the value of mathematics in regards to their other classes, future endeavors, and everyday lives.

So, how do interactive activities in the classroom affect students’ perceptions of mathematics and mathematics education? While the results of this project seemed to indicate that students found mathematics to be more enjoyable, important, and relevant, I am cautious as I render any type of generalizations for several reasons. First, were these changes in opinion due to the actual activities used or rather from the subsequent classroom lectures filled with tangible
examples? Did students enjoy mathematics more because of the activities or because they could finally see the usefulness of the mathematics they had previously learned? Were they communicating more due to the use of these activities only or did the discussion-based learning environment also provide for more engagement and communication? While the activities contributed to the style of classroom experience my students encountered, I am unsure that the activities alone would have had such a dramatic impact. The open, active, non-traditional style of instruction may have also played a significant role.

Second, did students see the importance and relevance of mathematics simply due to the nature of the Discrete Mathematics course? Based on previous years’ experiences, this unit – Mathematics in Nature – in and of itself often illustrates the relevance of math in the students’ everyday lives. Did the activities introduced this year make this relevance more pronounced or are the changes in students’ opinions regarding importance and relevance also due to the material being learned? Furthermore, did the students’ enjoyment of mathematics increase also due to the nature of the course. Discrete Mathematics is a course which includes topics generally not already “covered” in previous math courses. In this course, students are introduced to new terminology, algorithms, and ideas. Because they haven’t experienced years of repetition and been “spiraled” into apathy about the mathematical concepts, they are interested, curious, and ready to be engaged. As such, learning – regardless of the subject matter – would expectedly be more enjoyable with or without the activity component.

Last, did the use of voluntary subjects cause an unintended bias? In order to be included, both the students and their parents had to choose to participate, sign forms, and return them during the mandated timeframe as instructed and encouraged by me, their classroom teacher. Were the students who chose to participate different in any way that might have skewed the
resulting data? Were they more likely to be organized such that they were able to take the forms home, get them signed, bring them back, and turn them in? Were they more likely to be submissive such that they participated because it was requested? Or were the students volunteering to participate because they were enjoying the class? Did voluntary participation create a sample that was significantly different than my entire classroom population? While this methodology has been widely used in past products of learning, I am concerned that a significant confounding variable may have been introduced into the project thus diluting the conclusions that might have been made.

However, the students’ dramatically increased enjoyment of math, their elevated regards for mathematics’ importance and relevance, and their improved perception of communication as a mathematical skill lend themselves to the need for further study and perhaps experimentation in the use of activities within the mathematics classroom. Personally, I have found the implementation of activities and the recall of the activities within my classroom instruction, to be a great asset in my own teaching. While the effects of the activities on their own may not be conclusively discernable from the results of this project, the changes in my classroom’s learning environment while using them have been overwhelming positive.
ACTIVITY-BASED CURRICULUM FOR THE DISCRETE MATHEMATICS CLASSROOM

Literature Review

In 1983, Howard Gardner proposed a new view of intelligence incorporating seven components instead of the traditional two. Replacing verbal and computational intelligences with logical/mathematical, linguistic, spatial, musical, bodily/kinesthetic, personal and intrapersonal, Gardner expanded the concept of intelligence and set off a wave of change in education, including but not limited to the concept of students’ learning styles. Gardner’s Theory of Multiple Intelligences implies that teachers should not only recognize a broader range of talents, but also teach to that expanded pool. The thought is that presentation of concepts in a variety of ways not only excites students about learning, it also engages their wide array of differing intelligences and can facilitate a deeper understanding of the ideas (Brualdi, 1996). Using varying activities to introduce, reinforce, or supplement the concepts can help to reach students that are traditionally lost when teacher-based lecture is the only mode of delivery.

The daily grind of the lecture and drill traditional mathematics class has also been shown to be not only ineffective, but detrimental to student achievement. Masini & Taylor report that “… practices that involve drilling students were related negatively to mathematics achievement while practices that promote conceptual understanding of material were related positively to mathematics achievement.” (Masini & Taylor, 2000) My goal was to develop issue-based activities that could be used to introduce, illustrate, or reinforce the mathematical concepts. As stated in North Central Regional Educational Lab’s June 1999 Policy Issues, “less content taught well, and in more depth, lends itself to greater understanding.” (as cited in Masini & Taylor, 2000) With activities, not only did I expect my class to be more enjoyable, but based on the
research mentioned, this methodology should improve their understanding and achievement as well.

Activities also promote interpersonal interactions. Cooperative learning has been shown to produce positive outcomes including improved academic achievement, improved behavior and attendance, increased self-confidence and motivation, and increasing liking of school and classmates (Balkcom, 1992). But is improving self-perceptions enough? Does this lead to improved learning and higher achievement? “Academic self-concept has been shown to be a significant predictor of achievement on several types of academic outcomes and for students of various ages.” (House, 1993) Specific attitudes such as students’ confidence in their academic abilities, their expectations for success, and their comparisons of themselves with others, may be related to math achievement according to House. While further study is necessary, it seems rather intuitive that one’s math achievement, as in any other arena of achievement, could be improved with an increase in self-confidence, a setting of higher personal goals, and a feeling of belonging amongst one’s successful peers.

Constructivist theory also seems to foster the notion of the activity-based classroom. From the constructivist perspective, learning is an active – not passive – endeavor. Taking notes from a teacher-led lecture may be necessary at times, but active learning requires activities. But as ideal as the active classroom may be, Richetti & Sheerin seem to sum it up perfectly: “The overarching goals of constructivism are commendable and straightforward: helping students become autonomous learners and thinkers, explore important questions, and build and integrate deeper understandings of knowledge. Of course, the challenge lies not in embracing the theory but in implementing it.” (Richetti & Sheerin, 1999) I have found this to be especially true. I found a real lack of available resources, particularly in Discrete Mathematics, which would be
aligned with my particular course curriculum, interesting to my students, and accurate with attainable results. Many of the resources I was able to locate were either too simple and geared towards pre-teens or too complex and geared towards upper-level college students. After much effort, I was able to gather ideas from which I customized activities for my students. But this was very time consuming and, at times, completely failed to hit the mark. So, I wholeheartedly agree that while I may embrace constructivism, it’s challenging to fully implement.

So what are we to do? Some would point to the interactive technologies; surely this would produce students who are autonomous thinkers. However, even the technological revolution has not lead to the great promise its proponents made claim to. For as Dockterman chides, “Interactive technology is neat, but ultimately, it’s interactive classrooms that bring the real breakthroughs in learning.” (Dockterman, 1995) Classrooms can no longer be static, quiet lecture halls. They must be dynamic, energetic, lively, communicative, cooperative centers of activity. This product has been undertaken with that goal in mind.
ACTIVITY-BASED CURRICULUM FOR THE DISCRETE MATHEMATICS CLASSROOM

References


Appendices

Mathematics Survey instrument

Activity Evaluation instrument

North Carolina Standard Course of Study
  Discrete Mathematics
**MATHEMATICS SURVEY**

I am interested in how you feel about yourself as a student in general and mathematics specifically. Your responses will be kept confidential, so please answer honestly. Also, the answers you give will not affect your grade in any way.

Use the following table to rate how you feel about the following statements. Place an X in the column that reflects your opinion. Please also elaborate by adding comments below the statement.

<table>
<thead>
<tr>
<th>Mathematics is enjoyable to me.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strongly Agree</td>
</tr>
<tr>
<td>Mathematics is boring and old. There is nothing new to be discovered or learned.</td>
</tr>
<tr>
<td>Problem solving is a formal step-by-step process that requires little creativity.</td>
</tr>
<tr>
<td>Mathematics is best learned from lectures given by the teacher.</td>
</tr>
<tr>
<td>Math is something you’re just good at or not. This cannot be changed.</td>
</tr>
<tr>
<td>Communication is a mathematical skill.</td>
</tr>
<tr>
<td>The skills I learn in math class will help me in other classes.</td>
</tr>
<tr>
<td>Mathematical thinking is used in everyday life.</td>
</tr>
</tbody>
</table>
The Trouble with Tribbles

Tribbles are cute, furry creatures that exist in the world of Star Trek. Being hermaphrodites (both male and female), a single tribble can produce a litter of 10 babies all on its own. Furthermore, they are born adult and begin reproducing new litters every 12 hours!

1.) One tribble was trapped in the grain hold of the starship Enterprise for 3 days. Science officer Spock proclaimed that there were 1,771,561 tribbles in the grain hold at the end of this time. Is Spock mathematically correct, or was this simply TV mumbo-jumbo? Use the chart below to determine if Spock’s number was correct.

<table>
<thead>
<tr>
<th>Hours</th>
<th>Generations</th>
<th>Total Tribble Population *</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>1 adult</td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>1 adult + 10*1 babies = 11</td>
</tr>
<tr>
<td>24</td>
<td>1</td>
<td>11 adults + 10*11 babies =</td>
</tr>
<tr>
<td>36</td>
<td></td>
<td></td>
</tr>
<tr>
<td>48</td>
<td></td>
<td></td>
</tr>
<tr>
<td>60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>72</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* (Assume during this investigation that none of the tribbles dies.)

2.) Was Spock correct? ________________

3.) Use your calculator to create a scatter plot for the data above. Use Generations as the horizontal axis and Population as the vertical axis. Sketch your scatter plot below with labels on the axes.

Remember How?
- STAT – 1:Edit – (Enter Generations in L1 and Population in L2)
- STATPLOT – On – Scatter plot – L1, L2
- WINDOW – X: 0 to 7, scale 1; Y: 0 to 2000000, scale 100000
- GRAPH

4.) If you were to connect the points, what shape would it resemble? ____________________________
(A straight line, an umbrella, an arch, a hockey stick, etc.)

5.) What type of best-fit function does this suggest? ____________________________
(Linear, quadratic, exponential, etc.)
6.) Find the exponential regression equation for your data and graph it with your scatter plot.

   Remember How?
   • STAT – CALC – 0:ExpReg – Enter
   • Y = – VARS – 5:Statistics – EQ – 1:RegEQ
   • GRAPH

   \[ y = \] ______________________________________________________________________

7.) How well does the exponential equation “fit” your data? ____________________________

8.) Now look at the Table. What do the values in the X column represent? __________________

9.) Using the Table, how many tribbles would you expect after 96 hours? ____________

   [Hint: Be careful of the X-value you’re searching for… Also, the table is not very wide, so large
   numbers will be given in scientific notation. Highlight the scientific number you’re interested in,
   then see the full value below the table.]

10.) The rate of growth of a population can be found using this equation:

\[ r = \frac{b - d}{p} \]

   \[ r = \text{rate of growth; } b = \# \text{ of births; } d = \# \text{ of deaths; } p = \# \text{ of parents} \]

   Using the formula above, express the rate of growth for the tribble population. ______________

11.) If each tribble only had 4 babies per litter, express the rate of growth. __________________

12.) Can we find a pattern that may help us create a formula for finding the number of tribbles?

   Complete the chart below.

<table>
<thead>
<tr>
<th>Hours</th>
<th>Generations</th>
<th>Total Tribble Population *</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>12</td>
<td>1</td>
<td>( 1 + 10 \times 1 = (1+10) )</td>
</tr>
<tr>
<td>24</td>
<td>2</td>
<td>( 1(1+10) + 10 \times 1(1+10) = (1+10)(1+10) = \frac{(1+10)^2}{1(1+10)^2} )</td>
</tr>
<tr>
<td>36</td>
<td>3</td>
<td>( 1(1+10)^2 + 10 \times 1(1+10)^2 = (1+10)^3(1+10) = (1+10)^3 )</td>
</tr>
<tr>
<td>48</td>
<td>4</td>
<td>--------------------------</td>
</tr>
<tr>
<td>60</td>
<td>5</td>
<td>__________________________</td>
</tr>
<tr>
<td>72</td>
<td>6</td>
<td>__________________________</td>
</tr>
</tbody>
</table>

13.) Create a formula based on the pattern you see above. \( P_N = \) ______________________

14.) Show and verify Spock’s answer using this new formula: __________________________

15.) Show and verify your expected number of tribbles after 96 hours (#9 above) using this new formula:

   __________________________________________________________

**Bonus:** Show all work/thought on separate sheet of paper.
Rework the investigation starting with 3 tribbles. How does this affect your formula? What would your
formula be if you started with \( x \) tribbles?
ACTIVITY EVALUATION

I am interested in how you feel about the activity used in class today. Your responses will be kept confidential, so please answer honestly. Also, the answers you give will not affect your grade in any way.

Name of Activity: ____________________________

What did you know about this topic before the activity?

What did you learn about this topic from the activity?

How did the activity affect your learning? Did it explain, intrigue, confuse, entertain, bore, revolt, amaze, etc.? Explain.

What were the best parts of the activity and why? How did they affect your learning?

What were the worst parts of the activity and why? How did they affect your learning?

What advice would you give Mrs. Rodden in using this activity in the future?
**Discrete Mathematics**

Discrete Mathematics introduces students to the mathematics of networks, social choice, and decision making. The course extends students’ application of matrix arithmetic and probability. Applications and modeling are central to this course of study. Prerequisites:

- Describe phenomena as functions graphically, algebraically and verbally; identify independent and dependent quantities, domain, and range, input/output, mapping.
- Translate among graphic, algebraic, numeric, tabular, and verbal representations of relations.
- Define and use linear and exponential functions to model and solve problems.
- Operate with matrices to model and solve problems.
- Define complex numbers and perform basic operations with them.

### Number and Operations

**Competency Goal 1**
The learner will use matrices and graphs to model relationships and solve problems.

<table>
<thead>
<tr>
<th>Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.01 Use matrices to model and solve problems.</td>
</tr>
<tr>
<td>a. Display and interpret data.</td>
</tr>
<tr>
<td>b. Write and evaluate matrix expressions to solve problems.</td>
</tr>
<tr>
<td>1.02 Use graph theory to model relationships and solve problems.</td>
</tr>
</tbody>
</table>

### Geometry and Measurement

**Competency Goal 2**
The learner will analyze data and apply probability concepts to solve problems.

<table>
<thead>
<tr>
<th>Objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.01 Describe data to solve problems.</td>
</tr>
<tr>
<td>a. Apply and compare methods of data collection.</td>
</tr>
<tr>
<td>b. Apply statistical principles and methods in sample surveys.</td>
</tr>
<tr>
<td>c. Determine measures of central tendency and spread.</td>
</tr>
<tr>
<td>d. Recognize, define, and use the normal distribution curve.</td>
</tr>
<tr>
<td>e. Interpret graphical displays of data.</td>
</tr>
<tr>
<td>f. Compare distributions of data.</td>
</tr>
<tr>
<td>2.02 Apply properties, definitions, and theorems of angles and lines to solve problems and write proofs.</td>
</tr>
<tr>
<td>a. Use addition and multiplication principles.</td>
</tr>
<tr>
<td>b. Calculate and apply permutations and combinations.</td>
</tr>
<tr>
<td>c. Create and use simulations for probability models.</td>
</tr>
<tr>
<td>d. Find expected values and determine fairness.</td>
</tr>
<tr>
<td>e. Identify and use discrete random variables to solve problems.</td>
</tr>
<tr>
<td>f. Apply the Binomial Theorem.</td>
</tr>
<tr>
<td>2.03 Model and solve problems involving fair outcomes:</td>
</tr>
<tr>
<td>a. Apportionment.</td>
</tr>
<tr>
<td>b. Election Theory.</td>
</tr>
<tr>
<td>c. Voting Power.</td>
</tr>
<tr>
<td>d. Fair Division.</td>
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</tbody>
</table>

### Data Analysis and Probability

**Competency Goal 3**
The learner will describe and use recursively-defined relationships to solve problems.

<table>
<thead>
<tr>
<th>Objectives</th>
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<tbody>
<tr>
<td>3.01 Use recursion to model and solve problems.</td>
</tr>
<tr>
<td>a. Find the sum of a finite sequence.</td>
</tr>
<tr>
<td>b. Find the sum of an infinite sequence.</td>
</tr>
<tr>
<td>c. Determine whether a given series converges or diverges.</td>
</tr>
<tr>
<td>d. Write explicit definitions using iterative processes, including finite differences and arithmetic and geometric formulas.</td>
</tr>
<tr>
<td>e. Verify an explicit definition with inductive proof.</td>
</tr>
</tbody>
</table>