Classroom Discussion with Algebra PowerPoint Activities

Gregory A. Reese

Sonoma State University

April, 2013

Abstract

PowerPoint slide shows are easily created with clear large text and mathematical equations. The slides can be designed with animation so that at the click of a button, additional text is added to the screen. This investigation presented a prepared PowerPoint slide show to a class of 9th grade high school algebra 1 students. The teacher controlled the slide animation so that at the appropriate time text appeared on a large screen in the classroom. The PowerPoint slides contained mathematical manipulation solving a system of linear equations. As the class discussed the steps for solving the system of linear equations, the teacher called on students to volunteer the steps, one step at a time, for solving the system of linear equations. The teacher encouraged students to explain the reasoning to justify each step as it appeared on the classroom screen. The PowerPoint Algebra Activity was observed to have a positive effect on student engagement and resulted in an increase in student participation in discussion of the process of solving a system of linear equations. Most importantly, students practiced utilizing mathematical reasoning as they participated in the PowerPoint Algebra Activities.

Keywords: engagement, technology, mathematics

Introduction

The standards of mathematical concepts proscribed to be learned in a high school classroom in the United States are clear and the performance objectives are made apparent on the released review questions for the national standardized tests (National Governors Association Center for Best Practices, Council of Chief State School Officers, 2010). It is natural that the high school mathematics teacher whose objective is fostering in the students an aptitude for philosophical mathematical discussion should plan to encourage classroom discussion about the material likely to be tested for on the national standardized tests. Although a teacher's objective might be fostering philosophical classroom discussion, the teacher is not absolved from the responsibility of exposing the students to the mathematical theorems and relationships that will be encountered on the national standardized tests.

A critic might argue that a classroom discussion about how to combine two linear equations, or how to extract a pair of linear equations out of a word problem does not meet the objective of exposing students to the meaning behind the math. I have three responses to this valid point. First, what one teaches in ninth grade algebra class should be what is tested for on the national standardized test. Second, adopting the behaviors of participating in mathematical group discussion using mathematical language is the beginning of internalizing mathematical thinking and engagement in philosophical mathematical reasoning. Third, high school students are very young; with few exceptions, they are novices at mathematical reasoning and they are emotionally insecure. The high school mathematics teacher should not abandon what is possible and mandated, in pursuit of what the students are neither emotionally ready for nor adequately equipped for with prerequisites. In this research study, I presented prepared interactive PowerPoint Algebra Activities to a class of 9th grade algebra students. Students were encouraged to predict the next step in solving a system of linear equations. The objectives of the curriculum were to foster class engagement, participation, discussion, inquiry and mathematical reasoning, while solving a mathematics task and to enable the students to internalize one of the recommended procedures for performing a task that often appears on national standardized tests. In considering the curricular value of the PowerPoint Algebra Activities, it is most advantageous to analyze the value of discussion in a high school mathematics classroom.

A review of related literature

The use of discussion in the high school classroom in the United States is motivated by several effects that it has on students. First, classroom discussion can be a process in which students negotiate the personal meaning that they make out of community experiences. Second, classroom discussion can situate the level of difficulty of the mathematics within the zone of proximal development of the students actually in the classroom by altering the speed and direction of the classroom curriculum. Third, classroom discussion is a process of modeling and practicing mathematical reasoning. Finally, classroom discussion can engage students in learning. Analyzing the four effects of classroom discussion one at a time may provide a coherent justification for undertaking strategies to increase effective classroom discussion.

Negotiated Meaning

Pinar, Reynolds, Slattery, & Taubman (2008) defined negotiated meaning phenomenologically as the transformational manner in which an individual translates the concepts, explanations and experiences they are exposed to into a personal meaning. Classroom discussion is an important element in the student's construction of a personal negotiated meaning of the curriculum (Pinar et al., 2008). In group discussion, students participate in negotiating and verifying mathematical ideas and arrive at shared community understandings (Manouchehri & St. John, 2006). The traditional math classroom lecture does not exhibit the same negotiated meanings that are present in conversation between individuals. Discussion requires a mutual agreement on meanings whereas lecture is an individual expression that requires no reciprocal agreement (Davis, 1994). Discussion with another individual implies a collaboratory effort to make personal meaning in conversation. The process of probing and questioning within a conversation involves an intent to arrive at a deeper understanding of meaning (Davis, 1994). Davis (1994) described classroom discussion as, “a genuine potential for fusing of horizons, in part because the mathematical concepts are emerging from collective experiences, not being imposed on the individual understandings.” (p.283)

Language and social interaction have a fundamental influence on the individual student in making personal meaning of mathematics (Barwell et al., 2005; Forman & van Oers, 1998; Hoyles & Forman, 1995; Monaghan, 1999; Sfard, 2000; Sfard & Kieran, 2001 as cited in Mercer & Sams, 2006). The language with which the individual student negotiates internally with himself or herself is modeled on and extrapolated from the language that the individual student is exposed to and uses in classroom discussion (Vygotsky, 1978 as cited in Mercer & Sams, 2006). Further, the negotiated meaning that the individual student adopts for himself or herself is partly a reflection of the negotiated meaning of the classroom community which the individual student participates in constructing through discussion (Mercer & Sams, 2006). Classroom discussion places greater responsibility on the students to articulate their own knowledge rather than be presented with information to be memorized. To facilitate the student’s construction of a personal negotiated meaning, the process of articulation and communication is necessary in mathematics pedagogy to create a learning activity in which the students negotiate the construction and communication of mathematical concepts for themselves. “We adopt a Vygotskyan perspective in that we view whole-class mathematics discussions as teacher-guided meaning making experiences that can serve as interpersonal gateways for students to appropriate those meanings.” (Zolkower & Shreyar, 2007, p. 178)

In discussion, the students are forced to use the language and theorems and algebraic relationships actually at their disposal in order to make meaning out of the mathematical task, thereby extending the knowledge that the individual students actually internalize (Brakenbury, 2012). The acquisition of mathematical knowledge requires an internal effort by the learner to change their view of the world because an individual’s learning is constrained by the unique personal culturally determined meaning with which the individual describes their classroom experience to themselves (Borges, Do Carmo, Silva Goncalves, & Macedo Cunha, 2003).

The term “artifacts” can be employed to define the elements of the external world with which the individual interacts in forming personal understanding and meaning. Physical objects such as pencils, chalkboards, books and drawings; tools of fabrication such as hammers and compuses; tools of communication such as language, facial expressions and physical contact; experiences such as oral discussion or handling manipulatives; objects of cultural heritage such as theorems and algebraic relationships; technological objects such as smart phones and computers; can all be classified as “artifacts” which the individual is exposed to and from which the individual forms their personal philosophical understanding of the world. In educational curriculum, artifacts share a common function as tools with which knowledge and skills are communicated and solidified within the individual student's consciousness, transforming the individual (Bartolini Bussi, & Alessandra Mariotti, 2008). It may, therefore be useful in designing curriculum to study artifacts abstractly and collectively to uncover the common effects that they have on classroom education. Artifacts in the classroom give a concrete structure to the leaning process that orientates the individual in their leaning and coalesces groups around a common shared purpose and pursuit (Bartolini Bussi, & Alessandra Mariotti, 2008).

Written language is one example of an artifact. Learning a written language alters the logical and abstract thought processes of the individual because written language, which by its physical properties must address abstract situations that are not currently occurring, exposes the mind to thinking abstractly (McLuhan, 1962; Ong, 1967/1970 as cited in Bartolini Bussi, & Alessandra Mariotti, 2008). The attainment of literacy is accompanied by dramatic shifts in the individual's cognitive processes. (Luria, 1976 as cited in Bartolini Bussi, & Alessandra Mariotti, 2008). Writing is crafted for an effect on the reader, the process of reading and writing exposes the individual to following a logical organizational pattern (Bartolini Bussi, & Alessandra Mariotti,2008). Bartolini Bussi, & Alessandra Mariotti (2008) suggest that other artifacts of learning may have a similar effect on the thought processes of the individual in both how the individual perceives a group task and the structure of the individual's cognitive process. The use of the artifacts of geometry, for example, may have an effect on the use of deductive reasoning in the individual. Arzarello (2006 as cited in Bartolini Bussi, & Alessandra Mariotti) suggested that in geometry, investigation of geometric objects and theorems leads to changes in the individuals cognitive mathematical processes; individuals are able to understand mathematical relationships differently after they have been able to physically measure and manipulate goemetric artifacts and verify theorems of geometric relationships.

Technological artifacts, such as computers and PowerPoint activities, may also have a similar profound phenomenological impact on students' cognitive processes. (Rabardel & Samurçay, 2001 as cited in Bartolini Bussi, & Alessandra Mariotti, 2008).

> In the last decades a new kind of artifact has become easily available: the tools of the information and communication technologies. It is trivial to say that they have empowered and changed the human way of thinking. Their entrance in schools has, on the one hand, encouraged educators to reconsider curricula and, on the other hand, called attention to the relationships between students and computers (Bartolini Bussi, & Alessandra Mariotti, 2008p. 5).

One possible framework to use to understand the process of learning in a high school mathematics classroom is semiotic mediation. This perspective considers the teacher as a mediator working for the students to connect artifacts and semiotics (the language, symbols and graphic organizers that a student might make use of to cognitively understand and exchange information about the mathematical relationship and artifacts (Bussi, & Alessandra Mariotti, 2008). This view of teaching defines the teacher's role as one of instructing the students to communicate and express math ideas socially with cultural norms. Semiotic mediation assumes the Vygotskian perspective that all higher knowledge exists only as a manifestation of social interaction and communication. Thus the role of the teacher of mathematics is viewed as a mentor for developing words, symbols and behaviors to communicate about mathematical artifacts. (Vygotsky, 1978 as cited in Bartolini Bussi, & Alessandra Mariotti, 2008). Bartolini Bussi, & Alessandra Mariotti (2008) states, "The relationship between artifact and knowledge may be expressed by signs, culturally determined, produced by cultural development and crystallizing the meaning of the operations carried out with the artifact."(p.18) Students make use of artifacts as tools to perform tasks such solving a system of linear equations and use semiotics to describe a pattern of steps to arrive at a solution. Bartolini Bussi, & Alessandra Mariotti (2008) stated, "Because of the cultural significance of this process we call the teacher a cultural mediator. We do not refer only to the concrete act of using a tool to accomplish a task, rather to the fact that new meanings, related to the actual use of a tool, may be generated, and evolve, under the guidance of the expert (i.e. the teacher)."(p.19)

Zone of proximal development

A second important motivation for initiating discussion in the mathematics classroom is to locate the mathematics curriculum at the edge of the students preexisting knowledge (Henning & Balong, 2011). By empowering the students with discussion, the teacher surrenders some control over the speed and direction of the curriculum (Brakenbury, 2012). The students in a high school algebra class in the United States represent a wide range of levels of mathematical competence, past experiences and beliefs about learning math. Discussion incorporates these diverse perspectives into the curriculum to give students a footing from which to extend their knowledge and correlate new math experiences to familiar ones, enabling students to better make meaning out of what is new to them (Henning & Balong, 2011).

Semiotic forms include both the vocabulary and the symbols that the larger mathematical community uses to communicate mathematical ideas. In the framework of semiotic mediation and referencing Vygotsky's theory of the zone of proximal development, using natural language and physical gestures in group discussion is an integral part of the process of acquiring the cultural heritage of the semiotic forms of discussing mathematics (Bartolini Bussi, & Alessandra Mariotti, 2008). As students discus suggestions for handling mathematical theorems and algebraic relationships and practice structuring semiotic descriptions of new tasks, they gradually move toward greater command of the language and structure of mathematics (Martin, McCrone, Bower, & Dindyal, 2005). Students may use terms such as “move” or “replace” in their discussions about completing tasks in the math classroom. These words and phrases have both meaning specific to the culturally determined norms of formal mathematical discussion and also have related meaning in everyday use. Combined with gestures and inferences, students are able to practice manipulating mathematical theorems and algebraic relationships to create internal meaning from the task, theorems, relationships and semiotic signs they are being newly exposed to (Bartolini Bussi, & Alessandra Mariotti, 2008). Gradually transitioning from the everyday use of words that students are familiar with to the similar mathematical use of the words, students acquire the tools of mathematical communication (Martin et al., 2005). The mathematical language of a high school classroom is a mixture of the formal language of mathematical research, the language of the classroom textbook, and the mathematical communication standards set by the teacher (Martin et al., 2005).

As students participate in classroom discussion the teacher has an opportunity to listen to the students and gauge their competence in the use of formal mathematical language. The teacher can adjust his or her own language and presentation accordingly. The process of gradually moving from natural to mathematical language is recognized by the National Council of Teachers of Mathematics (NCTM) in their Principles and Standards (Henning & Balong, 2011).

Listening is an intentional act that is indispensible for discussion to occur (Davis, 1994). Davis (1994) defined listening as a way of being, not a physical act, that brings individuals into a communicating relationship where a common meaning is negotiated. Thus, by listening and responding to the student's needs and abilities, the teacher can modify the pace and language of the curriculum to enable the students to make meaning out of the learning experience.

Mathematical reasoning

The goals of a mathematics classroom include both teaching students mathematical skills and teaching students when and how to apply those mathematical skills (Manouchehri & St. John, 2006). The routine of a traditional mathematics classroom consists of an example problem presented by the teacher followed by similar practice problems for the students. In this routine, students are not ask to choose which math skill to apply to a new problem, the skill to be used is predetermined for them. Thus students experience applying the math skill but do not experience the questioning process of choosing which skill is appropriate from the list of skills they know (Boaler, 1999). The process of questioning what to do next and justifying why to do it, is mathematical reasoning.

Mathematical reasoning can be modeled and practiced as part of the mathematics class curriculum (Mercer & Sams, 2006). In order to employ mathematical reasoning, the student must be equipped with an arsenal of mathematical skills to choose from. These skills include mathematical theorems and algebraic relationships. To perform unfamiliar mathematical tasks, the student must also be able to employ mathematical reasoning, step by step, choosing from among their arsenal of skills, justifying each step, in a manner that accomplishes the task.

The ability to articulate convincing mathematical arguments may be defined as both what a student internally defines as mathematically convincing and how the student chooses to convince others (Harel & Sowder, 1998 as cited in Martin et al., 2005). Martin et al. (2005) measured students' mathematical sophistication by the forms of mathematical reasoning the students employ to defend their beliefs. Martin et al. (2005) identified three forms of mathematical reasoning of progressive sophistication. One: external conviction, students may rely on a single self contained source, for example 3 minus 2 is 1, why, because the teacher said this is the definition of subtraction. Two: empirical proof, students may rely on observed experiences to be convinced of the validity of an argument, for example a dropped object will fall down because it always does. Third, and most sophisticated: analytic proof, stringing together several simpler ideas each with its own reasoned defense in order to argue by deduction that if each part of the proof is true then the conclusion must follow. All these forms of “knowing something” involve mathematical reasoning.

Math discussion is practice for mathematical reasoning. Mercer & Sams (2006) found that students who engaged in frequent meaningful classroom math discussion were better able to employ mathematical reasoning to perform mathematical tasks. Students can learn the methods of arguing their positions using the communication style and tools customary in the larger mathematical community, but it is a gradual process that takes years of exposure (Goos, 2004 as cited in Kosko, 2012). What one expects students to have achieved in a high school algebra class is much less than what one can expect from a college differential equations class. There are two distinct changes that need to take place in the individual student over time. One is to learn to recognize and skillfully manipulate mathematical theorems and algebraic relationships. The other is to adopt the behaviors of purposeful discussion that identifies the resources and the objectives of a mathematical task and justifies logically the order in which they are employed to perform the task (Bartolini Bussi, & Alessandra Mariotti, 2008). Traditional high school mathematics classrooms focus on manipulating mathematical theorems and algebraic relationships (Davis, 1994). The second goal, that of mathematical reasoning, is intrinsic to participation in mathematical discussion in the classroom. Modeling mathematical discussion in the classroom while working as a whole group gives the individual student a pattern of mathematical reasoning to aspire to (Goos, 2004 as cited in Kosko, 2012; Vygotsky, 1978 as cited in Martin et al., 2005). “This joint negotiation of the proof allowed students to practice reasoning in a supported environment in which the obligation to think and reason was primarily left to the students.” (Martin et al., 2005, p.110)

One may conceptualize mathematical reasoning as a game with rules. In this analogy, one would consider the teacher as the coach, the local recognized expert in the language and justification of mathematical proof. The students are the players. The classroom discussion is the playing field (Martin et al., 2005). In the game, the teacher guides the students through tasks in which the teacher is neither a playing participant nor the referee, but rather the knowledgeable advising coach. The teacher exposes flaws in the students’ arguments and encourages students to provide justification for their conjectures. By requesting a justification for the students’ conjectures, the teacher models for the class the sociomathematical norm that conjectures must be made and that all conjecture must be justified or refuted. The students learn the rules and language of the game by actually playing the game. The students memorize mathematical theorems and algebraic relationships as they practice manipulating them playing the game of mathematical reasoning.

> In the traditional classroom, the role of the instructor is that of the knowing professional who dispenses her/his knowledge directly to the students. This is shown through methods such as lectures that describe new and complicated topics, stories from their past relevant experiences, and summaries of the material that is most relevant to examinations. In learner-centered teaching, instructors provide the architecture for learning but do not

directly state all of content to be learned. Instead, they design class activities that help students discover the important information. As a result, students learn more from the experience and each other than directly from the teacher (Brackenbury, 2012 p.15).

Boaler (1999) observed certain deficiencies in students taught mathematics by the traditional method of watching the teacher present an example and then working practice problems. First, students taught by the traditional method experienced difficulties when presented with unfamiliar math problems that required applying a mixture of skills they had mastered in previous lessons even when they remembered the skills and could demonstrate them. Second, students experienced difficulty using facts and information from their daily lives in solving math problems even when the facts were familiar to them. Third, students expected to use all the numbers given to them in a math problem and became confused if they had left over information. Boaler (1999) postulated that these behaviors are not due to a deficiency in the students' math skills, but represent the students' learned beliefs about what it means to solve a math problem. Boaler (1999) further postulated that the social and environmental conditions of the math classroom acclimate students to applying math in a rigid manner and students are unprepared for deviations from the daily routine. Additionally, Boaler observed that students taught mathematics by the traditional method experienced confusion when confronted by mathematical challenges that were unlike their previous classroom experiences. Conversely, students who had studied mathematics in a community problem solving environment were more likely to adapt to unfamiliar situations and challenges that required mathematical reasoning. Thus, students who are taught mathematics by the traditional method, develop an attitude that mathematics is made up of theorems and algebraic rules to be memorized and that there exists no connection between mathematical knowledge and their own thought processes (Schoenfeld, 1988 as cited in Boaler, 1999). In Boaler's (1999) analyses of the social environment of a traditional math classroom, she stated "Being effective in the classroom community involved a strict adherence to school and mathematical rules, the interpretation of non-mathematical cues and the suppression of thought. All of these practices which became part of the students' learning identities are incompatible with authentic activity." (p. 269)

The teacher exerts significant influence over the social aspects of the classroom in making the choices of what tasks are looked at, what classroom behavior is modeled by the teacher and by the student's peers, and which instruction strategy is used, direct instruction or cooperative learning. How the student comes to internally concretely define mathematical behavior is determined by these classroom experiences (Martin et al., 2005).

> The primary outcome of discourse in traditional mathematics classrooms is the dissemination of facts about the discipline and those mathematical techniques that either the teacher or the textbook characterizes as efficient and elegant. The teacher carefully designs and delivers lectures to ensure that mathematical truths are clearly communicated with students. This form of knowledge sharing is not transformational, since it may not lead to substantial change in the way students or teachers think about mathematics. In contrast, discourse of a learning community involves students in dialogues in order to construct, negotiate, and verify mathematical ideas (Cobb and Bauersfeld 1995). The product of discourse is the development of shared understandings, new insights, and a deeper analysis of mathematics on the part of both the teacher and the student (Lampert and Blunk 1998). (Manouchehri & St. John, 2006 p.548)

Engagement

> “Teachers must take into account the cultural, socioeconomic, and political realities that diverse and African American students face (Delpit, 1992; Gay, 1983). Without some understanding of ethnic heritages, values, priorities, and perspectives it is impossible for teachers to interact most constructively with ethnic students, or relate subject matter content and schooling processes to their experiential and cultural frames of reference" (Gay, p. 81 as cited in Moody, 2004, p 6).

Moody (2004) found that the culture with which a student self identifies is a key component of the student’s personal experience in the classroom. Moody asserted that culture acts as a lens through which the experiences in the classroom are viewed. Thus what a student interprets from of his or her classroom experiences is as much determined by the individual student’s cultural lens as it is determined by the student’s prerequisite knowledge of the subject matter. As a concrete example to illustrate Moody’s point, the experience of a devout Christian in a high school biology class studying the theory of evolution will be very different from what is experienced by a non-religious student. Likewise, for two equally prepared but culturally diverse students, key symbols of respect, disrespect, purpose and intention, will be seen and understood differently by each student depending on the cultural lens that the student brings with him or her to the classroom experience. “Researchers must conceptualize what diverse students find in their schooling experiences that is congruent or in conflict with their own cultural orientations (Moody, 2004, p 7).

In a qualitative study of two 8th grade African American male algebra 1 students, Berry (2005) found that active participation in group discussion was highly correlated with the students' engagement in the curriculum. (Berry, 2005) followed the progress of two academically gifted African American male students in an 8th grade algebra 1 class. Berry found that curriculum that met specific behavioral needs allowed these two students to be successful. To be successful, the students needed high energy level activities with change and stimulation to keep them engaged in the learning. They needed to be challenged and kept busy. They needed an opportunity to talk in class and express themselves. They needed to go to the front of the room and explain concepts. They needed more work and more challenging work. They at times needed to work with a partner or group and at times needed to work by themselves. Berry observed that these students' teachers, in order to be successful with them, had to design a curriculum that included individual work and group work, opportunities for the students to express themselves and contribute to the class discussion, and activities that challenged the students' thinking.

> The African American cultural frame of reference entails attributes that include (a) working in support groups, (b) telling tangential stories that may or may not relate to the problem, (c) valuing the personal relationship that can be nurtured by one using a conversational style discourse, and (d) perhaps leaving one's seat to answer a question (Stiff, p.156 as cited in Moody, 2004, p. 6).

"If teachers employ more equitable teaching practices one can expect an increase in the productive dialogue between teachers and African American students. This is an undeniable need because *far* too many African American classrooms exhibit conformity and unnatural silence rather than discussion and inquiry (Ladson-Bulings, 1997 as cited in Sheperd, 2011, p. 256). Sheperd (2011) argued that when teachers respect the knowledge and life experiences of students as valid contributions to the classroom curriculum, students' cultural identity is reaffirmed as and their cultural dignity is preserved. "When cultural characteristics of the children's experience and application of mathematics are realized and respected, it is not uncommon to observe "budding mathematicians' in action.” (Sherperd, 2011, p. 310)

Framing discussion is a technique of beginning a mathematical discussion with related topics about which most students have personal experiences. Because students have personal experiences they are able to contribute to the discussion, framing discussion is likely to increase student participation in group discussion. By soliciting the opinions of students about something they are knowledgeable, students can be drawn actively into the discussion. Once students are actively involved in an experience of community consideration, exchanging and justifying their ideas, students may tend to continue to be engaged in the discussion as it turns to considering the mathematical aspects of the topic (Henning & Balong, 2011).

Engagement is crucial to teaching and learning and must be a primary consideration of curriculum design. Students are more likely to be engaged by something that they enjoy doing. In a study by Hannafin (2001), most high school math students who were studied reported they had greater satisfaction with math classes that were taught with more discussion. A curriculum that takes into account the preferred leaning experience of the students is more likely to engage the students in the curriculum.

Discussion practices

Researchers have identified several practices that enhance the positive outcome of classroom discussion. Revoicing and rebounding are techniques a classroom teacher can use to manage a discussion (Martin et al., 2005). A teacher revoices by repeating a student’s contribution to a discussion to focus the whole group’s attention on the comment. A teacher rebounds by repeating a student’s question to the whole group to solicit an answer from the students in the group. Revoicing enhances the social status of the individual student by bringing the value of their contribution to the attention of the group. Rebounding models for the students the desirable behavior of discussing their questions with other students to find answers. Revoicing and rebounding increase participation and self esteem by recognizing and appreciating the contributions and knowledge of students. Revoicing and rebounding also emphasize to the students that they have knowledge which encourages them to go to each other to discuss math problems.

A high school math teacher may manage their classroom discussion using revoicing and rebounding within a structured framework of an example or task. The teacher may present a problem and solicit the steps and justifications for the steps from the group. The teacher asks for a step, the class provides the next step, the teacher asks for a justification, the class provides the justification. The teacher asks for the conclusion, the class provides the conclusion. In this way the teacher manages stringing together the full solution to a complex problem out of the contributions of the students in the class (Martin et al., 2005).

> Dialogic teaching is indicated by certain features of classroom interaction such as: questions are structured so as to provoke thoughtful answers and answers provoke further questions and are seen as the building blocks of dialogue rather than its terminal point; individual teacher–pupil and pupil–pupil exchanges are chained into coherent lines of enquiry rather than left stranded and disconnected (Mercer & Sams, 2006, p.509).

Manouchehri & St. John (2006) in comparing two high school math teachers who used classroom discussion, found that the style of classroom discussion differed greatly between the teachers. In the student centered classroom, the teacher made student contributions the primary source of knowledge in the classroom. The teacher solicited student contributions and language for group problem solving and revoiced and rebounded to encourage students to address each other’s questions and obtain knowledge from each other. The teacher led the group to generate the solution to problems from the students’ collective knowledge. In the teacher centered classroom, the teacher asked questions and corrected the answers he received from the class so that the steps of the problem followed a predetermined path established by the teacher. Students did not respond to other students’ contributions and the teacher was the sole judge of the value of student contributions. In the student centered classroom, the value of contributions was decided by the group based on whether it moved the class closer to the solution of the problem. In the teacher centered classroom, the value of student contributions was decided by the teacher as the teacher progressed through working the example problem.

Discussion includes both verbal and non-verbal dialogue and dialogue on a social level and on a mathematical level (Martin et al., 2005). On the social level, norms include: who's knowledge is valued, the process for how each individual offers their knowledge and the structure by which new knowledge is introduced. The mathematical level includes sociomathematical norms such as the vocabulary of mathematics used in the classroom and the criteria of what constitutes proof and valid argument (Cobb, 2000 as cited in Martin et al., 2005). The mathematical level also includes the tasks performed in the room such as writing out proofs or solving problems or verbally arguing for proofs or mathematical procedures.

Because there are many students enrolled in most high school classrooms, each student will not have very much time to talk in whole group discussion. Because mathematical reasoning is a skill that cannot be memorized, and is not effectively learned by observation, students need to practice mathematical reasoning in small groups where every student has more opportunity to contribute to discussion. Whole group discussion is the most effective preparation for students to learn to use discussion in small groups (Mercer & Sams, 2006). In whole class discussion, the teacher is able to influence the discussion to insure that it is well mannered and productive, and so model for the students what effective discussion looks like. Although modeling as a whole class is an effective tool to shape small group discussion in the classroom, it is not sufficient to guarantee that the time students are given to work together in small group discussion will be used productively. Students often waste time in small group discussion, talk about subjects unrelated to math, contribute inequitably to the discussions and when sharing answers, often do not justify and explain the answer (Bennett & Cass, 1989; Galton & Willamson, 1992; Wegerif & Scrimshaw,1997 as cited in Mercer & Sams, 2006). An important part of a curriculum to develop mathematical reasoning is explicitly teaching students how to work together: how to politely offer conjectures and then jointly evaluate and justify the conjectures giving everyone an opportunity to be heard. Therefore, an important aspect of whole group discussion is modeling for students how they are expected to behave in small group discussion. How to be polite and stay on task, therefore, needs to be made a part of the explicit curriculum in the high school math class (Mercer & Sams, 2006). Time needs to be allocated often in whole group discussion for explicitly asking students to recall the ground rules for behavior in small group discussion and asking students to discuss as a whole group the motivation for and benefits of small group discussion. The teacher needs to explicitly request students in whole group discussion to offer specific examples of the things students should be saying to each other in small group discussion. The benefits of discussion and how to practice discussion should themselves, therefore, become a frequent topic of discussion in math class (Mercer & Sams, 2006).

> Children are rarely offered guidance or training in how to communicate effectively in groups. Even when the aim of talk is made explicit – 'Talk together to decide'; 'Discuss this in your groups' – there may be no real understanding of how to talk together or for what purpose. Children cannot be expected to bring to a task a well-developed capacity for reasoned dialogue. This is especially true for the kinds of skills which are important for learning and practicing mathematics, such as constructing reasoned arguments and critically examining competing explanations (Mercer & Sams, 2006, p.510).

A final word of advice about classroom discussion, it is important to recognize that building trust and social relationships among the students in the classroom is a crucial prerequisite for establishing an atmosphere of effective discussion. At an extreme, off-task talk wastes valuable time that students could be using to practice mathematical reasoning, but some social talk, especially in small group work is very important to developing the kind of trusting relationships where children are willing to share their conjectures with each other and practice justifying and refuting each other's conjectures with mathematical reasoning. Essentially, social relationships in the classroom are not a hindrance to the curriculum but instead are an indispensible part of an effective discussion based curriculum (Davis, 1994). Positive social relationships have also been shown to be the most important factor in student satisfaction in school. Thus, encouraging some off-task social discussion in small group work increases both student engagement in the curriculum and student willingness to take emotional risks in discussing math with their classmates.

Methods

I demonstrated a PowerPoint Algebra Activity that I created to individuals knowledgeable about teaching math and then discussed with them afterwards their comments, observations and incites about the benefits and shortcomings of the PowerPoint Algebra Activities as a curriculum tool in for a high school classroom. While clicking on the steps of the PowerPoints, I demonstrated the style of discussion and dialogue that one would hope to see in a high school classroom. Two of the individuals I interviewed were Sonoma State University Professors who have a strong interest in high school math curriculum and experience in designing high school math curriculum. A third interview was conducted with the President of the Sonoma State University Statistics Students' Club. I then presented the PowerPoint Algebra Activities to a high school algebra 1 class, observed their reactions and solicited their comments and advice for improving the activity. A summary of the interviews and observation is included in Appendixes One to Four. A series of screen shots of the PowerPoint Algebra Activity is included in Appendix Five.

Results

The research I collected provides evidence to support the hypothesis that the PowerPoint Algebra Activities increase classroom discussion, engagement and the use of mathematical reasoning by high school algebra students. The individuals I interviewed stated that they believed the PowerPoint Algebra Activities would be beneficial in the high school algebra classroom. They offered arguments and reasoning that supports the hypothesis of the research. As a result of the encouraging evidence collected in this preliminary study, a more elaborate research project is justified. Some of the questions that remain to be answered are:

Would the PowerPoint Algebra Activities be useful to a broader spectrum of teachers and if so what training would be useful to make the PowerPoint Algebra Activities effective in a broad range of teaching environments?

What improvements could be made to the PowerPoint Algebra Activities that would make them more appealing to the students?

Could the activities and discussion be modified to include more of the "big ideas" of mathematics?

What technology is available that could make the PowerPoint Algebra Activities more responsive to the students' suggestions, so that the steps of the activity could diverge in a different direction if the students chose a different order of steps during the presentation?

Conclusion

The community reasoning that students experience in the PowerPoint Algebra Activities is not the same as watching the teacher present a prepared example of how to solve a particular math problem. The students' experience of the PowerPoint Algebra Activities is an exercise in using their own mathematical reasoning to approach a mathematical task. The PowerPoint Algebra Activities prepare the students to use mathematical reasoning independently. Students follow the steps of the Activity questioning themselves internally to reason out the next step. What students at first are able to do as a group with the assistance of the teacher and more advanced peers the students, with practice and experience, become able to do on their own (Vygotsky, 1978 as cited in Mercer & Sams, 2006). Learning to use mathematical reasoning is as important to mathematical ability as learning the theorems and algebraic skills of mathematics.

Although the PowerPoint Algebra Activities expose the students to mathematical theorems and algebraic skills, unlike the traditional method of teaching math, they also teach students to reason mathematically. The PowerPoint Algebra Activities were also observed to have positive effects on student engagement and participation.

References

Berry, I. Q. (2005). Voices of success: descriptive portraits of two successful African American male middle school mathematics students. Journal Of African American Studies, 8(4), 46-62.

Boaler, J. (1999). Participation, knowledge and beliefs: A community perspective on mathematics learning. Education Studies in Mathematics, 40, 259-281

Borges, M., Do Carmo, M., Silva Goncalves, N., & Macedo Cunha, F. (2003). Teaching and learning conceptions in engineering education: an innovative approach on mathematics. European Journal of Engineering Education, 28(4), 523-535.

Brackenbury, T. (2012). A qualitative examination of connections between learner-centered teaching and past significant learning experiences. Journal of the Scholarship of Teaching and Learning, 12(4), 12 – 28.

Bartolini Bussi, M.G, & Alessandra Mariotti.M. (2008). Semiotic mediation in the mathematics classroom: Artefacts and signs after a Vygotskian perspective. Handbook of International Research in Mathematics Education (2nd ed., pp. 746-783). New York: Routledge

Davis, B. A. (1994). Mathematics teaching: Moving from telling to listening. Journal Of Curriculum & Supervision, 9(3), 267-283.

Hannafin, R. D. (2001). Learning with dynamic geometry programs: Perspectives of teachers and learners. Journal Of Educational Research, 94(3), 132.

Henning, J. M. and Balong, M. (2011). The framing discussion: Connecting student experience with mathematical knowledge. The Clearing House: A Journal of Educational Strategies, Issues and Ideas, 84(2), 47–51.

Kieran, C., Forman, E., & Sfard, A. (2002). Learning discourse: Sociocultural approaches to research in mathematics education. Educational Studies in Mathematics, 46, 2-12

Kosko, K. W. (2012). Student enrollment in classes with frequent mathematical discussion and its longitudinal effect on mathematics achievement. Montana Mathematics Enthusiast, 9(1/2), 111-148.

Livingston, E. (2006). The context of proving. Social Studies Of Science (Sage Publications, Ltd.), 36(1), 39-68. doi:10.1177/0306312705053055

Manouchehri, A., & St. John, D. (2006). From classroom discussions to group discourse. Mathematics Teacher, 99(8), 544-551.

Martin, T., McCrone, S., Bower, M., & Dindyal, J. (2005). The interplay of teacher and student actions in the teaching and learning of geometric proof. Educational Studies In Mathematics, 60(1), 95-124. doi:10.1007/s10649-005-6698-0

Mercer, N., & Sams, C. (2006). Teaching children how to use language to solve math problems. Language & Education: An International Journal, 20(6), 507-528.

Moody, V. R. (2004). Sociocultural Orientations and the Mathematical Success of African American Students. Journal Of Educational Research, 97(3), 135-146.

National Governors Association Center for Best Practices, Council of Chief State School Officers. (2010). Common Core State Standards for Algebra 1. National Governors Association Center for Best Practices, Council of Chief State School Officers, Washington D.C. http://www.corestandards.org/the-standards

Pinar, W. F., Reynolds, W. M., Slattery, P., & Taubman, P. M. (2008).Understanding curriculum: An introduction to the study of historical and contemporary curriculum discourses. New York. Peter Lang.

Sheppard, P. A. (2011). Experience-Centered Instruction as a Catalyst for Teaching Mathematics Effectively to African American Students. *Journal Of Negro Education*, *80*(3), 254-265.

Zolkower, B & Shreyar, S. (2007). A Teacher's mediation of a thinking-aloud discussion in a 6th grade mathematics classroom. Educational Studies in Mathematics, 65, 177-202

Cited in sources

(Barwell et al., 2005; Forman & van Oers, 1998; Hoyles & Forman, 1995; Monaghan, 1999; Sfard, 2000; Sfard & Kieran, 2001 as cited in Mercer & Sams, 2006)

Barwell, R., Leung, C., Morgan, C. and Street, B. (eds) (2005) Special issue: Language and maths. Language and Education 19 (2).

Forman, E. and van Oers, B. (eds) (1998) Mathematics learning in sociocultural contexts. Learning and Instruction 8 (6), 469–72.

Hoyles, C. and Forman, E. (eds) (1995) Special issue: Processes and products of collaborative problem solving: Some interdisciplinary perspectives. Cognition and Instruction 13.

Monaghan, F. (1999) Judging a word by the company its keeps: The use of concordancing software to explore aspects of the mathematics of register. Language and Education 13 (1), 59–70.

Sfard, A. (2000) Symbolizing mathematical reality into being: How mathematical discourse and mathematical objects create each other. In P. Cobb, K.E. Yackel and K. McClain (eds) Symbolizing and Communicating: Perspectives on Mathematical Discourse, Tools, and Instructional Design (pp. 37–98). Mahwah, NJ: Erlbaum.

Sfard, A. and Kieran, C. (2001) Cognition as communication: Rethinking learning-by-talking through multi-faceted analysis of students' mathematical interactions. Mind, Culture, and Activity 8 (1), 42–76.

Cited in sources

(Vygotsky, 1978 as cited in Mercer & Sams, 2006)

Vygotsky, L.S. (1978) Mind in Society: The Development of Higher Psychological Processes. Cambridge, MA: Harvard University Press.

(Harel & Sowder, 1998 as cited in Martin et al., 2005)

Harel, G. and Sowder, L.: 1998, 'Students' proof schemes: Results from exploratory studies', in A.H. Schoenfeld, J. Kaput, and E. Dubinsky (eds.), CBMS Issues in Mathematics Education, Vol. 3, American Mathematical Society, Providence, RI, pp. 234–283.

(Goos, 2004 as cited in Kosko, 2012)

Goos, M. (1995).How do you know when you understand? Using explanation to monitor and construct mathematical understanding. Paper presented at the Postgraduate Research Conference Commemorating 50 Years of Educational Studies at the University of Queensland, Brisbane, Queensland, Australia.

(Schoenfeld, 1988 as cited in Boaler, 1999)

Schoenfeld, A. H. (1988). When good teaching leads to bad results: The disasters of "well taught" mathematics courses. Educational Psychologist. 23(2) , 145-166

Cited in sources

(Cobb, 2000 as cited in Martin et al., 2005)

Cobb, P.: 2000, 'Conducting teaching experiments in collaboration with teachers', in A.E. Kelly and R.A. Lesh (eds.), Handbook of Research Design in Mathematics and Science Education, Lawrence Erlbaum Associates, Mahwah, NJ, pp. 307–333.

(Bennett & Cass, 1989; Galton & Willamson, 1992; Wegerif & Scrimshaw,1997 as cited in Mercer & Sams, 2006).

Bennett, N. and Cass, A. (1989) The effects of group composition on group interactive processes and pupil understanding. British Educational Research Journal 15, 119–32.

Galton, M. and Williamson, J. (1992) Group Work in the Primary Classroom. London: Routledge. Wegerif, R. and Scrimshaw, P. (1997) (eds) Computers and Talk in the Primary Classroom. Clevedon: Multilingual Matters.

Appendix One: Interview with Dr. Brigitte Lahme, Professor of Mathematics, Sonoma State University

I presented before Dr. Lahme, the algebra PowerPoint Activity. I explained that the objective of the activity was to foster deeper, more meaningful classroom mathematics discussion. I demonstrated questions I would ask the class and explained the sort of answers I hoped to receive from students.

Some of the questions that I demonstrated to Dr. Lahme were:

What are we trying to find in this problem?

Why can't we solve either equation by itself?

What do we know is the same in both equations?

What could we do to put the equations together?

How is this transitivity? How does transitivity help us to find an answer for x and for y?

Now how do we find out what x is?

How can we move the numbers all to one side of the equal side?

Now what do we know so we can find y?

Dr. Lahme agreed that the presentation of the Algebra PowerPoint Activity together with the discussion that I modeled for her did meet her definition of age appropriate curriculum for a high school algebra class and did expose the students to the deeper philosophical meaning behind the math.

Dr. Lahme also commented that an unscrupulous teacher could use the Algebra PowerPoint Activities to just click through the example with no discussion and then hand out a worksheet to the class. I responded to Dr. Lahme that I had read a recent Journal Article concerning the development of the *Teacher Proof Curriculum*. I interpreted the article to say that any inept person could be a classroom teacher, it did not matter who was in the job cause all the teacher has to do is read a scripted curriculum to the kids. I informed Dr. Lahme that one of the Professors at SSU School of Education had also recently written a Journal Article initialed *The Curriculum Proof Teacher* in which she suggested that teachers must be highly qualified and capable individuals in order to do a good job teaching. Dr. Lahme concurred with my assertion that the Algebra PowerPoint Activities would be a valuable classroom recourses to promote classroom discussion in the hands of a skillful and knowledgeable teacher.

Appendix Two Interview with Dr. Ben Ford, Professor of Mathematics, Sonoma State University

I interviewed Dr. Ben Ford SSU department of mathematics and presented to him two prepared PowerPoint presentations. One presentation was for a problem from the SSU advanced math 220 class Dr. Ford is currently teaching, the other problem was from a high school algebra class. I articulated to Dr. Ford that I believed that teaching math had two curriculum objectives. The first objective is to convey to students the algorithms, formulas and theorems that the students would need to make use of to perform mathematical tasks. The second curriculum objective was to prepare students to approach any problem asking four basic questions. Dr. Ford concurred with my argument that teaching math by the traditional method will only prepare students to do what is done in a traditional math class, to observe the teacher work and example and then practice plugging new numbers into the same algorithm that the teacher has just demonstrated. Dr. Ford also concurred that national standardized tests and real world situations do not resemble that experience and so it is largely not a transferable knowledge. Dr. Ford also agreed that presenting a problem to a whole class for discussion and working through the problem with input from the class was much more like the experience that students have when they face an unknown problem on a standardized test. Dr. Ford agreed that modeling for the class the experience of asking - where are we going, what do we know, what do we do next, why do we do that - and negotiating the steps as a class would be a beneficial preparation for students to prepare them for problems they will encounter on national standardized tests (NSTs). Dr. Ford also agreed that the hesitation between the steps in the PowerPoint presentations was a good simulation for the thinking process that students should utilize when solving NST problems. Dr. Ford was also interested in the momentum and excitement that the slide shows generated and stated that he would like to see more evidence about how the PowerPoint presentations generate excitement and class participation. I explained to Dr. Ford my belief that using the PowerPoint slides reduced the confrontational relationship between the students and the teacher by reducing the teacher's role in demonstrating the example. I explained that the slideshow, like a textbook, became the sourse of information instead of the teacher. I also explained that because of the great increase in classroom participation because of using the slide show, students were generating knowledge for themselves and obtaining knowledge from other students in the class instead of obtaining knowledge directly from the teacher. In this way students took both ownership and control of the classroom and their learning experience and so felt less resentment against the teacher's power and authority in the classroom. Dr. Ford was intrigued by the analysis and interested in observing the use of PowerPoint slides in a real classroom situation. In addition, Dr. Ford said he would be interested in seeing a PowerPoint presentation designed to prepare students for the new common core evaluations and said that he believe that this could be done. One suggestion that Dr. Ford made for the improvement of the slides is to try to incorporate alternative solutions to problems so that the slideshow could proceed in different ways depending on the choices that the class as a group made. Since many multistep problems have multiple ways to proceed from different stages in the problem, Dr. Ford recommended that the PowerPoint presentation be expanded so that the teacher could select which slide to show next depending on what choices the class agreed on for the next step.

Appendix Three Interview with Michael Cardoso, President of the Sonoma State University Statistics Club

I interviewed Michael Cardoso, an undergraduate math major at Sonoma State University and demonstrated to him a PowerPoint Algebra activity and a PowerPoint activity designed for an upper division college math class. Michael observed that as I demonstrated the activities, he was internally working through the next steps or sometimes internally several steps ahead of the PowerPoint slide show, just as in a mystery movie one is often contemplating what will happen next. Michael stated that it was interesting to him to observe, as the slides were unfolding, if the PowerPoint would reveal the steps in the order that he had already internally decided. Michael also stated that the rigid framework of the PowerPoint gave him an opportunity to negotiate internally and justify to himself what he would do differently and how he would explain to himself the steps that he would have taken and compare the differences. Michael noted that the language and descriptions that I was using as the PowerPoint was unfolding precipitated an internal dialog within him contrasting the differences between the verbal mathematical reasoning that I presenting to him and the mathematical reasoning that he was internally verbalizing. Michael asserted that the most interesting thing to him about the PowerPoint activity experience was analyzing and anticipating my next comment on the steps of the slide show.

Michael agreed that his internal discussion and my out loud descriptions about the PowerPoint activity contained big ideas about mathematics. He advocated the importance of the idea of transitivity as one of the fundamental building blocks used in all college mathematics. He stated that transitivity was a meaningful concept that a mathematician must consider when exploring the significance of any mathematical relationship. Michael stated that the concept of maintaining equality while manipulating equations was both deep and meaningful and a guiding consideration that lies at the forefront of his cognitive processes during all mathematical reasoning tasks. Michael agreed that the concepts discussed during the PowerPoint activity would submerge novice mathematicians in the process and topics of mathematical reasoning that would eventually evolve in sophistication into undergraduate and graduate level mathematical reasoning.

Appendix Four Presentation in 9th grade algebra 1 classroom.

I presented the PowerPoint Algebra Activity to a 9th grade high school algebra classroom. All the students were 14 or 15 years old. The class was evenly divided between male and female students, with 13 of each. Four of the students were Latino, and 5 were Asian, the rest of the students were white. Students were very cordial and friendly towards me before, after and during the presentation. They displayed excellent math skills and enthusiasm for classroom discussion and participation. It was possible to string together all the steps in solving each algebra problem out of contributions from the students. The students were also able to provide justifications and alternative solutions at many points during the presentations. Of the 26 students in the class, 17 of them contributed to the discussions. 6 of the female students contributed to the discussion and 11 of the male students contributed. Many of the comments made contained arguments to support the student's position. Several male students supported their arguments by using a calculator to demonstrate how the numbers supported their cell phone decision or car loan position. In discussion of slide number 3, solving the system of linear equations, two students each offered an alternative for the step after 6-x=x+4, the students were able to provide their reasons for their preference and acknowledged the relative merits of each position.

In the framing discussion about cell phone contracts, students were able to identify the up front and the hidden costs in the cell phone contracts. Students were able to argue that which deal was best depended on the personal situation of the individual so that what was better for one person might not be better for the other. Students commented on their recognition that both deals were changing which makes the comparison more complicated. Some students compared the total cost of each phone by the end of the contract. Other students compared how the difference between the two phones was changing by $50 every month. The students commented on their recognition that both comparisons were valid arguments for one phone against the other one.

In the framing discussion about car loans, students had difficulty deciding which information was most relevant to the discussion. Students also commented that car loans were generally outside the daily consideration of the most 15 year olds. Whereas in the phone discussion we were talking about something everyone knew about and had something to say about, in the car loan discussion student comments were limited to the numbers of the problem with little discussion of the individual's circumstances that would cause someone to finance a car at the dealer or at a bank. One of the students commented that car loans are outside the daily lives of the students in the class and so don't excite the students' interest as much as phone contracts. This student made the insightful suggestion that analyzing familiar decisions made the discussion more interesting.

Students appeared to be interested and engaged in the PowerPoint Algebra Activities. They appeared to be willing and able to contribute to the classroom discussion. Many students seemed to be working the problems in their heads several steps in advance of where the discussion had reached, apparently the students were utilizing internal language and mathematical reasoning to proceed through the steps of the problems. The out loud discussion in the classroom seemed to be giving confirmation to what the students were internally deciding.

Appendix Five PowerPoint Algebra Activity screen shots.

Page 1

Samsung Galaxy S III
MetroPcs
$500
$60 a month

Samsung Galaxy S III
Sprint
$0
$109 a month

Page 2

Offer 1
$1,500
Retail Customer Cash

Offer 2
APR Financing
0.0 % for 36 months
0.9 % for 48 months
1.9 % for 60 months
3.9 % for 72 months

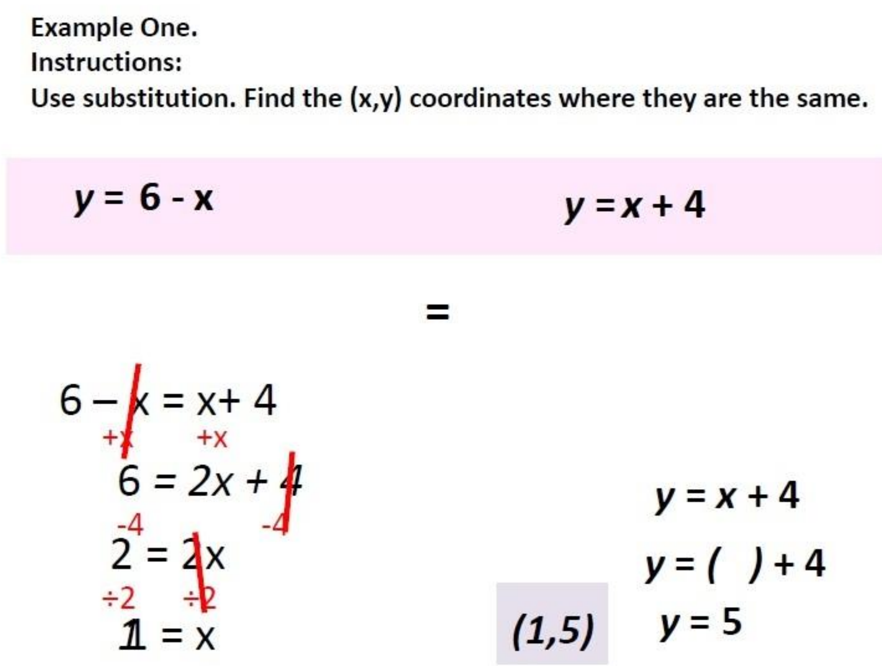
and

$1,000

Interest is $50 a month

Appendix Five continued, PowerPoint Algebra Activity screen shots.

Page 3



Page 4