A Content Analysis of Educational Scaffolding Used in Post-and-Reply Sessions on a Mathematics Homework Help Message Board

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By
Nick Darrah
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Date

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Thesis Adviser

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Thesis Reader

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Thesis Reader

ABSTRACT

With the great influx of resources available to students within their own homes, answers and assistance to traditional homework assignments are being sought. Online searches and discussion boards have become an immediate refuge for those with a lack of understanding. Classical educational theories, too, have been translated for these digital realms to better assess authentic learning experiences. Analyzing and understanding the discussion patterns and key phrases employed by message board members acting as online tutors in terms of scaffolding theory may yield a better clarification and assessment of learning experiences within an online math homework help message board. The discovery of these relationships may help optimize quests for new information by demonstrating the need and importance of communication skills in mathematics.

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OPENING VIGNETTE

Math Problems

Sitting in the front row, Tim frantically waves his arm during an algebra lesson.

Teacher: Tim, you have a question?

Tim: Yeah. I don't get it.

Teacher: I'm sorry Tim, but you will have to help me out. What don't you *get*?

Tim: Everything.

Teacher: Okay. Where do you start a problem like this?

Tim: I don't know.

Teacher: Well, what do the terms have in common?

Tim: (Blank stare.)

Teacher: What can you divide both terms by?

Tim: 3, *right*?

Teacher: Good, but what else?

Tim: (Blank stare.)

Teacher: Is there a variable that you can pull out—divide by, too?

Tim: I think b.

Teacher: Very good! What will that look like?

Tim: $3b\left(25x^2 + 4\right)$.

Teacher: *Plus* 4?

Tim: Oh wait! *Minus* 4. $3b\left(25x^2 - 4\right)$.

Teacher: Sounds good to me. Is there anything else you can do?

Tim (*Reluctantly*): Um… no?

Teacher: What is special about 25 and 4? What do you know about these numbers?

Tim: (Blank stare.)

Teacher: I'll give you a hint: It's now the difference of two squares.

Tim: (Blank stare.)

Teacher: What are two identical numbers that multiply to 25? How about 4?

Tim: Five and five and two and two.

Teacher: Good, good!

Tim: (Blank stare.)

Teacher: So your answer is going to be $3b(5x-2)$ and what else?

Tim: $5x+2$?

Teacher: Yes! Good!

Tim: It is? Why?

*   *   *   *   *   *   *   *   *   *   *

The conversation is familiar to high school teachers of mathematics.   The recursion of questions becomes an automatic response for those veteran teachers blessed with a freshman algebra assignment.

A classroom, under the supervision of an expert, is the ideal place for students to ask questions when they become lost or are uncertain in their mathematical voyage. Unfortunately, the true test of student knowledge and mastery occurs when the students leave for the classroom and must perform algebraic tasks at home. Hours may be spent staring at a mass of strange symbols, unusual combinations of letters and numbers with no other directions except for a single word such as *factor*, *solve,* or *simplify*. Help may be out there, however, for those who know where to seek it.

Introduction

Members of online learning communities connect to each other and request and receive new information instantly through the use of message boards. These connections exist through communicated posts and allow members to freely exchange information to facilitate understanding and academic growth. Through these open discussions, true online communication and online communities are created (Rheingold, 2000) with the goal to share knowledge for the betterment of the entire community (Epstein, 2001; Trausan-Matu, 2009).

In regards to online mathematics help message boards, such sharing of knowledge, however, may not be as free flowing as the original definitions of online communities may have suggested. Human tutors and those posting questions may become dissatisfied with their experiences within such online mathematics help communities. In past studies (Martinovic, 2004; Engelbrecht & Harding, 2005; Cole & Todd, 2003), tutors have been unhappy with the questioning techniques used by those asking for assistance. Students asking for an immediate answer do not receive the full benefit of the community. It is through carefully constructed communication that the framework for online discussion may be generated.

Within the text of post-and-reply sessions found on such message boards, authentic learning may become questioned. Translations of traditional classroom theories have emerged for these web-based learning environments. It is through these theories, educators and students may be able to assess these online communities for instances of authentic learning.

Through a review of scholarly literature, this thesis investigates the question, *What are the educational benefits of participating in an online message board for homework help in mathematics?*

Emerging from this review of previous research, more specific questions utilizing educational theories will be addressed. In particular, a content analysis of the message board hosted by the website Free Math Help.com—Homework Help! will be conducted. Using Vysgosky's (1978) theory on educational scaffolding as a framework for measuring educational benefits and authentic learning, the following questions will be addressed: *What are the dominant educational scaffolding elements utilized within post-and-reply sessions on a mathematics homework help message board? To what extent are these elements used?*

REVIEW OF RELATED LITERATURE

Mathematics Education

"Math class is tough!"
~Barbie Doll 1992

"Math is like love—a simple idea but it can get complicated."
~Albert Einstein

Famed physicist Albert Einstein and toy company Mattel's plastic doll share something: a common view on mathematics education. As with any subject matter, the key concepts of mathematics are, for many, difficult to grasp in isolation. Despite the ever emerging emphasis on technology and science in today's society, these disciplines' partner, mathematics, falls short with many students. According to researchers Sheldon and Epstein (2005), students in the United States struggle in mathematics primarily due to (a) curriculum and instruction in classrooms, (b) student attitudes about mathematics, (c) student readiness and background characteristics, and (d) level of support for mathematics in home environments.

Effective instruction must greet the open minds of students in order for genuine learning to occur. Learning mathematics revolves around the appropriate support from teachers, experts, families, and entire communities—both physical and online. Reflected in the *New York State Learning Mathematics Standards* (*Figure 1*), communication shares a spot of equal importance as the expected problem solving, algebra, and geometry. This idea of communication within the context of mathematics reaches beyond regular classroom hours. Homework may provide new opportunities for social interaction. "One unique role for homework in a modern era is to provide social communication and contact among peers, especially peers who live beyond the neighborhood school, thereby increasing a sense of community" (Corno, 2000).

Parental Involvement

For students struggling with mathematics, research points towards a possible solution: positive and encouraging home support. According to Sheldon and Epstein (2005), students who shared mathematics assignments and discussed the various problems with family members consistently earned higher grades on mathematics achievement tests than students who did not discuss their homework. Individual performance tests were also significantly higher in households with mathematics material on-hand. Similarly, cited by Ferrara and Ferrara (2005), Walberg (Walberg, 1986 in Eagle, 1989) concluded that an academically stimulating home environment is one of the chief determinants of learning. From his synthesis of over twenty-nine studies, Walberg determined that family supported learning created an effect twice that of the family's socioeconomic status. This support presented itself as simple tasks such as everyday conversations between family members and students, assistance with homework, ensuring classroom assignments are completed, and positive encouragement about current classroom instructional topics. In a 2006 study, mothers were monitored as they assisted their children with mathematics homework. According to the study, "[a] mother's math self-confidence showed a stronger correlation with the quality of the mathematical content of her teaching than the mother's mathematics preparation" (Hyde, 2006). Confidence, positive attitude, and effort are the key ingredients for parental homework help.

Although as simple as the concept is, solid parental support is not always present for young academic learners. Students with assignments from disciplines such as reading or history may receive more parental support than those of mathematics. Assignments in the language arts are often text-based requiring reading and interpreting of printed materials. Mathematics assignments, on the other hand, tend to be more procedural based with limited initial instructions. Only those family supporters at home with knowledge of such procedures may offer constructive assistance, especially during the student's later junior and high school years as the mathematical concepts and tasks become more abstract and complex (Sheldon & Epstein, 2005). In fact, evidence has been found that supports the claim for a negative correlation between parental involvement and student achievement in mathematics. According to a 2008 study, researchers discovered that the effect of parental assistance decreased due to the amount of time the parents had been away from the mathematics classroom to learn both concepts and procedures for current mathematics classes (Patall, 2008).

Collaboration and Online Communities

When halted by mathematical ambiguity, students, as well as the families of students, must realize the importance of community aspect of mathematics. According to Epstein (2001), "There are many reasons for developing school, family, and community partnerships. The main reason to create such partnerships is to help all youngsters succeed in school and in later life." For some, it is only through reaching for help from the greater community that progress and understanding may be achieved. Technology has greatly changed the notion of community to include not only immediate neighbors living within the same geographic location, but may be extended to an entire online community. Help is out there for those who know how to ask for it.

With the great influx of online communities and online learning, the notions of learning and the formation of knowledge have been given new life within this relatively new global community. This notional of online or virtual communities was pioneered by Howard Rheingold. According to Rheingold (2000), a virtual community is defined as "social aggregations that emerge from the Net when enough people carry on those public discussions long enough, with sufficient human feeling." According to Trausan-Matu (2009), Rheingold's notions of virtual communities are thriving in online learning environments. Knowledge is transferred freely through complexity of online social learning environments. " Knowledge is considered a public good where members of the community collectively contribute to its provisions and all members may access the knowledge provided. From this perspective, the motivation for knowledge exchange is not self-interest, but care of the community" (Trausan-Matu, 2009).

Wasko and Faraj (2000) agree with this notion of community knowledge. "When people consider knowledge as a public good, people are motivated to share it with others due to a sense of moral obligation rather than an expectation of return" (Wasko & Faraj, 2000). Such sharing is indicative of the practice of collaborative learning. According to Carlson (2004), collaborative learning occurs when learners interact with one another in an interpersonal environment—sharing and building ideas from free flowing knowledge from the individuals. Carlson is cautious, however, stating that merely working in the same proximity is not enough to constitute collaborative learning. “To be considered collaborative learning, these interpersonal interactions must include the sharing of information, meanings and understandings in such a way that all parties educationally benefit from the interaction and come to broader and more integrated understanding of material” (Carlson, 2004).

The ideas shared by Trausan-Matu (2009), Wasko and Faraj (2000), and Carlson (2004) allude to the benefits of online collaborative structures. The post-and-reply nature of message boards creates a vessel for mathematical collaboration. This phenomenon has already produced results in the form of a number of sites where individuals and institutions offer their expertise and service without charge. Implementing experts, teachers, tutors, and peers, mathematics homework help message boards have become online communities for assistance and knowledge sharing. Communication here is asynchronous, text-based, and service is provided on demand. Questions and answers are public and available for the review of all visitors to the site. Such sites are not related to any specific course and are usually designed as bulletin boards. Here, online educators have rare opportunity to learn the kind of questions students ask in a virtual space that affords “anonymity” (Martinovic, 2004). Such anonymity serves those students anxious about mathematics to have refuge. In a study on mathematics education, Schoenfeld (2000) found students being heavily monitored by a mathematics instructor felt anxiety and pressure to write anything mathematical, even if what they wrote did not pertain to a mathematics lesson. The notions of busy work and calculating simply to appear to be *doing* something mathematical is not necessary within a digital realm. Such a shift in thinking and pedagogy has been recently explored as learners shift away from traditional classroom experiences. Life in the classroom becomes a game of "Can you guess what I'm thinking?" in which teachers ask known-information questions—questions for which they already have answers and search the room until they get a response that matches the one in their head (Ruddell, 2001). According to Martinovic (2004), "[Within a traditional classroom,] students sometimes ask questions not because they have a genuine interest or do not understand something, but because they are expected to. Such motivation is certainly not relevant for users of mathematics online help. Therefore, we take that the questions posted online are the consequences of the recognized bottlenecks in learning, genuine interest, or convenience of getting homework done."

While the Internet is a massive tool for communication displays and collections, communication, or lack thereof, has been cited as the downfall of many online learning experiences. According to a Thurmond, Wambach, Connors and Frey (2002) study, student satisfaction with online group interaction found a negative correlation indicating students who were in favor of group projects, presentations and assessments generally were dissatisfied with their online learning experience. For these students, the lack of face-to-face interaction proved to be a major deterrent in their personal learning experience.

An essential quality of effective online teaching and learning is creating a sense of connection. Wurman (2001) suggests connections are the key to learning and motivation. Everett Shostrom cited a teacher in his book *Man, the Manipulator* which reiterates Wurman's advice in terms of education. Shostrom (1968) noted, "I teach children, not math." Within the confines of digitally transmitted packets of information, it is easy to lose track of the people on the other end of the screen. Keeping active and open means of communication allows students to personalize their e-learning experiences. According to Barbour (2007) and Churches (2008), personalization is a key in producing effective asynchronous online learning models. Connections between students and teachers can be forged in open online environments allowing the instructor the ability to personalize examples for students. This familiarity and personal interest or investment in examples allows the learner an opportunity to obtain and retain information. Wurman (2001) sums this notion with a definition of learning: "Learning may be defined as the process of remembering what you are interested in."

Online course bulletin boards may counteract the feelings of isolation of some online participants. Discussion boards achieve the level of communication necessary to the learning processes of many online students. According to Chan and Waugh (2007), students enrolled in online courses often sought message boards to post questions and to gain clarification in regards to the current course topics. The ability to access others' previously posted questions and comments allows students to achieve a level of classroom communication similar to that of a traditional setting. In a classroom, students often have the opportunity to raise their hands and ask questions for clarification. When this happens, it is not only the student asking the question who receives the benefit of the teacher's and other students' responses but the entire class. The same is true of questions students may ask a neighboring student when working on an in-class assignment. The students within the proximity of the questioners may also benefit or jump into the discussion. Online message boards invite such collaboration (Chan & Waugh, 2007).

Online Tutoring

While effective computer tutoring programs may be on the horizon, current mainstreamed artificial intelligence systems have had little success in regards to mathematics tutoring. Students entering questions tend to receive only validation if they submit an attempted answer. Beginning cues are often misleading when asking for initial assistance. Such fully-digital tutoring systems, currently, tend to be “relatively good at passing on knowledge, but were poor at teaching how to use the knowledge” (Martinovic, 2004).

Human tutors using digital media may provide a realistic, present solution for distant homework assistance. Using online resources such as message boards, tutors can offer their expertise. Depending on the website, tutors may range from college professors to the peers of the students seeking advice. In many free homework help websites (Yahoo! Answers, Free Math Help, Math.com, etc.), electronic bulletin and message boards are used to foster communication between students posting questions and the tutors replying. On these websites, tutors may be any registered site user. Experts, teachers, and other students may offer advice and assistance and take on the role of a tutor. It is the responsibility of the initial user to evaluate his or her replies to an initial post and set validity accordingly. Most often, the replies given are written for genuine assistance fostering the notion that “the motivation for knowledge exchange is not self-interest, but care of the community” (Trausan-Matu, 2009).

Despite the ideals of the electronic message board being a place for the free flow of information, not all information is readily available to the tutors at all times. This may become problematic to tutors when attempting to help other users. In a 2004 study, tutors of an online homework help site expressed the need to know more about the background of the student (age, grade, subject,…); context in which the student was seeking this information (curiosity or assigned work); topics already familiar to the student (course/level); type of assignment (homework, term assignment); nature of the problem the student has (conceptual understanding or inability to apply procedures); depth to which the student went in solving a mathematics problem; strategies/pathways the student attempted before asking for help; and as much of the student's actual work on the problem. This information could greatly assist the tutors' types of responses and the levels of conversation the tutors would feel most comfortable communicating with the students (Martinovic, 2004).

From that same study, Martinovic (2004) noted that expert tutors approach online communication with students holistically, noticing every little detail. They categorize: (a) questions according to mathematical or educational grounds (e.g. subject, level); (b) the type of student; (c) math problems; (d) communication with a student; (e) a mathematics task; (f) student background and, (g) a problem solving history. All of these tasks are reflected in one-on-one, face-to-face tutoring sessions. The communication necessary for this type of interaction between student and tutor is reflected by the research of Kiernan and Stoneham (2010). According to their study, moderated forums promote healthy socialization and allows for the personalization of learning experiences by students.

The work of online tutors goes beyond categorizing and classifying students. When a respondent begins assisting another user, a teacher must emerge. Often times, the tutor, when asked a straight-forward, single-answer question, will not reply with the single answer until the student on the other end has shown effort and has posted an attempt. For example, Martinovic (2004) found if a student asks a specific question, like: "Solve $2x – 5 = 3$," which may easily be a homework question, a tutor is likely to provide a hint, such as: "Isolate the variable on the left side, move everything to the right." However, if a student sends a general question of the type: "What is a graphical interpretation of a system of equations?" a tutor is more likely to provide thorough explanations and even some solved examples.

"Thank you" notes, which students sometimes send to online tutors, are valuable since it points to the closure of the threaded communication. Only when the learner presents the revised, or completed work, or description of it, is there some evidence that the mathematics problem was really comprehended (Martinovic, 2004). Interviews with five expert tutors from the two Web sites pointed to the following: It is difficult to keep being enthusiastic about this service since they (tutors) often do not even know if their answer was received, not to mention how helpful it was; tutors struggle with a conflict of interest in terms of how much help to provide without jeopardizing the school assessment methods; tutors struggle with lacking appropriate model of a learner (background info, feedback from the student, etc.) (Martinovic, 2004).

One problem with bulletin boards is that they are linear in nature, with postings intermingled in such a way that it may be difficult to determine who is responding to whom and in what capacity. On the peer tutoring sites, there are cases where one person answers somebody's question and somewhere in the same thread starts asking questions. Sometimes the person who asks a question also answers it later, thus making the tracking of communication complex. Even more, a tutor can post a comment to another tutor's posting as well as to a student's. Comments can be addressed to more than one person as in: "You are all wrong/right" (Martinovic, 2004). Engelbrecht and Harding (2005) are cautious in praising the use of asynchronous message boards for teaching since it suffers from "the lack of immediate feedback, students not checking in often enough, the length of time necessary for discussion to mature and the sense of social disconnection experienced by students" (Engelbrecht & Harding, 2005). Daymont and Blau (2011) note the importance of student and teacher discipline when participating in an asynchronous course. Student and teachers alike must be available at all times to the asynchronous classroom platform to fully gain educational insights (Deymont and Blau, 2011).

Cole and Todd (2003) criticized the idea of feedback as a form of reinforcement, substituting an information-processing view about reinforcement. Under this view, feedback is a tool to help the learner identify errors in learning and substitute correct information. Cited in Cole and Todd (2003), researcher Kulhavy described several criteria under which feedback is most effect. One factor he identified is that feedback is most effective when the student is certain about the answer but gets it wrong. In this situation, the learner is more likely to carefully examine the feedback and the processes that led to his or her wrong answer. Through doing so, he or she may reconcile the two in a way that is more likely to be correct and retained. Kulhavy thought delayed feedback was more effective than immediate feedback, because human pride associated with the belief in incorrect answer being true is more likely to interfere with immediate feedback than with feedback that has been delayed long enough for the incorrect answer to decay in strength and vividness. This effect is known as the perseveration-interference hypothesis. In addition, Kulhavy identified feedback as ineffective if it is available before the learner has had time to construct a response (pre-search availability) or when the learner does not understand enough about the subject to construct a meaningful answer (Cole & Todd, 2003)

Questioning Methods and Taxonomies

Help online may only be given to those seeking assistance. Through message boards, online tutors and peers present pertinent information to those who know how to either ask or search for the information. Questioning techniques—how a question is posed and background information provided in an initial message board post—have adapted to take on an immense role in regards to online data collection and retrieval. By asking the right questions, students are able to solicit the proper assistance needed to formulate solutions in online communities.

In 1954, Benjamin Bloom and his colleagues published the hierarchy of questions and learning process known as Bloom's Taxonomy (Bloom, 1954). This hierarchy has been investigated and applied to specific disciplines such as mathematics as well as the relativly new digital communities of learning (Hopson & Knezek, 2002; Manninaro, 2005; Churches, 2008). While the principles and general structure remains the same, certain terminology has been replaced or adapted to better suit these specific and new pedagogies.

The basic structure of Bloom's Taxonomy consists of six levels of questioning prompts to elicit a specific classification of answers. Bloom's original six classifications consisted of knowledge, comprehension, application, analysis, synthesis, and evaluation

(Bloom, 1954). These terms, written in ascending order from the most basic to the greatest level understanding, provide the framework for questioning techniques. According to Vockell's (1994) interpretation of Bloom's work, the *knowledge* level pertains to recalling information. Memorization and repetition with out specific meaning to the information belong to this level. The knowledge level is seen as a building block for all of the other stages. *Comprehension*, the next stage, takes the recognized object or concept and begins to give a meaning to the information. Once assigned a meaning, the information may be utilized in other situations, the *application* stage. The next level of understanding, *synthesis*, is demonstrated when the student may take apart a problem, and investigate, classify, and understand the individual components through the lower levels of understanding. The hierarchy concludes with *evaluation*. In this stage, the student is able to step into new situations and compare it to previously acquired information.

In the realm of online message boards, the type of question being asked and the level at which it is being asked demonstrates various student informational needs. These prompts must then be interpreted by online tutors in order to generate the best possible reply, often a question itself. In tutoring instances employing discussion boards, tutors and students often continue questioning until the student demonstrates a level of higher understanding of the problem at hand. According to Churches (2008), the basic actions of post and reply on an online message board constitutes the higher level skill of evaluation. "[Posting comments] are an increasingly common element of students' daily practice. Good postings, like good comments, are not simple one-line answers but rather are structured and constructed to evaluate the topic" (Churches, 2008).

Daly Mannarino (2005) adapted Bloom's original taxonomy towards mathematics education. Within Mannarino's framework, questioning prompts and question analysis may be investigated by a mathematics teacher, tutor, or student. These prompts provide the general guidelines for most mathematics tutoring sessions: (1) student asks question; (2) tutor replies with some information followed by another question; (3) student replies to the new question answering the original question in the process.

Educational Scaffolding

Combining the ideas of collaboration and questioning level with technique gives rise to the educational philosophy of scaffolding. Young (1993) defines educational scaffolding as, "an instructional strategy that involves supporting novice learners by limiting the complexities of the context and gradually removing those limits as learners gain the knowledge, skills, and confidence to cope with the full complexity of the context." This educational model was first noted by Vygotsky (1978) and corresponds with his definition of a learner's zone of proximal development. According to Vygotsky (1978), the zone of proximal development is, "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance, or in collaboration with more capable peers." These definitions have been interpreted to various educational systems, including online tutoring sessions (Nussbaum et al., 2004). According to the educational theory, within such sessions, the communication and interaction between student and tutor plays a crucial role. A student begins by initializing a question. This is followed by a tutor responding with hints, suggestions, or further questions. Ideally, at no point in the early stages does the tutor reveal the answer to the originally posed task; rather, the tutor acts as a guide and lets the student discover the correct answer and procedure through his or her own path.

The technique of scaffolding has been dissected into key components. Hyde et al. (2006) documented nine such elements of educational scaffolding in regards to mother-student educational experiences: (1) Recruits the child's interest; (2) Simplifies the task to manageable, small components; (3) Sustains the child's motivation; (4) Notes errors or imperfect solutions; (5) Controls the child's frustration; (6) Demonstrates how to solve the problem; (7) Matches teaching to the child's level of understanding (zone of proximal development); (8) Transfers responsibility to the child at appropriate times; (9) Displays interest. Although originally designed to be specific to mother-child interactions in regards to mathematics homework, the list generated, with few alterations, may be applied to any conversation-based learning environment, including those online.

Research points towards several benefits of educational scaffolding in regards to learned material including student ownership, increases in student confidence, and ability for retention and reproducibility of newly acquired skills (Conner & Cross, 2003; Murphy & Messer, 2000; Paz Dennen, 2004; Larkin, 2011). In regards to computer-mediated communications, scaffolding has been noted. Researchers note message boards, text messages, online chat sessions as well as blogs as points of scaffolding instances (Conner & Cross, 2003). In the case of message boards, the dialogue interaction between an original poster and a primary responder mimics that of a face-to-face session between a student and tutor (Nussbaum et al., 2004).

Literature Review Summary

While parental and family involvement is key to a student's level of academic success, time constraints and personal lack of subject familiarity inhibit help from always being present at the kitchen table when students being nightly homework. It has become increasing important to understand the roles of online and digital communities as a place for such students and families to go to for assistance. Online tutor services are a viable source for community support for such matters. Through the use of established learning models, such as scaffolding, members of online message boards may be able to collaborate and develop great understanding pertaining to higher level mathematics.

METHOD FOR DATA COLLECTION AND ANALYSIS

Question

This content analysis investigates the primary question: *To what extent can authentic learning occur on a homework help message board for mathematics?* To narrow this broad question and to define authentic learning, educational theories were evaluated including Vygotsky's (1978) scaffolding theory. As a result, this thesis will use this theory as a means of measure to define authentic learning experiences and will more specifically address the questions: *What are the dominant educational scaffolding elements utilized within post-and-reply sessions on a mathematics homework help message board? To what extent are these elements used?*

Babbie (2006) defines a content analysis as "the study of recorded human communications." For this thesis, a content analysis will be conducted following the processes outlined by Neuendorf (2000): theory and rationale; conceptualization decisions; operational measures; human coding schemes; sampling; training and initial reliability; coding; final reliability; and tabulation and reporting.

Theory and rationale

The purpose of this content analysis is to explore the question: *To what extent can authentic learning occur on a homework help message board for mathematics*? Based on a review of Vygotsky's (1978) educational scaffolding theory, more specifically, this content analysis will examine the existence and use of key elements of educational scaffolding during the post-and-reply sessions (PARS) of a mathematics homework-help message board. The results of this study may aide in the decision process of students and educators as to the educational value of PARS on the examined message board.

For this study, the message board Free Math Help.com—Homework Help! was investigated. This board was selected for study due to its free membership policy and archived past posts. An initial descriptive study was completed on May 8, 2011 of message board.

Board description

The message board on Free Math Help.com—Homework Help! was founded in December 2002 with the purpose of offering online help to students of mathematics. The site offers free registration to become a member. Nonmembers and members are able to browse PARS on the board. Only members, however, are able to contribute to PARS. During the timeframe for the initial study, the board consisted of 19,703 registered members and included one administrator and five moderators. The board hosted the most users, a total of 98, on Sunday, June 13, 2010.

The board itself consists of three main categories: Important Stuff, Free Math Help, and Calculators. (The creators of this message board chose to name these categories as *topics* as well as giving the name *topic* to original posts. To avoid confusion within this paper, the term *topic* will refer only to original posts.) These main categories are further broken down into subcategories through which members post questions and reply to other members.

The category Important Stuff generalizes the rules and regulations of the board. The board administrator (username Ted) and the five board moderators (usernames Aladdin, galactus, staple, tkhunny, and Subhotosh Khan) offer troubleshooting advice and general recommendations to all users from this category.

The Free Math Help category offers eleven math courses for users to select. The courses are organized by increasing course level in terms of the typical high school and college level of completion. The courses are Arithmetic, Pre-Algebra, Beginning Algebra, Intermediate/Advanced Algebra, Geometry and Trig, Calculus, Differential Equations, Probability/Statistics, Advanced Math, Math Odds & Ends, and Finance/Business Math. The course Intermediate/Advanced Algebra hosts the most topics with 25.5% of all of the total category topics and the most subsequent posts to the topics with 26.7% of the category total (see *Table 2*). For this paper, the topics relevant for most junior and senior high school students (Arithmetic, Pre-Algebra, Beginning Algebra, Intermediate/Advanced Algebra, Geometry and Trig, and Calculus) will be used for further analysis.

As the name suggests, the Calculator category pertains to issues using various styles of calculators.

Board membership

Membership to Free Math Help.com—Homework Help! is free to internet users provided new members submit an activated email account and agree to the terms of use for the site (see *Figure 4*). Registered members are able to upload profile information and have access to view other members' profiles. Members on the site are ranked according to the number of total posts they have completed. Titles for the ranks range from New Member to Elite Member and are indicated graphically through the use of pencil icons below a member's username. On May 8, 2011, the site hosted a total of 19,706 members with a posting range of 0 to 9,959. The majority of the members, 93.5%, have posting totals between 0 and 9 (see *Table 1*).

Conceptualization decisions

For conceptualization decisions, Neuendorf (2000) states the content analysis must answer the question, "What variables will be used in the study, and how do you define them conceptually?" In order to answer the broad question of this thesis (*To what extent can authentic learning occur on a homework help message board for mathematics?*), educational theories where researched in order to provide a measure and definition of authentic learning experience. Vygotsky's (1978) theory on educational scaffolding has been documented as such a theory applicable to tutoring and one-on-one dialogue learning experiences (Hyde et al., 2006; Murphy & Messer, 2000). For this analysis, quantitative and qualitative data will be collected to measure the extent of scaffolding within discussion board PARS. Quantitatively, the frequencies of the instances of educational scaffolding elements will be documented within the sampled PARS. Key phrases and conversational elements matching those outlined by scaffolding theory will be tabulated and analyzed. Qualitatively, a subjective score of the level through which primary responders utilize scaffolding techniques will also be collected and analyzed.

Operational measures

Neuendorf (2000) notes this stage of a content analysis as the time to identify what are the units of measure. For this analysis, the identifiable instances of educational scaffolding by a primary responder (PR) during PARS will be noted in both quantity and quality. According to Hyde et al. (2006), the use of scaffolding elements may not be enough to demonstrate significance to educational instances. For example, Hyde et al. cite sustaining a student's motivation as a scaffolding element. Within the study of mother-child scaffolding instances, it was observed certain mothers offered scaffolding conversation cues such as, "What do you think you should do next?" and, with the same surface meaning, "Next…" (Hyde et al., 2006). While both messages contained the same surface meaning, the first instances places a direct verbal cue for the child to take responsibility for the knowledge creation. This is echoed within the online text of message boards. Due to the conversational elements of the PARS, instances of scaffolding may become manifested as direct written language or may be observed as latent content within the recorded text. Thus, the importance of the duel collection of quantitative and qualitative data must not be overlooked within this study.

Coding schemes

To consistently assess PARS within the sample of this content analysis, coding forms Frequency of Identifiable Scaffolding Elements (see *Figure 9*) and Scaffolding Variables and Rubric for Assessing Primary Responders as Tutors during Post-and-Reply Sessions (see *Figure 10*) will be used. Data from the forms will be recorded in Microsoft Excel 2003 for later analysis.

Sampling

An initial screening of the PARS will take place in order to generate an appropriate sample for this study. The PARS selected for the sample were chosen using the following screening process:

1. The PARS will be from middle and secondary education courses listed on the message board: Arithmetic, Pre-Algebra, Beginning Algebra, Intermediate/Advanced Algebra, Geometry and Trig, and Calculus.
2. The PARS will have a length no less than 15 replies.
3. The PARS dialogue must dominantly follow that of an OP-PR-OP-PR-OP… pattern.

Junior and senior high school level courses will be considered for research due to their embedded, traditional skill level hierarchy. Students within a traditional school setting generally follow a mathematics course pathway mirroring the course link order established on the message board: Arithmetic, Pre-Algebra, Beginning Algebra, Intermediate/Advanced Algebra, Geometry and Trig, and Calculus. Through utilizing this established hierarchy, comparisons between skill courses may be opened for further analysis, description, and explanation.

From the 26,179 PARS contained within the junior and senior high school level courses, an initial sample of posts will be taken based on reply totals. Of all submitted PARS, only the 280 PARS with a reply total greater than or equal to fifteen will be considered for the survey. While key scaffolding and educational moments may arise within shorter PARS (Pratt et al., 1992), the greatest instances for scaffolding elements occur within the conversational elements of communication (Murphy & Messer, 2000). Thus, longer PARS theoretically will yield more instances of educational scaffolding for documentation and analysis.

Within each PARS meeting the minimum length requirement, an individual screening was completed documenting the dialogue pattern between active participants. In order for the PARS to mimic a face-to-face, traditional tutoring session, an original poster (OP) must be aided by a primary responder (PR). A two person dialogue follows the notion of a tutoring session. It is important to note, however, that more than two members may participate within a given considered PARS. Board members other than the OP and PR must remain as supplemental instruments within the PARS or, due to the open asynchronous nature of the message board, adopt the role of a PR. Thus, the PR is defined as the responder, or responders, who act as a tutor towards the OP by directing the OP towards mathematical learning through educational scaffolding and conversation. The screening of 280 PARS with a minimum length of 15 posts yielded a total of 130 PARS from the junior and senior high school level courses that fulfilled the conversational patterns and elements needed for this study.

Training and initial reliability

Due to the subjective measures of the latent text and overall quality of scaffolding elements present within each PARS, a question of reliability, the ability to repeat a study with the same results (Babbie 2006), becomes evident. To maximize the reliability of this analysis, two coders were used to assess sampled PARS using the coding forms. The coders are two mathematics educators from the Westmoreland School District in Central

New York. As Neuendorf (2000) indicates, these coders trained together by simultaneously scoring sample posts. After evaluating samples, open discussion between the coders clarified definitions and developed key strategies for consistent score assignments for the variables under consideration.

Coding

Upon the approval of this content analysis, the coding of the sampled PARS took place during May and June 2011. As Neuendorf (2000) suggests, coders evaluated a minimum of 10% overlapping PARS to evaluate the reliability of the analysis in the next stage of the content analysis. For this study, 16 of the 130 PARS were examined and scored by the two coders. Using the *Figure 9*, coders documented the post number as determined by the page's URL, the subject where the post exists, the PR's username, the number of replies the OP receives, and the median differences in time between consecutive posts. After the preliminary data was extracted from the PARS, the coders tabulated the frequencies of the following scaffolding elements as demonstrated by the PR: simplifies tasks; sustains motivation; notes errors or imperfect solutions; demonstrates how to solve the problem; and transfers responsibility to child at appropriate time. After taking frequency counts, coders then assessed the level through which the PR addressed and utilized the various levels of educational scaffolding. Using the rubric established on *Figure 10*, coders were able to determine a numeric score for this level based on the outlined progressive scale.

Final reliability

From the 16 overlapping, preliminary PARS, statistical reliability tests were conducted. Using Microsoft Excel 2003 Professional Edition and the ReCal 0.1 Alpha statistical analysis program, Scott's Pi, Cohen's Kappa and Krippendorff's Alpha were calculated in order to observe the internal reliability of the qualitative measures of this study. According to Larson and Farber (2000), these three statistical values, Pi, Cohen's Kappa and Krippendorff's Alpha, illustrate a higher level of validity as the values become closer to 1. Although somewhat controversial (Gwet, 2008), Landis and Koch (1977) note values of 0–.20 as slight, .21–.40 as fair, .41–.60 as moderate, .61–.80 as substantial, and .81–1 as almost perfect agreement. From *Table 3*, the calculations yield substantial to almost perfect values for three of the five scaffolding techniques measured. A discussion between coders followed the primary data collection and analysis to determine the discrepancies within the assessment of the *Simplifies the task to manageable components* and *Demonstrates how to solve the problem scaffolding* techniques, the two techniques with the lowest inter-coder scores. It was noted that simplifying a task into manageable steps may be thought of as a method for demonstrating how to solve a problem. A distinction between the two categories was agreed upon. Simplifying a task into manageable steps would be noted as a list or outlined description of what an OP could do to solve a problem whereas a demonstration of how to solve the problem would be defined as a PR using the data provided by the OP and applying it directly to an equation or other solving measure through substitution.

After the discussion, a secondary simple random sample of 16 PARS was selected from the screened PARS. The two coders assessed only the *Simplifies the task to manageable components* and *Demonstrates how to solve the problem* scaffolding techniques using the newly established definitions and assessment guidelines. This assessment data was once again used to calculate Scott's Pi, Cohen's Kappa and Krippendorff's Alpha. The resulting figures, displayed in *Table 4*, display almost perfect agreement on the scale developed by Landis and Koch (1977) indicating a high level of internal reliability for this study.

Tabulation and reporting

Within the final stage of this content analysis, data was collected, displayed and explained from the coding instruments. The number of instances of the key scaffolding methods was tabulated as well as a general score of PARS in regards to the quality of scaffolding techniques employed by PRs. Cross tabulation data comparing data collected from various subject levels was found, statistically verifying significant differences in quantity and quality of scaffolding.

Mean Frequencies and Qualitative Assessment Scores

From the data collection, descriptive displays of the total frequencies of scaffolding elements and the total qualitative assessment values were generated in the form of histograms. The resulting graphs, *Figures 12* and *13* respectively, display nearly normal distributed data, following the general shape of a bell curve. From this initial representation, it may also be observed that over 72% of the PARS contain at least 10 instances of scaffolding techniques. When taken into consideration with average of 9.7 posts generated by a PR per sampled PARS, an average of 1.2 instances of scaffolding per PR post can be calculated. An examination of the mean frequencies and qualitative assessment scores of individual scaffolding techniques can also be seen in *Table 5*. Applying the mean frequencies from this data to the average number of PR replies produces the data displayed in *Table 6*. From this table, it can be seen that *Demonstrating how to solve a problem* and *Simplifying the problem into manageable steps* are the dominant scaffolding techniques implemented by PRs with 30% of the total PR relpies. *Sustaining motivation*, found within only 8% of all PR posts, was the least observed element. An argument, however, may be made for the low observed frequency. The length of the PARS and the completion of a problem by the OP and PR may be a non-textual method of observing motivation that was not recorded during this study.

Cross Course Investigation for Scaffolding Frequencies and Qualitative Assessment Scores

Using the data recorded from the PARS, frequencies and assessment scores for individual scaffolding elements were also tabulated by course level in order to investigate differences in the quantity and quality of scaffolding techniques used throughout the different course levels. These results, displayed in *Tables 7* and *8*, show topical mean differences for both quantity and quality of the scaffolding elements used in the PARS at different mathematical course levels. Further data analysis was performed to statistically determine any course differences.

An analysis of variance (ANOVA) test was performed to test the claim that scaffolding techniques in both quality and quantity should be the same regardless of the original poster's level of mathematics chosen on the message board. Under a 90% confidence interval, the ANOVA tests returned statistically significant differences in all but the *Sustaining motivation* category for the frequency of scaffolding elements in terms of the course the original poster began the PARS and also returned significant differences in the mean qualitative assessment in the *Demonstrates how to solve the problem* and *Notes errors and imperfect solutions* scaffolding categories. The critical test and *p*-values for this analysis are summarized in *Tables 12 and 13*.

Although the ANOVA test did return a high probability of differences between the mean values of the six subject areas from the board, an ANOVA test cannot disclose which pairs of the courses the differences in means are most dominant. In order to have a clearer understanding of where the differences occur, paired two-tailed *t*-tests for samples with unequal variances were conducted between each of the courses for each scaffolding element. These *t*-tests all had the same null hypothesis: The difference between the means of the frequencies or qualitative scores of the scaffolding elements would be the same from both message board courses within the pair. The results for the *t*-tests are noted in *Tables 14* and *15*.

From this further investigation of scaffolding frequencies displayed in *Table 16*, under a 90% confidence interval, a statistically significant difference in means is present within various groups. Most notably, however, is the pattern of significant differences in the *Simplifying the task in to manageable components* element. Here, the differences all occur between two courses that are separated by at least two levels. Upon further investigations, the mean frequencies (*Table* 7) for *Demonstrating how to solve the problem* are higher in the higher level courses. This is contrary to Herber and Nelson-

Herber (1989) who noted that the further along a student is in his or her studies, the less the need for such instruction. However, based on the data, this is not the case on the math message board.

The *t*-test values for the category of *Transferring responsibility at an appropriate time* are also worthy of note. This analysis found significant differences in the frequency means between all but two course pairings. This variation demonstrates the individualization based on proximal development discussed by Kiernan and Stoneham (2010) and Vygosky (1978). From observing the mean frequencies of this element across the course level, the increase in transferring responsibility increases with course level difficulty demonstrating Herber and Nelson-Herber's (1989) belief of a direct relationship between learning independence and educational learning level.

Paired two-tailed *t*-tests were also conducted between the six subject areas with the qualitative assessment values for the scaffolding elements noted by the ANOVA test as having highly probable differences between course means. *Table* 17 displays the results of the two-tailed *t*-tests for independent samples with different variances for this data. Although the analysis for *Notes imperfect solutions* did not produce any noticeable patterns, the *Demonstrates how to solve the problem* category produced a notable series of differences between Arithmetic and all other courses. When comparing means, the Arithmetic course had the highest mean score for the category in terms qualitative assessment. Interestingly, however, the course had the lowest average in terms of observable frequencies for the same scaffolding element. Observations of the Arithmetic course PARS reveals the problems posted generally require only one or two procedural steps. For instance, in one PARS, the PR lead the OP through a problem pertaining to adding two fractions with unlike denominators. Being a procedural problem, the PR only demonstrated the traditional method of finding a common denominator and adding the numerators of the fractions. This thorough demonstration was the only approach given and needed for the OP to gain understanding to the addition process. Within other subject areas, such as Calculus, more than one approach is often needed as the problems posted are often more than procedurally based. For instance, one Calculus PARS involved the OP asking for assistance with a rated rate problem for water flowing from a hose. The PR, rather than demonstrating all parts of the problem at once, wrote a list (*simplifies the task into manageable components*) of problem solving techniques for the OP such as drawing a picture, listing formulas and declaring variables. Directly showing the OP how to solve the problem in one step was not conducive to the learning environment created by the OP and PR in this instance.

Median Time between Posts

The median inter-post time was recorded for each of the 130 PARS sampled. From *Figure 11*, a distinct right skewed distribution can be observed indicating the majority of the data contained within the first three classes. Therefore, the modal wait time between posts is between 1 to 30 minutes. The range of 1 to 30 minutes of wait time reinforces Cleveland-Innes and Ally's (2011) notion of reflection and correction time. During the wait time between posts, an OP may have time to continue working on a problem or reflect upon the feedback sent by a PR.

According to Engelbrecht & Harding (2005), the wait time between posts and user satisfaction has an inverse relationship. A linear regression analysis was performed using the collected data from the Free Math Help.com—Homework Help! message board. Median time between posts was used as the independent variable and was pair-tested with total scaffolding frequencies and qualitative assessment scores. The resulting regression analysis tests are summarized in *Tables 7* and *8*. From this analysis, both cases generated a Pearson's r^2 *value* that is less than 0.01, indicating little to no linear correlation between the variables. To investigate the possibility of non-linear relationships between the median time between posts and the frequencies and scores, scatter-plots were generated (*Figures 14* and *15*) and analyzed. From the scatter-plots, no correlation, linear nor non-linear, can be determined. This analysis indicates that, contrary to Barbour (2007), for this message board, median time between posts cannot be used as a measure of the quality nor quantity of educational opportunities.

A final consideration was given to the possible differences in median time between posts in reference to the message board courses. A series of *t*-tests for independent samples with different variances was used for the comparison. The results of the tests are summarized in *Table 11*. The results conclude that, under a 95% confidence interval, there are not any significant differences for the median post times between the different courses. Therefore, original posters and primary responders act in very similar ways in terms of time throughout all junior and high school courses on the message board.

Legal and ethical restrictions

Due to the nature of this study and the proposed methods for collecting data, legal and ethical restraints must be considered. Before publishing any posts, users of Free Math Help.com—Homework Help! message board must first register and officially sign into the site. In doing so, members agree to the terms of the site as written by the moderators and authors of the code which digitally runs the board. Unlike other message boards, these agreements do not include a copyright or board ownership over submitted materials. Information and data collected, posted, and commented upon are intended solely for educational purposes ("Free math help.com--homework," 2011). In the event of a hidden copyright over the posted material, the nature of this study—nonprofit, educational, fact-driven, and non-impacting ofthe economic value of the message board—allows the study to fall under fair use as described by sections 107 through 118 of the United States copyright laws ("Copyright office--fair use," 2009).

Ethically, the use of online discussion posts is not as clear as the current legal standings for message posts. The current ambiguity of cyber-ethics has left scholars debating the proper and responsible methods for surveying and collecting data from open digital forums. In the case of this study, the data being collected as well as the unobtrusive collection methods are conducive to the ethical use of digital media outlined by Ess and the Association of Internet Researchers Working Committee (2002).

Babbie (2007) cites the unobtrusive nature of content analysis as one of the research method's chief strengths. "The content analyst seldom has any effect on the subject being studied. Because the novels have already been written, the paintings already painted, the speeches already presented, content analyses can have no effect on them" (Babbie, 2007). While Babbie's analysis of physically recorded objects may hold true, the open and continuous nature of an online message board does not necessarily have a definitive ending post to indicate completion. The PARS held on the Free Math Help.com—Homework Help! message board may be altered and commented upon at anytime. This flexible nature of the message board, however, should not have an impact upon this study. The length of the PARS sampled of 15 replies or higher was partially selected to create a bank of completed sessions: question, explanation, solution. Therefore, additional posts generated after the collection of data should have little to no impact upon the study.

The method used for collecting the units of analysis for this study should also have little to no impact upon individual board participants. Although a unique identifying number will be used for each PARS, these numbers will not be published, but rather, will be used for replicating and clarifying recorded data for the author and coders for this study. Individual names of participants will not be taken. In the event of the usage of text from PARS in the written analysis of this study, names will be coded using generic, subscripted terms for participants to protect the immediate privacy of the participants. In this way, the ethics of this particular content analysis mirror those faced during unobtrusive field studies.

The units of analysis to be used for this study also allows for minimal to no obtrusion into the privacy of the individuals generating the text from which the data is collected. For this study, the incidences of scaffolding will be assessed. These incidences are not to be used to further define nor to alter the definition of educational scaffolding, rather they will be tabulated as a means to show their presence on the message board. Consequences of these methods not being used do not necessarily indicate the nonexistence of authentic learning. Other learning and teaching strategies may be present and may be implemented instead of scaffolding. At no time should this study be used as a definitive answer to the question of the presence of online learning. This study merely uses the presence of one educational structure as a means for measuring the existence of authentic learning.

According to Ess and the Association of Internet Researchers (2002), individual privacy concerns in regards to social research are generally addressed by the context of the web-based media through which the participants are engaged. "The greater the acknowledged publicity of the venue, the fewer obligations there may be to protect individual privacy, confidentiality, right to informed consent, etc" (Ess and the Association of Internet Researchers, 2002). The structure of the proposed message board to be investigated presents itself as a public forum. When members post an initial question, they are searching for guidance from the online community present on the message board. When members offer assistance or comments to posted questions, again, it is done with the expectation that the online community composed of members and nonmembers will acknowledge their works through reading, commenting, and analyzing. The on-going record produced by the message board is presented in a way to encourage the searching of past posts and comments. All internet users who visit the message board are welcome to read and search past posts without registration. Such searches are encouraged on the board. The first post on most of the course specific categories lists the rules and procedures for PARS. Within most of these guidelines is a phrase indicating and encouraging board participants to search before posting in an effort to stop the reposting of previously addressed questions. Such encouragement reinforces the public nature of this specific message board.

Summary, Limitations, and Conclusion

The primary goal of this thesis was to explore the possibility of authentic learning on a mathematics homework help message board. With scaffolding techniques used as a measurement tool, the data illustrates various opportunities and levels of authentic learning. Differences within the means for both qualitative and quantitative assessments were found to be statistical significant between different mathematics learning levels for individual scaffolding elements.

Caution should be taken, however, when interpreting the results of this study. The PARS used for analysis were screened and selected for having the highest probability of scaffolding occurrences. The 130 PARS used for this study represent all of the sessions containing at least 15 posts and follow the OP-PR-OP-PR… conversation pattern. This number represents only 0.5% of the total PARS contained on the message board. Further study would be needed to answer more generalized inquiries as to the authentic learning opportunities on the entire Free Math Help.com—Homework Help! message board. Other questions could also be investigated by sampling outside of the screen PARS used in this study. For instance, the majority of the PARS contain less than ten posts. What teaching and learning techniques are being used (if any) within these posts? Of the 93.5% of the message board's PARS with length less than ten, 64.2% are only one or two posts long. What questions are being asked to solicit such short PARS?

Are posts being answered? Are there trends in unanswered original posts? What comparisons can be made between PARS and original questions posted?

Further study could also be given towards comparing tone used on the message board at the various educational levels. Although in this study correlation analysis between median time between posts and the qualitative and quantitative assessments of scaffolding instances returned no conclusive relationship, tutor and student satisfaction on a message board may be measured in other ways. Tutor sarcasm and overall tones of entitlement could be observed on many PARS. Throughout several posts at all levels, primary responders would respond with denials of help to original posters who did not ask specific enough questions or would respond with comments criticizing original posters of cheating for simply using the message board. According to Sava (2001), such attitudes and comments from primary responders acting as tutors do not promote healthy student-teacher relationships and hinder academic growth. These attitudes and comments can be initially seen through the scaffolding element *Sustains motivation.* The mean qualitative score of 2 (Remains neutral and does not offer any comments to the original poster) depicts a cold, discouraging learning environment.

When arriving home, students can have the world at their fingertips. Through online communities such as message boards, students can ask questions outside of traditional classroom settings and receive insightful answers. Knowing how to ask for information may be the key to receiving meaningful answers. The relationships explored in this thesis paper should assist students and mathematics educators in their understandings of the best practices for obtaining desired information on mathematics messages boards.

TABLES AND FIGURES

Table 1: Number of Replies from Members on Free Math Help.com—Homework Help! Message Board (May 8, 2011)

Number of Replies	Frequency	Percentage
0-9	18423	93.5
10-19	704	3.6
20-29	226	1.1
30-39	98	0.5
40-49	68	0.3
50-59	34	0.2
60-69	29	0.1
70-79	16	0.1
80-89	22	0.1
90-99	10	0.1
100 or more	76	0.4
total	19706	100.0

Table 2: Number of Replies from Members on Free Math Help.com—Homework Help! Message Board Based on Junior and Senior High School Courses (May 8, 2011)

Subject	Number of Replies to an Original Post					
	0-4	5-9	10-14	15-19	≥20	Total
Arithmetic						
Frequency	655	153	31	5	1	845
Percentage	77.5	18.1	3.7	0.6	0.1	100.0
Pre-Algebra						
Frequency	752	170	25	4	2	953
Percentage	78.9	17.8	2.7	0.4	0.2	100.0
Beginning Algebra						
Frequency	3526	840	143	30	15	4554
Percentage	77.4	18.4	3.2	0.7	0.3	100.0
Intermediate/Advanced Algebra						
Frequency	5643	1646	238	45	18	7590
Percentage	74.3	21.7	3.1	0.6	0.2	99.9
Geometry and Trig						
Frequency	3030	715	107	31	15	3898
Percentage	77.7	18.3	2.7	0.8	0.4	99.9
Calculus						
Frequency	6622	1357	246	94	20	8339
Percentage	79.4	16.3	3.0	1.1	0.2	100.0

Table 3: Statistical Reliability Comparison Tests between Two Coders for Qualitative Assessment of Scaffolding Techniques

	Percent Agreement	Scott's Pi	Cohen's Kappa	Krippendorff's Alpha	N Agreements	N Disagreements	N Cases	N Decisions
Simplifies the task into manageable components	81.25	0.581	0.586	0.594	13	3	16	32
Sustains motivation	87.50	0.760	0.763	0.768	14	2	16	32
Notes errors or imperfect solutions	87.50	0.802	0.802	0.809	14	2	16	32
Demonstrates how to solve the problem	75.00	0.333	0.347	0.354	12	4	16	32
Transfers responsibility to the student at appropriate time	100.0	1	1	1	16	0	16	32

Table 4: Secondary Statistical Reliability Comparison Tests between Two Coders for Qualitative Assessment of Scaffolding Techniques

	Percent Agreement	Scott's Pi	Cohen's Kappa	Krippendorff's Alpha	N Agreements	N Disagreements	N Cases	N Decisions
Simplifies the task to manageable components	93.75	0.861	0.862	0.866	15	1	16	32
Demonstrates how to solve the problem	93.75	0.871	0.872	0.876	15	1	16	32

Table 5: Mean Frequency and Qualitative Assessment Score for Sampled PARS

Scaffolding Element	*Mean Frequency*	*Mean Score*
Simplifies the task to manageable components	2.884	2.477
Sustains Motivation	0.754	2.000
Notes errors or imperfect solutions	1.985	2.000
Demonstrates how to solve the problem	3.662	2.562
Transfers responsibility to the student at appropriate time	2.431	2.338

Table 6: Percentage of Primary Responder Posts Containing Scaffolding Techniques Categorized by Element

Scaffolding Element	*Percentage of PR Posts Containing Scaffolding Elements*
Simplifies the task to manageable components	30%
Sustains Motivation	8%
Notes errors or imperfect solutions	20%
Demonstrates how to solve the problem	38%
Transfers responsibility to the student at appropriate time	25%

Table 7: Mean Frequencies of Scaffolding Elements Categorized by PARS Course

Scaffolding Element	*Arithmetic*	*Pre-Algebra*	*Beginning Algebra*	*Intermediate/ Advanced Algebra*	*Geometry and Trig*	*Calculus*
Simplifies the task to manageable components	2.000	1.400	2.250	3.023	3.353	3.400
Sustains Motivation	0.200	1.000	0.643	0.818	0.706	0.839
Notes errors or imperfect solutions	0.800	1.800	2.750	1.977	1.353	1.871
Demonstrates how to solve the problem	1.600	3.600	3.036	3.955	4.000	3.419
Transfers responsibility to the student at appropriate time	0.600	1.000	1.679	2.273	2.941	3.516

Table 8: Mean Qualitative Assessment Score of Scaffolding Elements Categorized by PARS Course

Scaffolding Element	*Arithmetic*	*Pre-Algebra*	*Beginning Algebra*	*Intermediate/ Advanced Algebra*	*Geometry and Trig*	*Calculus*
Simplifies the task to manageable components	2.800	2.400	2.250	2.591	0.118	2.613
Sustains Motivation	2.000	2.400	1.857	1.977	2.235	2.226
Notes errors or imperfect solutions	1.200	1.400	2.463	1.886	1.706	2.129
Demonstrates how to solve the problem	3.000	2.400	2.536	2.773	2.353	2.348
Transfers responsibility to the student at appropriate time	2.400	2.800	2.463	2.250	2.059	2.419

Table 9: Regression Analysis of Median Time between Posts and Qualitative Assessment Score

Regression Statistics	
Multiple R	0.075
R Square	0.006
Adjusted R Square	-0.002
Standard Error	64.972
Observations	130

Table 10: Regression Analysis of Median Time between Posts and Total Frequencies of Scaffolding Techniques

Regression Statistics	
Multiple R	0.030
R Square	0.001
Adjusted R Square	-0.007
Standard Error	65.127
Observations	130

Table 11: Statistical Two-Tailed T-Test Values for Differences of Means for Median Time between Posts for Paired Course

	Arithmetic	*Pre-Algebra*	*Beginning Algebra*	*Intermediate/ Advanced Algebra*	*Geometry and Trig*	*Calculus*
Arithmetic						
Pre-Algebra	0.140					
Beginning Algebra	0.414	0.287				
Intermediate/Advanced Algebra	0.425	0.058	0.919			
Geometry and Trig	0.460	0.082	0.807	0.844		
Calculus	0.384	0.123	0.928	0.789	0.667	

Table 12: ANOVA Test for Results Summary for Frequencies of Scaffolding Elements

Scaffolding Element	*F*	*P-value*	*F crit*
Simplifies the task to manageable components	2.625	0.027	2.287
Sustains Motivation	0.442	0.818	2.287
Notes errors or imperfect solutions	3.126	0.011	2.287
Demonstrates how to solve the problem	1.895	0.100	1.894
Transfers responsibility to the student at appropriate time	7.002	0.000	1.894

Table 13: ANOVA Test for Results Summary for the Qualitative Assessments of Scaffolding Elements

Scaffolding Element	*F*	*P-value*	*F crit*
Simplifies the task to manageable components	1.343	0.251	1.894
Sustains Motivation	1.474	0.203	1.894
Notes errors or imperfect solutions	2.471	0.036	1.894
Demonstrates how to solve the problem	2.322	0.047	2.287
Transfers responsibility to the student at appropriate time	1.325	0.258	2.287

Table 14: Statistical Two-Tailed T-Test Values for Differences of Means in the Frequency of Scaffolding Elements for Paired Courses

	Arithmetic	Pre-Algebra	Beginning Algebra	Intermediate /Advanced Algebra	Geometry and Trig	Calculus
Arithmetic						
Pre-Algebra	0.897					
Beginning Algebra	0.091	0.100				
Intermediate/Advanced Algebra	0.027	0.044	0.783			
Geometry and Trig	0.031	0.042	0.670	0.792		
Calculus	0.703	0.017	0.354	0.294	0.633	

Table 15: Statistical Two-Tailed T-Test Values for Differences of Means in the Quality of Scaffolding Elements for Paired Courses

	Arithmetic	Pre-Algebra	Beginning Algebra	Intermediate/ Advanced Algebra	Geometry and Trig	Calculus
Arithmetic						
Pre-Algebra	1.000					
Beginning Algebra	0.710	0.804				
Intermediate/Advanced Algebra	0.929	0.956	0.686			
Geometry and Trig	0.221	0.408	0.074	0.045		
Calculus	0.009	0.369	0.971	0.638	0.049	

Table 16: Statistical Two-Tailed T-Test Values for Differences of Means in the Frequencies

		Arithmetic	Pre-Algebra	Beginning Algebra	Intermediate/ Advanced Algebra	Geometry and Trig	Calculus
Simplifies the task to manageable components	Arithmetic						
	Pre-Algebra	0.284					
	Beginning Algebra	0.697	0.103				
	Intermediate/Advanced Algebra	0.088	0.000	0.128			
	Geometry and Trig	0.039	0.000	0.058	0.439		
	Calculus	0.032	0.000	0.037	0.330	0.941	
Notes errors or imperfect solutions	Arithmetic						
	Pre-Algebra	0.346					
	Beginning Algebra	0.025	0.318				
	Intermediate/Advanced Algebra	0.119	0.614	0.048			
	Geometry and Trig	0.417	0.840	0.001	0.057		
	Calculus	0.154	0.960	0.019	0.671	0.124	

		Arithmetic	Pre-Algebra	Beginning Algebra	Intermediate/ Advanced Algebra	Geometry and Trig	Calculus
Demonstrates how to solve the problem	Arithmetic						
	Pre-Algebra	0.196					
	Beginning Algebra	0.017	0.546				
	Intermediate/Advanced Algebra	0.131	0.674	0.024			
	Geometry and Trig	0.175	0.693	0.068	0.923		
	Calculus	0.041	0.845	0.416	0.210	0.281	
Transfers responsibility to the student at appropriate time	Arithmetic						
	Pre-Algebra	*					
	Beginning Algebra	0.005	0.005				
	Intermediate/Advanced Algebra	0.000	0.000	0.094			
	Geometry and Trig	0.000	0.000	0.003	0.000		
	Calculus	0.000	0.000	0.000	0.002	0.191	

* The Arithmetic and Pre-Algebra mean and standard deviation scores were identical for this test resulting in an undefined *t*-score.

Table 17: Statistical Two-Tailed T-Test Values for Differences of Means in the Qualitative Assessments

		Arithmetic	Pre-Algebra	Beginning Algebra	Intermediate/ Advanced Algebra	Geometry and Trig	Calculus
Notes errors or imperfect solutions	Arithmetic						
	Pre-Algebra	0.846					
	Beginning Algebra	0.166	0.198				
	Intermediate/Advanced Algebra	0.415	0.684	0.010			
	Geometry and Trig	0.537	0.518	0.004	0.537		
	Calculus	0.275	0.348	0.152	0.351	0.139	
Demonstrates how to solve the problem	Arithmetic						
	Pre-Algebra	0.070					
	Beginning Algebra	0.000	0.628				
	Intermediate/Advanced Algebra	0.001	0.890	0.045			
	Geometry and Trig	0.011	0.201	0.464	0.011		
	Calculus	0.000	0.882	0.347	0.023	0.995	

Figure 1: New York State Learning Strands for Mathematics (2003)

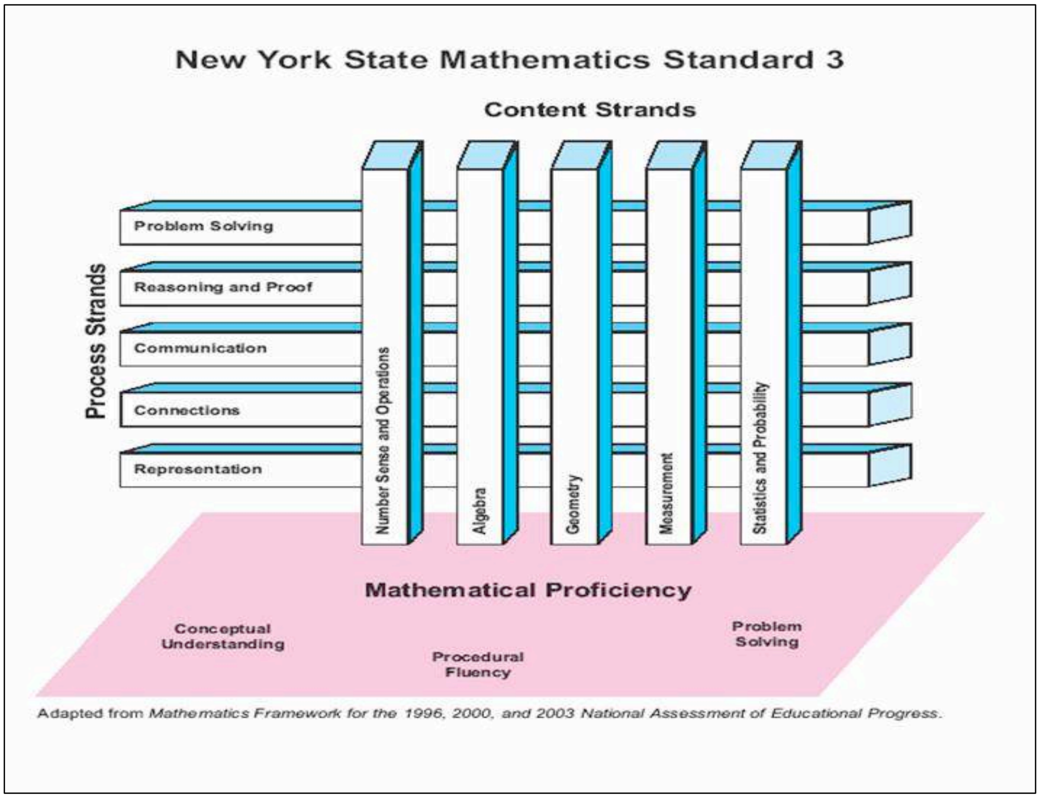

Figure 2: Bloom's Taxonomy Applied to Mathematics Education (Mannarino, 2005)

Levels	Verbs	Sample Tasks
KNOWLEDGE Learn terms, facts, methods, procedures, concepts	Draw, Recognize, Count, Group, Reproduce, Memorize, State, Tabulate, Identify, Point, Follow Directions	1. Can you identify the different place values in the metric system? 2. State the mode, mean, median, and range from your set of data. 3. How do you reproduce a circle using a compass?
COMPREHENSION Understand uses and implications of terms, facts, methods, procedures, concepts	Change, Classify, Convert, Estimate, Interpret, Measure, Put in Order, Show, Suggest, Express in other terms	1. Classify polygons by regularity, concavity, and line symmetry. 2. Explain how to convert between fractions, decimals, and percents. 3. What is your interpretation of the data expressed on the graph?
APPLICATION Practice theory, solve problems, use information in the new situations	Calculate, Compute, Construct, Demonstrate, Derive, Graph, Manipulate, Operate, Practice, Prove, Solve	1. How do you calculate the percent of a given whole? 2. Solve for area of a rectangle by using A= l x w. 3. What information do you consider when graphing data derived from a survey?
ANALYSIS Analyze structure, recognize assumptions, breaking down material into parts	Break down, Deduce, Diagram, Distinguish, Formulate, Group, Order, Separate, Simplify, Sort	1. What methods can be used to compare and order fractions? 2. Analyze the relationship between variables on a graph. 3. What factors do you consider when formulating a plan for problem solving?
SYNTHESIS Putting information together into a new and creative way.	Construct, Create, Derive, Develop, Document, Generate, Integrate, Plan, Predict, Prepare, Propose, Specify, Tell	1. Describe some patterns that you recognized in the construction of Pascal's Triangle. 2. What kind of table can you create that represents change in temperature? 3. What prediction can you make from this graph?
EVALUATION Set standards, Judge with purpose, accept or reject on basis of criteria	Appraise, Choose, Compare, Conclude, Decide, Describe, Evaluate, Justify, Measure, Validate	1. Evaluate the expression after changing the order of operations. 2. Describe how to solve a problem using the 4 step method. 3. Justify your reason for choosing the strategy selected.

Figure 3: Free Math Help.com—Homework Help! Message Board Front Page (May 8, 2011)

Figure 4: Free Math Help.com—Homework Help! Message Board Terms of Use (May 8, 2011)

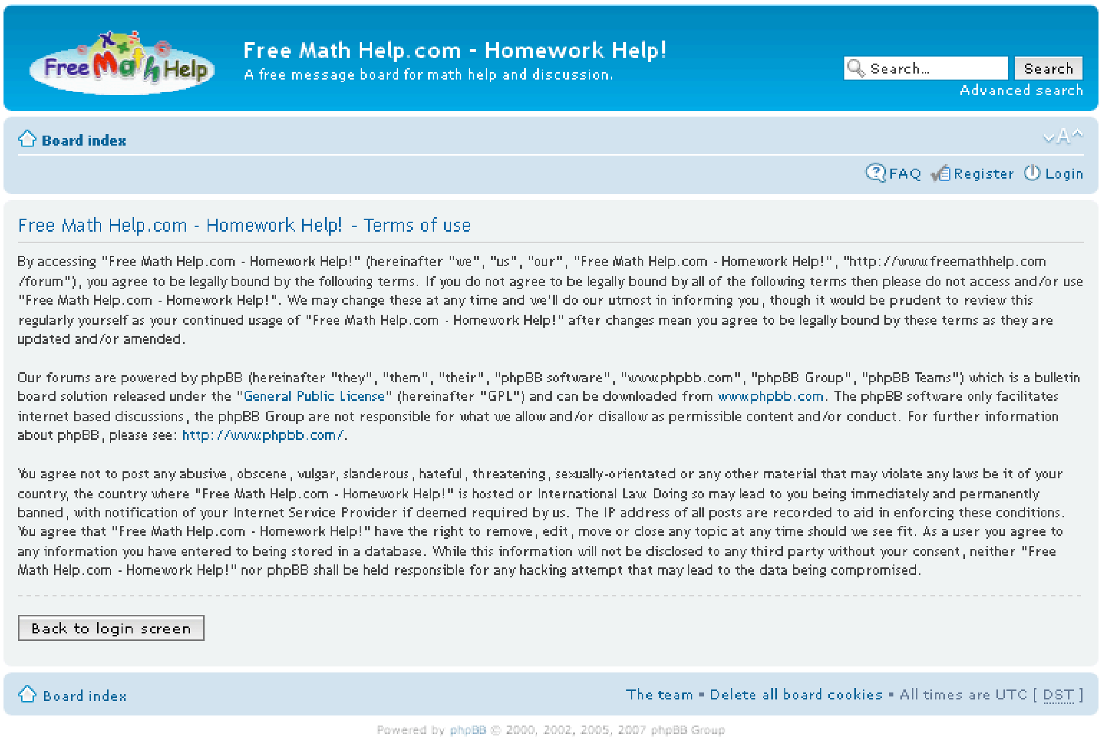

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Figure 5: Free Math Help.com—Homework Help! Message Board New User Registration (May 8, 2011)

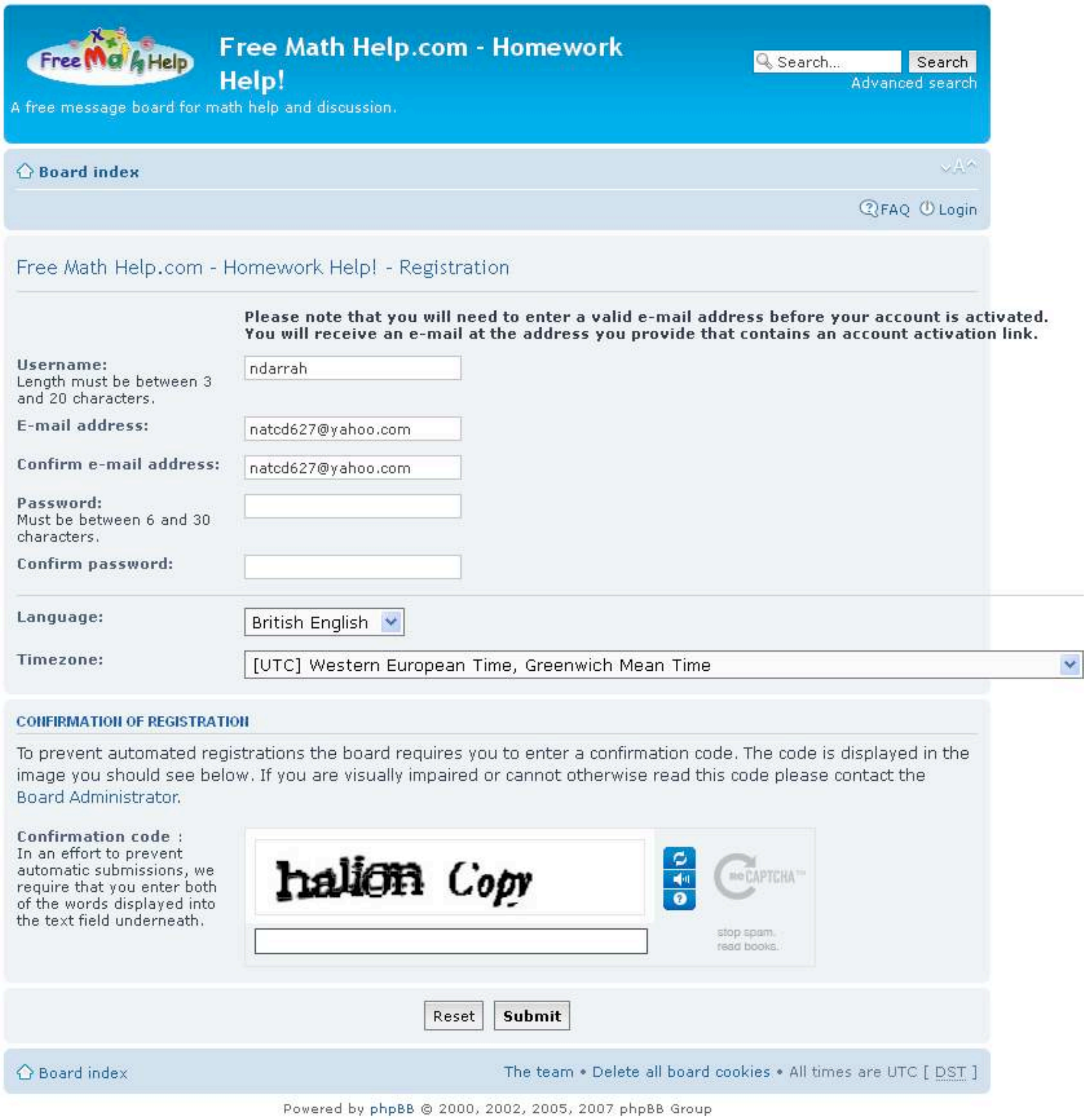


Figure 6: Free Math Help.com—Homework Help! Message Board User Control Panel (May 8, 2011)

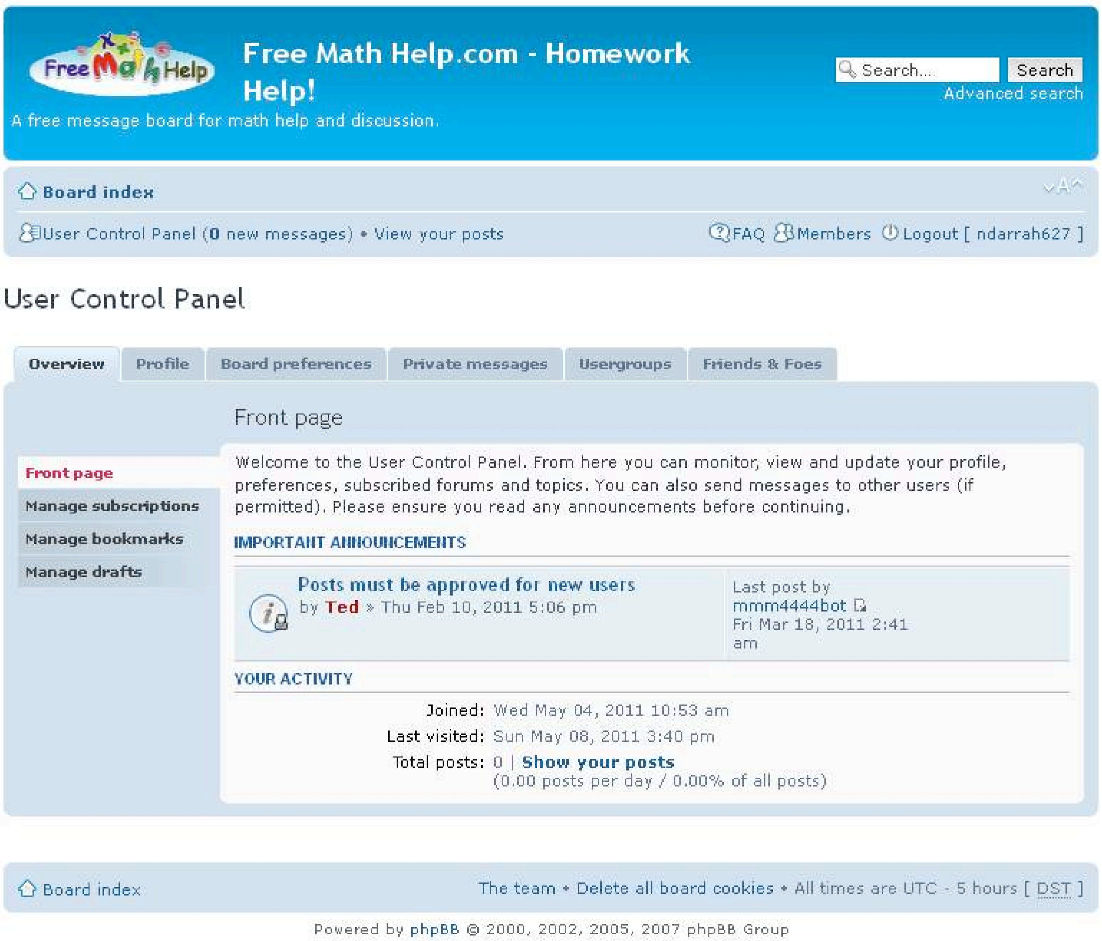
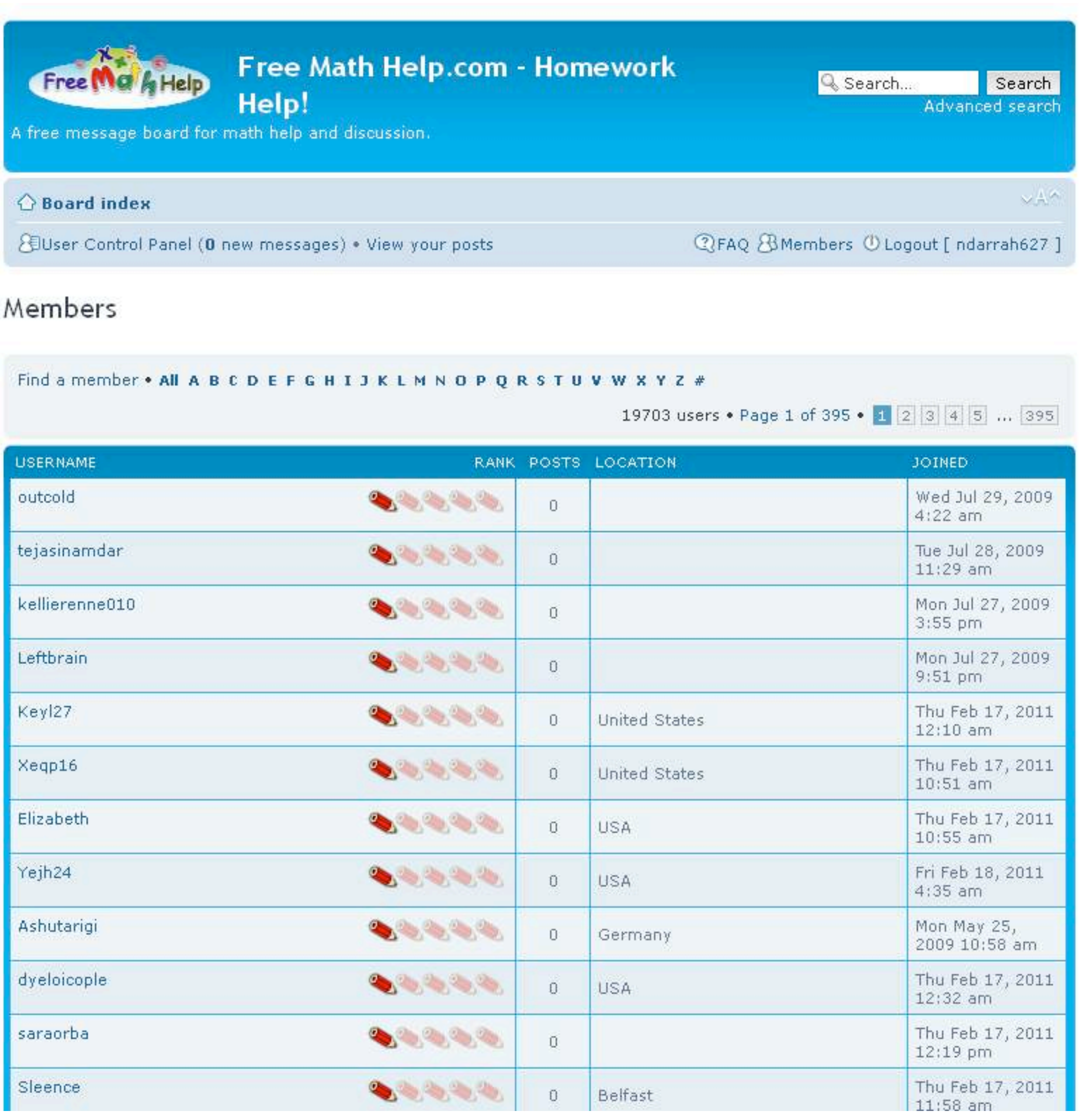


Figure 7: Free Math Help.com—Homework Help! Message Board Page 1 of Member Listing (May 8, 2011)



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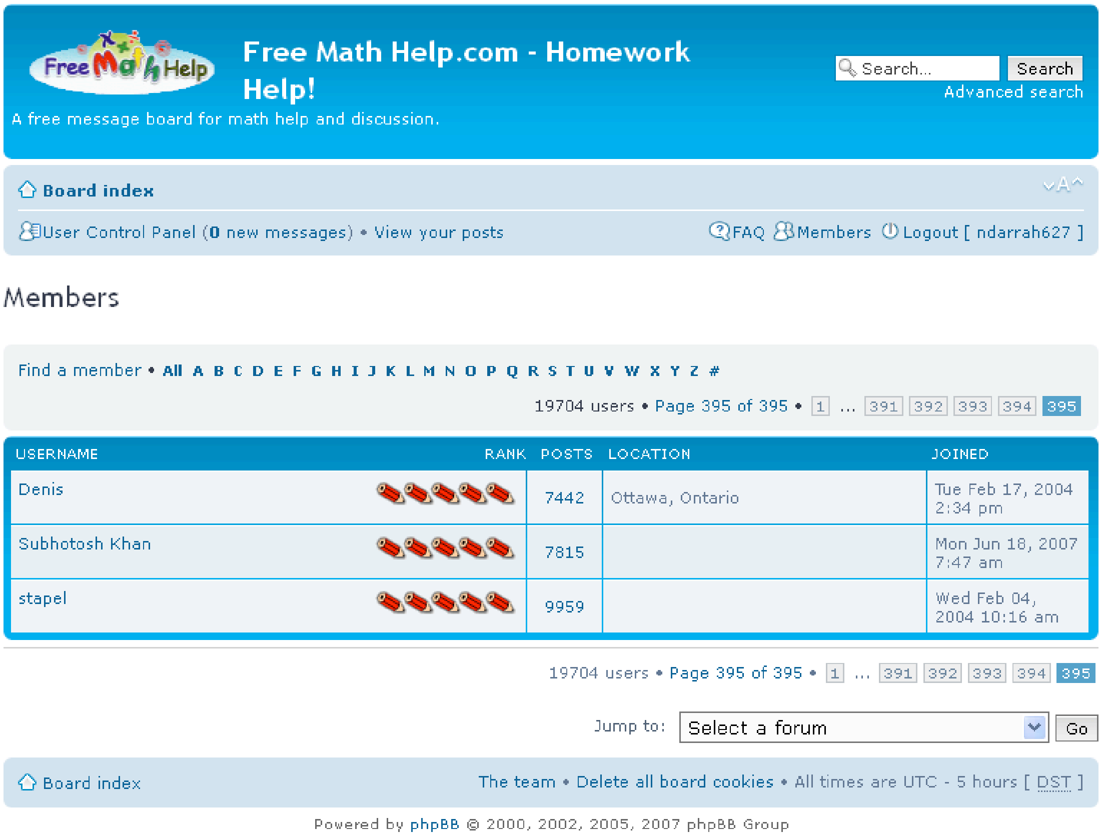
USERNAME	RANK	POSTS	LOCATION	JOINED
outcold		0		Wed Jul 29, 2009 4:22 am
tejasinamdar		0		Tue Jul 28, 2009 11:29 am
kellierenne010		0		Mon Jul 27, 2009 3:55 pm
Leftbrain		0		Mon Jul 27, 2009 9:51 pm
Keyl27		0	United States	Thu Feb 17, 2011 12:10 am
Xeqp16		0	United States	Thu Feb 17, 2011 10:51 am
Elizabeth		0	USA	Thu Feb 17, 2011 10:55 am
Yejh24		0	USA	Fri Feb 18, 2011 4:35 am
Ashutarigi		0	Germany	Mon May 25, 2009 10:58 am
dyeloicople		0	USA	Thu Feb 17, 2011 12:32 am
saraorba		0		Thu Feb 17, 2011 12:19 pm
Sleence		0	Belfast	Thu Feb 17, 2011 11:58 am

Figure 8: Free Math Help.com—Homework Help! Message Board Page 395 of Member Listing (May 8, 2011)



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19704 users • Page 395 of 395 • 1 ... 391 392 393 394 395

USERNAME	RANK	POSTS	LOCATION	JOINED
Denis		7442	Ottawa, Ontario	Tue Feb 17, 2004 2:34 pm
Subhotosh Khan		7815		Mon Jun 18, 2007 7:47 am
stapel		9959		Wed Feb 04, 2004 10:16 am

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Figure 9: Frequency and Score of Identifiable Scaffolding Elements

PAR Number		
Subject Level		
Number of Replies		
Median time between posts		
Scaffolding Element	*Frequency*	*Score* (1, 2, 3, NA)*
Simplifies the task to manageable components		
Sustains motivation		
Notes errors or imperfect solutions		
Demonstrates how to solve the problem		
Transfers responsibility to the student at appropriate time		

*Score based on Figure 10: Scaffolding Variables and Rubric for Assessing Primary Responders as Tutors during Post-and-Reply Sessions

Figure 10: Scaffolding Variables and Rubric for Assessing Primary Responders as Tutors during Post-and-Reply Sessions

Variable	*Score*	*Explanation*
Simplifies the task to manageable components	1	Does not simplify the original task or provides too much information at one time
	2	Partially explains and simplifies some components of the original task
	3	Explains and simplifies all components of the original task at appropriate times
Sustains the original poster's motivation	1	Discourages original poster through the use of negative comments
	2	Remains neutral and does not offer any comments to the original poster
	3	Responds with encouraging phrases such as, "Good job", "Good attempt", "Keep going! You're doing great!"
Notes imperfect solutions	1	Never points out errors
	2	Points out errors without explanation
	3	Points out errors and provides explanation
Demonstrates how to solve problems	1	Does not demonstrate how to solve problems by providing only an answer without an explanation
	2	Demonstrates how to solve most problem components but remains unclear about order or structure
	3	Demonstrates how to solve problems in a clear, linear structure
Transfers responsibility to the student at appropriate time	1	Does not transfer responsible at all; answers question immediately
	2	Transfers the responsibility too early or too late
	3	Transfers the responsibility at an appropriate time (when the student appears to be comfortable with the previous materials)

Figure 11: Total Time between Posts Histogram

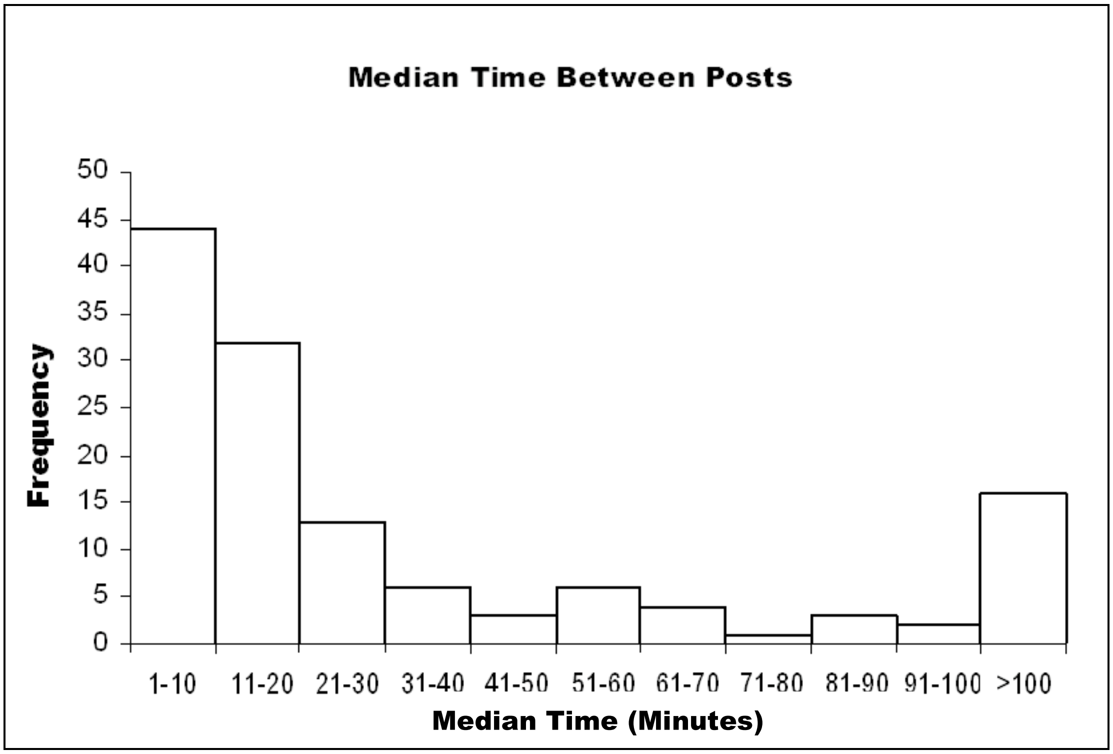


Figure 12: Total Frequencies of Scaffolding Elements Histogram

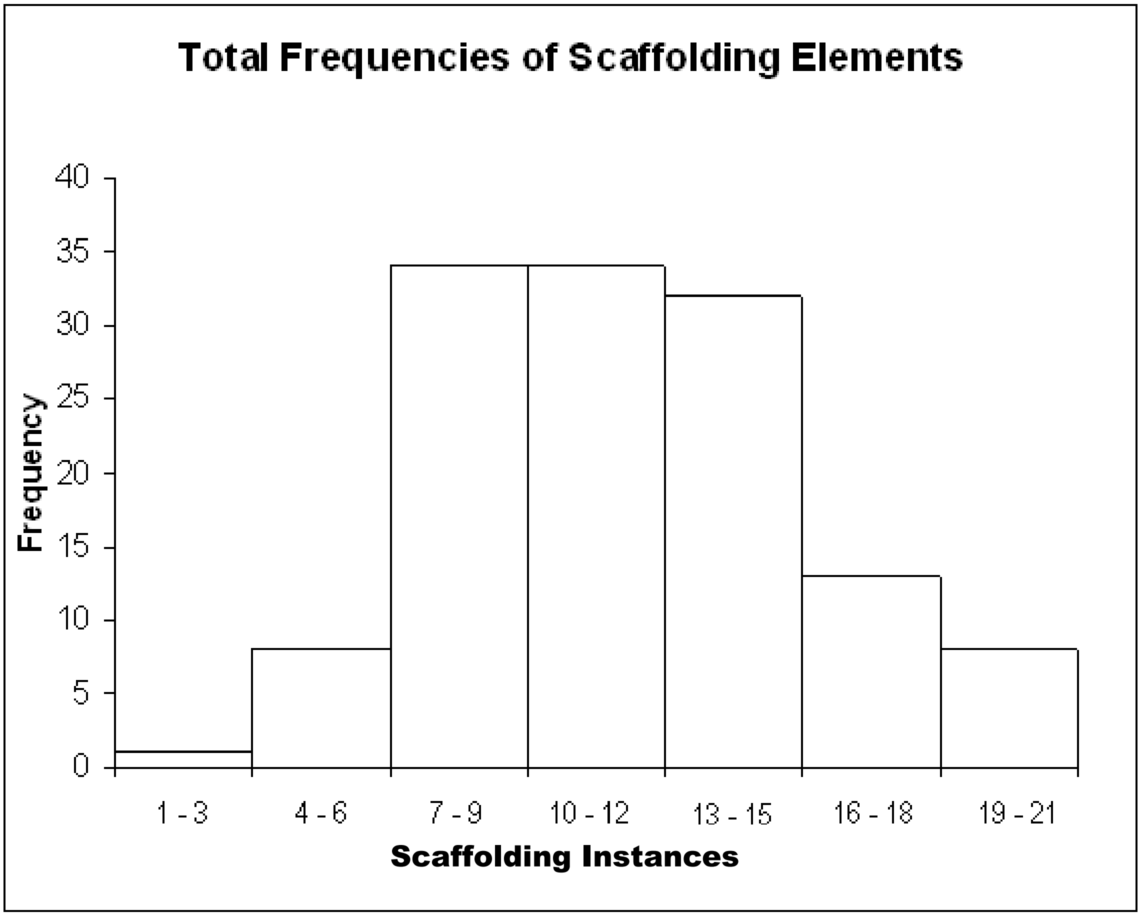


Figure 13: Total Qualitative Assessment of Scaffolding in PARS Histogram

Figure 14: Total Frequency of Scaffolding Elements vs. Median Time between Posts

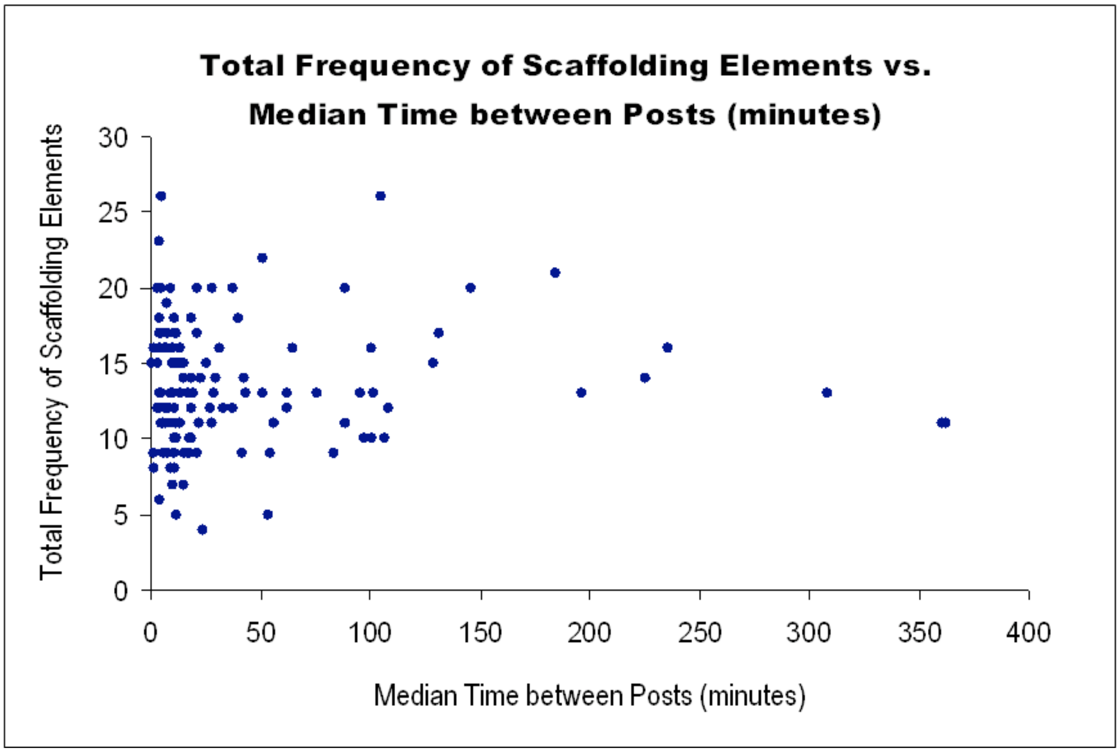
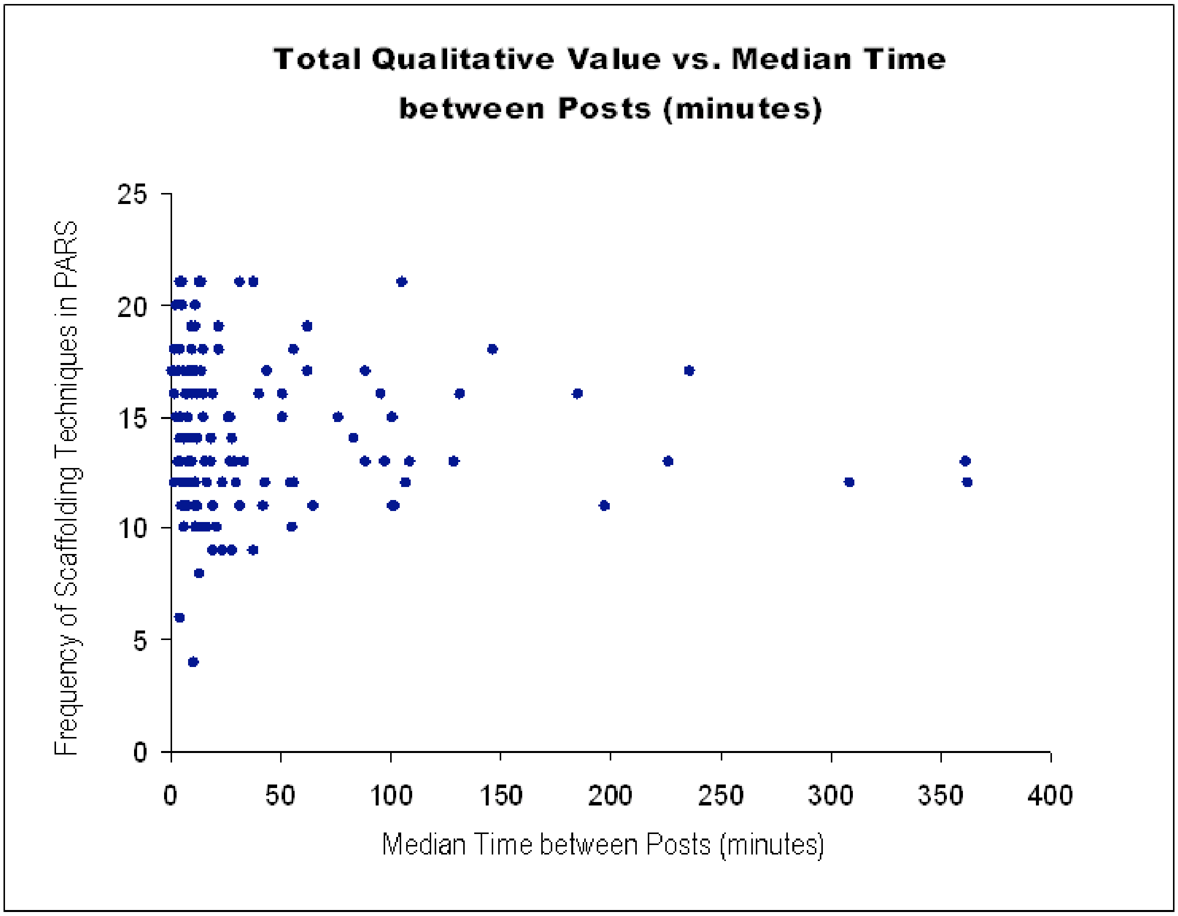


Figure 15: Qualitative Assessment Scores of Scaffolding Elements vs. Median Time between Posts



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