Teach Ourselves: A Peer-to-Peer Learning Community Linking In- and Out-of-class Activity

Carole R. Beal, Jane Strohm, Lauren Schwindy, and Paul R. Cohen

***Abstract*—**Teach Ourselves is an online collaborative learning environment designed to engage middle school students with math and science through the inclusion of peer-to-peer activities and game-like components. Students learn from and teach each other as they solve and create math and science word problems, and earn points and badges. An exploratory study with 132 students in six classrooms indicated that much of the activity occurred during out-of-school hours, suggesting that the social elements helped to attract students to continue the activity outside of the formal classroom setting. Qualitative feedback from students and teachers was strongly positive.

***Index Terms*—Collaborative Learning, Informal Education, Computer-Assisted Instruction, Serious Games**

I. INTRODUCTION

THIS paper presents a case study of Teach Ourselves (TO), a web application designed to encourage and engage middle school students with math and science. The middle school years have been identified as a critical point at which many students, particularly girls, lose interest in science, technology, engineering and mathematics (STEM) subjects [1], [2]. Innovative approaches are needed to ensure that students remain engaged with these subjects through high school and beyond.

Teach Ourselves is an online community in which students solve math and science word problems created by other students, and create and share their own problems with peers. Teach Ourselves includes features that were inspired by recent research on the engaging properties of computer games, including the chance to earn points and badges, to compare progress with other users, and to engage in social activities such as communicating with peers and providing feedback in the form of compliments ("+1") or criticisms (flagging) [3]. The number of points that can be earned by solving and creating is determined by a dynamic economy that varies with the number of problems available to solve in various domains. Students can track their points on their profile page, and can compare their performance to others by checking the leaderboards.

In addition to its game-like components, Teach Ourselves is also designed to support creative activity by students. This aspect of the system was inspired by research on the cognitive and motivational benefits of "problem posing." In problem posing, students generate new problems and questions from available information, or seek out information about a topic of interest and use the information to discover new relations [4], [5], [6]. Problem posing is thus distinct from the much more common practice of requiring students to solve problems that have been prepared by teachers or that are presented in textbooks. Problem posing is argued to provide students with the opportunity to reflect on what is known and not known, to restate a problem in a new equivalent form or to vary problems in new ways, and to engage in explanation: all processes that should lead to better problem solving and transfer to new problems [7].

In addition to the hypothesized cognitive benefits, problem posing has also been claimed to increase student motivation, whereas solving problems defined by others day after day often leads to student boredom [8], [9]. Teachers have reported anecdotally that the activity of problem posing leads to class engagement and higher interest, especially among students who are not generally enthusiastic about math and science subjects [10]. Problem posing has also been suggested to help students become more confident and feel a greater sense of "ownership" about the topic [9].

II. FEATURES OF TEACH OURSELVES

A. Problem solving

When the student logs in to TO, he or she can view a list of the problems that are already available to be solved (i.e., word problems created by prior student users), along with the current points value for each problem. If the student solves a problem within three attempts, he or she earns the points. Each incorrect attempt elicits a brief feedback hint, and the problem solver can also view a multimedia help file created by the problem author. If the student does not enter the correct answer, he or she can try the problem again (although the points value may have fluctuated).

B. Problem posing

Students can also earn points by creating their own

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problems. In fact, the values for creating new problems are significantly higher than for solving existing problems, because problem authoring is generally more challenging and time-consuming. To create a new problem, the student works with a template that includes areas for typing in problem text, adding a graphic, entering two pieces of feedback that would be shown if the future problem solver enters incorrect answers, and a help item [11]. An example is shown in Figure 1, below.

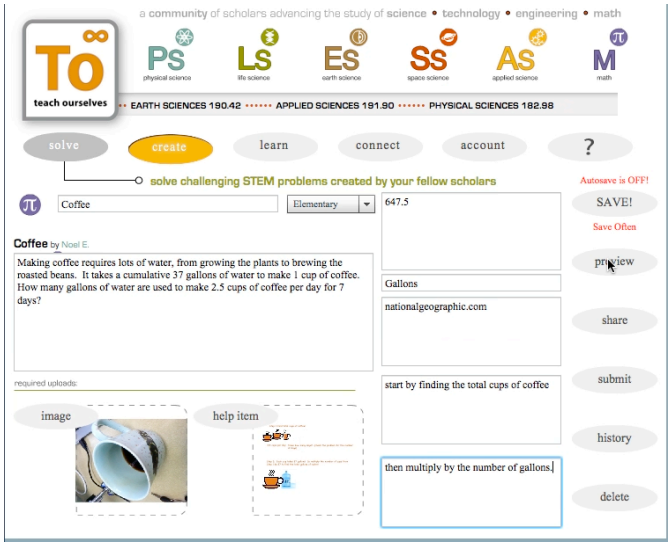

Fig. 1. Problem authoring template in Teach Ourselves

Help items can be pictures, slide shows (created with PointPoint), screencast or cell phone videos or other media. Help items are intended to provide an explanation or worked example that can guide the user to the solution but without providing the answer.

When students are ready, they submit their work to their teacher for review. Teachers use an integrated rubric to check that the problem includes accurate and appropriate content, that the answer is correct along with any associated units that need to be specified, and that the attributions for any source materials are listed. If the teacher approves the problem, the student can publish it so that it is available for other students to solve within the TO application, and earns the contracted number of points. Teachers can also return the problem to the author with comments and suggestions for revision. Sample student-authored problems available in the "try this!" area of www.teachourselves.org.

C. Social and game-like components

TO includes social networking features such as the ability to +1 ("like"), flag and comment on a problem, along with discussion boards. Also included are game-like features such as leaderboards that show users in terms of overall points, points by domain, class, school and other groupings. Individual progress summaries can be viewed by the student on his or her profile page, including points earned by solving and creating, +1s (compliments) provided by other students, badges earned and stars provided by teachers for high-quality work and helpful feedback given to peers. Students can check their progress and status (badges, compliments, flags) on their account page, as shown in Figure 1.

Figure 2. Student account page in Teach Ourselves

III. Exploratory Study

We conducted a pilot study to explore the feasibility of Teach Ourselves as a classroom activity, and to obtain initial feedback from students' and teachers to the application. The study was conducted in six middle school classrooms in Arizona, USA, and ran for about 90 days on average. As the study progressed, we realized that there was a fair amount of unexpected activity occurring at times that would not typically be considered part of the school day (i.e., before 7:30 a.m., and after 3 p.m.). Thus, the study research questions were extended to include an analysis of in-school versus out-of-school use by students.

A. Participants

The study included 132 students who were 12.3 years old on average; 73 (55%) were girls, and 59 (45%) were boys. Class sizes ranged from 15 to 28 students per teacher.

B. Procedure

Teachers participated in one two-hour training session conducted using web-conferencing software. Teachers received a modest stipend in compensation for the out-of-school time involved in learning to use TO and providing feedback to the research team.

The TO application was seeded with approximately 100 word problems that had been created by previous users.

After completing the training, teachers created accounts for their students, and then integrated the activity into the classroom. Participating teachers were free to integrate TO into their instruction in various ways. Some had students work on solving and creating problems as part of a required in-class activity that sometimes carried over into homework. One teacher used it exclusively as extra credit, while another

teacher used it intensively as part of her technology elective. In some cases teachers used additional incentives, such as extra credit points towards a grade, a class party upon meeting the goals, or converting TO points to class currency to purchase real rewards.

At the end of the activity, teachers and students were asked to complete an anonymous online survey about their reactions to TO.

C. Data Collection

Students' navigation actions within the TO application were automatically time-stamped and recorded, including logging in, choosing an activity (e.g., solving problems, creating problems, looking at leaderboards, making comments on the discussion boards, etc.) and logging out.

In addition, students' work within the application was available, including records of the points earned, and the number of problems solved and published.

Students' and teachers' responses to the online survey completed at the conclusion of the study were not linked to user identification numbers to preserve confidentiality.

D. Data processing and scoring

Data were assembled for each student, including the number of points earned from solving and publishing word problems, and the number of problems solved and published.

Quality of the problems created by the students was analyzed after the study was completed. A measure of problem quality was established based on a rubric for problem text (i.e., complexity, 0 to 4 possible points), help item quality (i.e., level of helpful information provided, 0 to 4 points), and solvability (i.e., was the problem readily solvable as a contained unit or did it require additional research or learning; 0 to 4 points). The maximum value 12 indicated the highest quality problem. Problems were rated by one of two trained researchers; disagreements based on a subset of 20 problems were rare and were resolved by discussion.

Navigation events logged for each student were extracted and the event timestamps were used to categorize the events by day (weekday or weekend; holiday weekdays were counted as weekend days) and time (by hour, from midnight to midnight). School activity was defined as events occurring between 7:30 a.m. and 3:00 p.m. Evening activity was defined as actions occurring between 8:00 p.m. and midnight. The total number of navigation events in these categories was calculated for each student.

IV. Results

A. Student problem solving and creating

On average, students solved 146 problems and created 5.2 new word problems. Consistent with previous work with older students, students earned more of their points from solving other students' problems (80% of total points earned) than creating their own (20% of total points earned) [12].

B. Problem quality

The new word problems that were created and published by students in the study were rated for quality by the research team following a rubric ranging from 0 (unintelligible text, poor or non-existent help item, no clear right answer) to 12 (ideal, clear problem with a single right answer, no errors and effective help item). On average, students' work was rated 7.5 out of 12 possible points, with a low 4 points to a high of 10 points.

Average problem quality varied somewhat across the six classrooms, from a low of 6.6 to a high of 8.5. Not surprisingly, students who earned more points overall also had problems that were independently rated as being of higher quality, suggesting that more extended involvement with TO was associated with better work.

C. Out-of-school access

We used navigation events such as logging in, clicking on menu items and entering responses to ascertain when students were accessing TO. Students had an average of 1,210 total navigation events recorded during the study, with a range from 50 to 7,318. Of these, 49% occurred during out-of-school hours, meaning at times other than Mondays-Fridays from 7:30 a.m. to 3:00 p.m. In fact, only 27 students (20% of the sample) *never* accessed TO during out-of-school hours.

Looking more closely at the out-of-school access information, most appeared to be in the evening hours (8:00 p.m. through 12 midnight); evening use accounted for about 15% of the total navigation events. Weekend activity accounted for about 9% of the navigation events, with 35% of the students logging in at least once on a weekend day. Interestingly, there was a significant correlation between the number of events during evening hours and events on weekend days, suggesting that those students who were more engaged with TO after school were also likely to check in over the weekends.

The average percentage of navigations that occurred out of school was compared across the six classrooms. The results of a one-way ANOVA indicated that there was significant variation across the classrooms, $F(5,126) = 34{,}195$, $p < .01$. One teacher reported that she used TO primarily as a homework activity, so the high percentage (90%) of events occurring out of school for her students was not unexpected. A second classroom included students who rarely (11.6%) accessed the system outside of school. This left four classrooms (85 students) where TO was implemented by teachers during the school day. In these classrooms, 45% of the navigation events still occurred outside of school hours.

D. Qualitative responses from participants

Because students' feedback was provided anonymously, it was not possible to link specific comments with individual student data recorded within the TO application. However, the feedback provided by students was generally very positive. Students reported that they liked the social connection to peers, and the ability to learn through creating and solving problems while earning points. Sample comments (errors in originals) include: "One thing I really like about Teach Ourselves is the idea of competition. The leader boards really

keep kids on their toes to try and get to the top. I think it makes people more focused on the problkems and more determined to solve them." "I like how it tells you which questions are worth more and how you can ern ponts on it." "I enjoyed extremely the leader board I think it is kinda fun." "I trying to git in first ranking." "I love Teach Ourselves. I like the thrill of getting points and getting on the leader board." "I like how it focuses on points and badges." "I like how it makes learning fun and I am doing it on my own time!"

Teachers identified many benefits to using TO with their students including self-evaluation, critical thinking, digital literacy, and reinforcing STEM knowledge. All (100%) said that they thought their students had enjoyed TO and that it had helped them learn domain-specific material; 89% said it helped students improve higher-order thinking. "TO provided them with opportunities to practice and master math and science skills being taught in their core subject classes." "Creating help items and writing their own problems allowed them to organize new ideas and evaluate their own learning process."

Teachers were asked to describe one thing they liked about the activity and one thing that they felt needed to be improved. Positive comments included the following: "It helped the students be more analytical about their work." "They had to decide the best way to express their question and the appropriate format for the answer." "It got the students really thinking about the information and how to ask a robust question about it instead of just telling someone the information." "I enjoyed seeing the creative problems that were created." "I'm amazed at how creative and well-written some of my students' questions are." "I really think this is helping my students with their higher-order thinking." "Their excitement about the program was evident - they LOVED having Teach Ourselves days." "I witnessed my students take pride on their work and become more confident and sure of themselves."

V. Conclusion

Both the qualitative feedback and the behavioral data collected as students worked with Teach Ourselves suggested that the application was successful at engaging students both in and out of school. Of course, one limitation is that the behavioral analyses were based on raw navigation event logs, meaning we do not know what students were actually doing within the application. We also do not know why they were accessing TO after school; it is possible that some were completing assignments that had been started during the school day. Even so, the finding that 80% of the students used TO out of school was striking given the focus on math and science topics, which are not always highly appealing to many middle school students. Adolescents spend a great deal of their out-of-school time engaged with entertainment media and social networking. The experience with Teach Ourselves suggests that incorporating some of the social and game-like elements into an academic application may have the potential to bridge formal and informal learning.

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