

Increasing Parental Engagement in Student Learning

Using an Intelligent Tutoring System

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Abstract

This study explores the ability of an Intelligent Tutoring System (ITS) to increase parental engagement in student learning. A parental notification feature was developed for the web-based ASSISTments ITS that allows parents to log into their own accounts and access detailed data about their students' performance. Parents from a local middle school were then invited to create accounts and answer a survey assessing how engaged they felt they were in their students' education. A 60 day exploratory study was run during which messages were sent home to parents regarding what their students were studying in class and how they were performing. After having them take a post-survey, it was found that parents felt significantly more engaged in their students' education. Additionally, the messages increased how frequently parents logged in to check reports on their students' performance data using the ASSISTments system. Qualitative feedback from both parents and teachers was very positive.

Increasing Parental Engagement in Student Learning Using an Intelligent Tutoring System

Our intuition and experience suggest that parents¹ play an important role in a student's education. We believe parental support can be critical to keeping a child on the right track and instilling in them the importance of performing well in school. Research on this subject, meta-analyzed in Cotton & Wikelund, 1989, showed that parental involvement leads to improvement in student achievement in a multitude of different areas. A more recent meta-analysis by Fan & Chen, 2001 found less of a consensus but still reported a strong correlation between some forms of involvement and student well-being. We also suspect that even if such involvement does not directly influence performance, it may nonetheless be desirable based on the potential for indirect benefits. For example, a key meta-analysis of studies on homework by Cooper, Robinson, & Patall, 2006 found that it had a net positive impact on student learning. Homework completion is one area we believe parental involvement has enormous potential to improve, as parents have the ability to make sure their students complete their homework in a timely fashion.

This ability is contingent, however, upon access to information related to their students' performance, such as what topics are being covered in class, whether or not they are completing their schoolwork, and how they are behaving in class. Unfortunately, students have been known to be less than forthcoming with this information. Often the only feedback parents receive is a report card once every semester, and the ability to successfully monitor and guide a student's progress on this information alone is questionable. E-mails and phone calls home from teachers

¹ We are sensitive to the fact that students have a variety of familial arrangements outside of the traditional two-parent household. We use the term "parents" for the purposes of clarity and brevity, with the understanding that it includes both single and multiple parents, step-parents, legal guardians, and any other family members or persons who might be responsible for a student's well-being.

can provide more frequent data but are time consuming for the teacher. Additionally, these reports generally lack the detailed data necessary to contextualize² the feedback.

Intelligent Tutoring Systems (ITS) offer a potential solution to this problem. The purpose of an ITS is to provide in software the services of a private tutor at least as well if not better than a human. Among many reasons, this is desirable because software is much more cost effective and scalable than hiring an army of human tutors for every student. ITS typically have students solve problems and then provide direct feedback on their performance, as well as assistance if required. Often cognitive models of each student are built using the learning data collected by the system in order to provide individualized instruction. Unlike teachers using pencil and paper assignments, ITS are able to electronically record significant amounts of detailed data related to student performance and make that data available in meaningful ways, all automatically. This has the potential to increase parental engagement in student learning by simply making this data accessible to parents, and with minimal effort. ITS can also provide teachers with the facilities to send contextualized messages home that reference this data, reducing the time required to communicate directly with parents. Sending such messages through an ITS rather than email or phone also would allow the teacher to control the nature of the communication, making the investment in such communication less daunting.

There are a variety of popular ITS in existence today, including Carnegie Learning's Cognitive Tutor (Carnegie Learning, 2010), the Andes physics tutor (University of Pittsburgh, 2010), and the IMMEX system (UCLA, 2010). While all of these software systems collect and analyze considerable amounts of data on student learning, none of them provide comprehensive

² When we use the term "context" in relation to parent-teacher correspondence, we are referring to learning data that provides evidence for the assertions made in the correspondence. For example, if a teacher informs a parent that their student is struggling with Pythagorean Theorem, "contextualizing" that message would refer to including copies of a student's work that demonstrates their difficulty in grasping this particular skill.

facilities for parents to access this data. Similarly, there is an abundance of software packages for schools meant to keep parents and teachers informed of student progress, such as Pearson's PowerSchool (Pearson School Systems, 2010). However, these programs are not ITS. While they do provide access to data, monitor trends, and alert parents and teachers when these trends indicate a problem, the data used has to be entered by the teacher manually. Furthermore, this data consists primarily of what one might find in grade books—averages on important assignments and tests. It would be next to impossible for a teacher to manually enter the fine-grained, problem-level³ data from all assignments and homework that ITS automatically provide.

Additionally, there is a class of electronic assessment tools that seek to mimic the traditional offline assessment model using software. Some of them, including the popular Study Island (Archipelago Learning, 2010), attempt to combine the fine-grained data collection inherent in electronic assessments with the parental notification facilities found in student management systems. However, these are not classified as Intelligent Tutoring Systems—they are not “intelligent,” meaning they do not attempt to reproduce the assistance of a human tutor by building cognitive models of student learning and responding with individualized instruction. They simply replicate the assessment, not the tutor. On the opposite side of that spectrum, there is at least one system (Lahart, Kelly & Tangney, 2007) that attempts to replicate the services of a tutor, but for the parent rather than the student. While certainly a promising approach, we are more interested in exploring whether or not we can increase parental engagement by taking advantage of the data collection facilities provided by *student* Intelligent Tutoring Systems.

³ “Fine-grained” and “problem level” merit further explanation. Data collected by teachers for their gradebook typically consist of just the percentage of problems answered correctly for a given assignment. ITS also record which particular problems in the assignment were answered (in)correctly, what the student answered, how many attempts they made, how much tutoring they requested, how much time they spent on the problem, and other such minor but important details that are near impossible for a teacher to record manually.

In order to do this, we developed a parental notification feature for the ASSISTments ITS and conducted a study to explore its effectiveness at increasing parental engagement. The ASSISTments system (www.assistments.org) is a free, web-based ITS developed at Worcester Polytechnic Institute and used by thousands of students in the greater Worcester area. It provides a virtual classroom environment where students sign up for accounts and enroll in classes created by their teachers, who also have their own accounts. Teachers can then assign problem sets and monitor their students' progress using the system's extensive reporting functionality. These reports display the considerable amount of fine-grained data collected by the system in ways that inform teachers and students how they need to adjust their teaching and learning, respectively. While using the system, students are being assessed while they are learning, saving valuable classroom time as described in Feng & Heffernan, 2007. The ASSISTments project uses this assessment data to perform research on student learning, such as detecting when and why students game the system as described in Baker, Walonoski, Heffernan, Roll, Corbett & Koedinger, 2008.

Preliminary Work

During the summer prior to the 2009-2010 school year, the authors implemented a parental notification component for the ASSISTments ITS. This component adds a parent role to the system, allowing parents to sign up for accounts on the website. In order to do this, however, a teacher has to enable the feature for a particular class. Students are then prompted to enter their parents' email addresses into the system, and these addresses show up in the teacher's digital roster. From there, the teacher can invite parents to sign up for accounts, which causes the system to send out an email to the address specified by the student containing a link to a special sign-up page.

The parents' accounts are automatically linked to their students' accounts, allowing parents to log in at any time and from any web-ready device and check-in on their students' performance. The system exposes several important pieces of functionality that provide parents with data about their students' progress. When parents first log in, they are presented with the Summary view, which displays upcoming, completed, and past-due assignments within a customizable window of time. This page also shows any new messages sent by the students' teachers and a list of daily reports. These reports contain a detailed breakdown of every problem that students worked on in a given day, including what answers students gave and what the correct answer actually was if students answered the problem incorrectly. These reports give parents a temporal sense of their students' activity and enable them to enforce good time management, an area we feel parental involvement has the potential to be particularly beneficial.

at Oak Middle School

Assignments Due/Completed (within days - see all [here](#)):

223 - Median	Due: 16 Mar, 2010, 09:10 AM
225 - Range	Due: 18 Mar, 2010, 09:11 AM
41 - GGG Exit Card - Investigation #1 (completed)	100%
42 - GGG - Exit Card - Investigation #1 (completed - 4 DAYS LATE)	50%
44 - GGG Investigation 2.2 Book Mastery Homework (in progress)	Due: 08 Mar, 2010, 08:06 AM
45 - GGG Investigation 2.3 Book Mastery Homework Honors (completed - 4 DAYS LATE)	85%
18 - Solving Percent problems (mastered)	Mastered in 1 days

Messages (0 new - see all [here](#)):

No recent messages.

Daily Student Reports (see all [here](#)):

Icon Key: Viewed. Not viewed.

- [Report for 14 Mar, 2010](#)
- [Report for 10 Mar, 2010](#)
- [Report for 08 Mar, 2010](#)

Figure 1. Summary page presented to parents upon login.

Clicking on any of the assignments listed in the Summary view brings parents to the Item Report for that assignment. The Item Report is the ASSISTments system's most commonly used report, and is accessible by both teachers and students. It provides clear and detailed information about student performance on a particular assignment. The report consists of a table with a row for each problem in the assignment, with the first column containing a link allowing parents to preview the problem themselves and review it with their students. The second column displays students' responses to the problems and whether or not they were correct. The last column shows how many hints students requested for those problems. The bottom of the table displays students' grades on the assignment and the class average. Parents can also click on a link to see a second by second breakdown of their students' activity on the assignment, allowing them to detect if their students are getting distracted and wasting time. This report updates in real time, permitting parents to monitor students as they do their homework, regardless of their location.

The parental notification component also exposes new functionality to teachers in the form of a messaging system. This feature allows teachers to easily send messages to the parents of their students through the ASSISTments system, as well as see who viewed them. These messages can be sent to the whole class or to individual students or groups of students. Parents are notified by email when they receive a message. The notification email does not contain the message itself; instead, it contains a link to the parent's inbox on ASSISTments that automatically logs them in. This was a conscious decision designed to encourage parents to utilize the rest of the ASSISTments system by forcing them to log in whenever they wanted to read a message from their students' teachers. Teachers can send messages from a typical email-like interface or they could use the Item Report, allowing them to send contextualized messages tied to relevant data. The teacher's Item Report differs slightly from the parent and student

version in that it contains a row for each student in the class, with columns representing the individual problems in the assignment. An additional column is present when the teacher has parental notification enabled, containing a form to send either a generic or custom message to a particular student or the whole class regarding the assignment. This message contains a link to the Item Report of the relevant assignment that automatically logs them in.

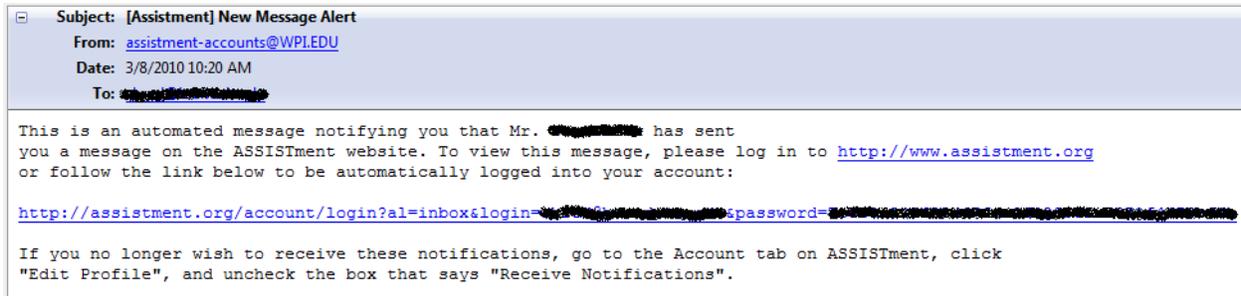


Figure 2. Notification email sent to parents upon receipt of a message.

XXXXX *	Select a comment	90%	✓ 6.5	(Ungraded Essay) noi because to find the volume you do $L*W*H*1/2$ but the hypotenuse is not either of them so it is not needed.	✓ 30
XXXXX *	Select a comment XXXXX seemed to struggle applying the	63%	✓ 6.5	(Ungraded Essay) You do need to know the length of a for surface area, but not area.	✗ 60
				(Ungraded Essay) no you do not need to find the	

Figure 3. Teacher version of the Item Report with comments enabled.

One point to note about the messaging feature is that parents cannot respond to teachers through ASSISTments. This restriction was specifically requested by our partner teachers, and while it may seem counter-intuitive, it serves an important purpose. Teachers are often hesitant

to send messages home to parents because it invites further correspondence from the parent, adding even more of a burden to an already time-consuming process. This correspondence is often trivial and argumentative, making the decision to send a message home a daunting one and often discouraging teachers from communicating with parents. Thus, we want communication to be asymmetrical, with considerably more correspondence flowing from teacher to parent than the other way around. Email and phone cannot provide this asymmetry, but a custom messaging system built into an ITS can. The key is to make it much easier for teachers to send messages than for parents. The parental notification component of ASSISTments provides teachers with a means to send messages home much more efficiently, but does not provide those same facilities to parents. If parents need to communicate with their students' teachers, they can still use email or phone—however, this requires more effort than just clicking a “Reply” button and thus maintains the asymmetry.

It should be noted that the development of the parental notification feature for the ASSISTments ITS was not a difficult task. Most of the important functionality, such as the Item Report, was already implemented and available to students and teachers. Adding this feature simply entailed making such functionality available to parents as well. The minimal effort required to implement this feature suggests that adding such functionality to other ITS's could be an equally favorable cost/benefit proposition.

Method

The parental notification feature was completed in the summer and pilot tested during the fall semester. Two of the authors of this paper are 8th grade math teachers at a local suburban middle school and use the ASSISTments system extensively in their classroom. During this study, each taught 4 periods of roughly 20 students, 2 honors and 2 non-honors. At the start of

the pilot, students signed up for accounts on ASSISTments and were instructed to provide their parents' email addresses. Invitations were then sent out to parents to create accounts. Of the 176 students, 127 (72%) of their parents signed up for accounts. We then monitored the server logs in order to measure how frequently parents logged in to check on their students. Unfortunately, participation rates were far lower than expected. Parents rarely logged in to check on their students' performance after they first signed-up. We were quite puzzled as to why parents were not taking advantage of this feature.

We hypothesized that perhaps because parents tend to be busy, they needed some sort of reminder to prompt them to log in and check on their students. We feared that sending out generic reminder emails, however, would not be received well. The messaging feature of the parental notification component offered a promising alternative to spamming parents. A message home from a student's teacher provided an excuse to remind parents to log in, especially since we believed they were unlikely to ignore such a message. Thus, we conducted an exploratory study in the spring semester to answer the following questions. First, does sending home messages via ASSISTments increase parental utilization of the system? Secondly, does use of the parental notification feature result in increased parental engagement⁴ in student learning? Lastly, if an increase in engagement is observed, does it actually increase student performance? We compared our results from the spring study to those from the pilot test in the fall in order to answer these questions.

One honors and one non-honors class from each teacher was selected to receive messages during the spring, totaling 86 students. A letter was sent out early in January to the parents of these students informing them of the study and prompting them to sign up for a parent account

⁴ The notion of parental "engagement" or "involvement" is addressed briefly in the introduction, and is defined and measured primarily by the survey given to parents during the study. Please see the survey description for more information.

on ASSISTments if they had not already done so in the fall. The letter simply mentioned that they would be receiving messages via the ASSISTments system—we tried not to confound the study by telling them its intent. These parents were also prompted to complete a pre-survey meant to gauge how involved they felt they were in their students' education. The survey contained questions asking how much parents felt they knew about what their students were studying, how well the school was keeping them informed of their students' performance, and how often they checked their students' homework and gave consequences if it was not satisfactory. The students were given a similar survey intended to measure how much they perceived their parents to be involved in their education.

We anticipated that parents might overstate their engagement in their students' learning due to the embarrassment of being perceived as a 'bad parent,' and also that we risked giving away the intent of the study based on the nature of the questions asked. We attempted to avoid this by carefully wording the survey. A preamble was inserted that described junior high school as a transitional period for students and parents, moving from the constant supervision of elementary school to teaching students independence and responsibility in high school. The intent of the survey was described as finding out where in this transition parents were at this stage in their students' education. We hoped this would allow parents to indicate a lack of involvement without feeling guilty, as they were simply trying to teach their students responsibility for their own education. The survey questions and answers were phrased using this same framework.

Out of the original 86 students, 63 (73%) of their parents signed up or already had accounts on ASSISTments. For 60 days during the spring semester, teachers sent messages home to parents through the parental notification feature of ASSISTments. In total, 46 messages were

sent over that time period. Of these messages, 29 of them were sent to the parents of an individual student or a small group of students and contained feedback specific to those students. Not every student received such individualized feedback, as this would have placed an unacceptable burden on the teachers. Students were selected to receive feedback based on need, and often these students' parents were sent more than one message in order to track progress, which was deemed more important than attempting to involve each student at least once. The remaining 17 messages were sent to every parent in a given class and contained general information related to what was going on in the classroom, such as class activities and upcoming exams. After the 60 day messaging period, parents and students were asked to complete a nearly identical post-survey in order to measure changes in their feelings of parental engagement.

Results

Of the 63 parents who signed up for accounts, 47 (75%) of them logged in to check their messages regularly during the study period. While 62 parents completed the pre-survey, participation in the post-survey was disappointingly low, with only 27 parents responding. Of these, 8 had either not completed the pre-survey or did not log into ASSISTments during that period, even to check their messages, necessitating the discarding of their responses. This left a very small 19 person sample size (out of an original 186) with which to perform analysis.

As suspected, our results seemed to indicate that parents interacted with ASSISTments more frequently during the spring than in the fall. The more important metric, however, was whether or not parents were visiting the other parts of the site in addition to their message inbox. This would have provided strong evidence that they were being reminded to check up on their students' performance in ASSISTments whenever they received a message, as hypothesized.

We devised the following metric to measure whether or not parents were using ASSISTments' reporting functionality more frequently during the period they were receiving messages. Analyzing the server logs, we determined how many unique days each of the 19 active parents made page requests to the non-messaging related portions of the ASSISTments site. This was then normalized by dividing by the number of days between when the parent created their account until the letter was sent home about the study. One way to look at this measure is the probability that a parent would log into ASSISTments and use the reporting functionality on a given day during the fall pilot. Two parents had not created accounts until the start of the study in the spring; their results were discarded, leaving 17. The same measure was then taken for the spring period, during which parents were receiving messages. The probability that they would check in on their students' performance on a given day increased significantly, from 1.5% to 4.6% with $p < 0.03$ and an effect size of 2.05. We believe this strongly indicates that parents checked on their students more frequently during the period when they received messages.

The survey results, which were intended to measure any changes in parental engagement as a result of the messages and increased participation they potentially fostered, were less pronounced but still promising. The majority of questions on the survey were scored on a scale of 1 to 5, usually representing "Strongly disagree" to "Strongly agree", or some form of frequency ("Once a month", "Once a week", etc). Paired T-tests were performed in order to determine if changes in the responses to any of these questions between the two surveys were significant. A significant change was detected in only one of the questions, with $p \sim 0.05$ and an effect size of 0.35. While the other questions did not have significant p-values, they did indicate some informal trends in parental engagement. A question related to how well parents felt they

were informed about their students' performance increased, while the frequency with which parents checked on their students' homework and handed out consequences decreased.

Table 1

Parent responses to pre-survey questions on engagement

Survey Question	Survey Answer Averages			% of parents whose score:		
	Pre	Post	Post - Pre	Increased	Decreased	Neither
I feel I have a good understanding of what is going on in my student's math class.	3.58 (0.90)	3.9 (0.88)	0.32 ^a	42%	21%	37%
I feel I have a good understanding of HOW my student is doing in math class.	4.06 (0.80)	4.22 (0.65)	0.17	33%	22%	45%
My child thinks I know how well he or she is performing in math class.	4.33 (0.69)	4.33 (0.59)	0.00	17%	17%	66%
I feel my school is *not* giving me enough information to adequately monitor my student's progress.	1.61 (0.78)	1.78 (0.88)	0.17	28%	28%	44%
In the past week, how frequently did you check up on your student's homework?	2.58 (1.22)	2.16 (0.9)	-0.42	16%	32%	52%
How often do you give consequences (rewards/punishments) for grades and homework completion?	2.42 (1.26)	2.16 (1.21)	-0.26	26%	47%	27%
How often have you interacted with ASSISTments in the last 30 days?	2.16 (1.26)	2.63 (0.9)	0.47	58%	26%	16%
How often did you initiate contact with your student's	0.11 (0.32)	0.05 (0.23)	-0.05	5%	11%	84%

teacher in the last 30 days?

Standard deviations are noted in parentheses.

^a $p \leq 0.05$ (approx.), effect size = 0.35

Another survey question asked how frequently parents interacted with ASSISTments during the study period. We were surprised that this value did not significantly increase, given that participation in the fall was so poor and these particular parents had logged in to view messages frequently in the spring. This seemed to contradict the findings from our analysis of the server logs, which we believed to be more reliable. The Discussion section offers some insight as to why this may have happened.

The student version of the survey did not provide any significant results. Students were asked three questions relating to how informed they thought their parents were about their education. These questions closely matched questions on the parent version of the survey, except they were from the students' perspective. Informal trends again indicated an increase in perceived engagement, but not at statistically reliable levels. What one might consider to be the most tangible form of engagement—parents sitting down and working with their students on ASSISTments—even *decreased* slightly. It should be pointed out that if the averages are compared from the parent and student surveys, it appears parents believed they were more informed about what their students were doing in math class than students did, but students believed parents knew more about *how* they were doing in class than their parents believed they did.

Table 2

Student responses to pre-survey questions on engagement

Survey Question	Survey Answer Averages			% of students whose score:		
	Pre	Post	Post - Pre	Increased	Decreased	Neither
I think my parents know what I'm doing in math class.	3.22 (1.06)	3.31 (1.03)	0.08	34%	29%	37%
I think my parents know HOW I'm doing in math class.	4.25 (0.84)	4.34 (0.78)	0.09	28%	21%	51%
My parents say down and helped me with my ASSISTment work this year.	36%	34%	-2%	7%	9%	84%

Standard deviations are noted in parentheses.

While the purpose of the study was to measure increases in parental engagement, analysis was also performed to determine whether or not any observed increase in engagement led to better student performance. Unfortunately, reliable results were not detected, even when we focused on only those students whose parents participated in the study or who had received individualized messages; findings are presented here for completeness. Two different measures of student “performance” were analyzed: homework completion rates and semester grade point averages for the fall and spring. The average gains were computed in each metric between the fall and spring semesters for both the students whose parents received messages and those that did not. Half of the students were used for each measure—that is, one of the teachers used the “due date” functionality of ASSISTments, making homework completion analysis feasible, while the other provided semester grades for her students.

Homework completion was measured in three ways: percentage of assignments completed by each student by the due date, percentage of assignments completed by the end of the semester, and average number of days late per assignment. Each of these measures had a

different sensitivity to certain aspects of the intervention; for example, one of the teachers would occasionally send out messages informing parents that their students had outstanding assignments. These assignments were not completed by the due date, but the message may have prompted students to finish them by the end of the semester under pressure from their parents. On the other hand, if a parent was frequently logging into the Summary view during the intervention, they would have been able to see when their student's assignments were due and could put pressure on their student to complete them on time.

Table 3

Changes in Homework Completion Rates Based on Message Reception

Homework Completion Rate	Gain	
	Received Messages	Didn't Receive Messages
Homework completed on time.	-1.06% (14%)	2.13% (20%)
Homework completed by end of semester.	5.09% (22%)	3.77% (13%)
Average days late	-5.84 (9.49)	-4.44 (5.96)

Standard deviation in parentheses.

As the table indicates, none of the measures showed a reliable increase in homework completion rates (or decrease in average days late) versus the group that did not receive any messages; in fact, the group whose parents were sent messages actually decreased its on-time completion rate (though not significantly). That group beat the non-message group on the other metrics, but again not reliably. When focused in on only the non-honors students, however, the

results looked more promising. This made sense because the lower knowledge students offered the most room for growth in these areas. As can be seen from the table below, once analysis was limited to only these students, the differences between the two groups became clearer, though still not enough to be statistically reliable.

Table 4

Changes in Homework Completion Rates Based on Message Reception (Non-honors Students)

Homework Completion Rate	Gain	
	Received Messages	Didn't Receive Messages
Homework completed on time.	4.38% (16%)	-0.55% (24%)
Homework completed by end of semester.	9.33% (30%)	5.93% (13%)
Average days late	-10.63 (11.27)	-6.78 (6.62)

Standard deviation in parentheses.

When our analysis was focused even further on only those students whose parents actively read their messages, slightly different results were found. The table below shows that when the homework completion rate averages of only those students whose parents received individualized messages were taken into account, there was little difference compared to the non-honors averages. However, when we looked at the correlation between the gains in homework completion rates and the gains in the frequency with which parents logged into non-inbox parts of ASSISTments as outlined previously, there was at least one strong, reliable value. It should be

kept in mind though that this included only those students whose parents logged in consistently to check messages.

Table 5

Correlation of gains in homework completion rates with frequency of requests by parents for non-inbox pages of ASSISTments

Homework Completion Rate	Gain	
	Average	Correlation
Homework completed on time.	-6.03%	0.78**
Homework completed by end of semester.	10.74%	0.54
Average days late	-9.13	-0.33

** $p \leq 0.01$

Detection of any changes in students' grade point averages seemed even more unlikely, as such a measure can be thought of as another leap down the causal chain from homework completion, which is already a leap down the chain from parental engagement. We predicted that at each leap, reliably detectable results would be diminished without the support of a strong experiment designed to measure those metrics directly. As expected, the difference in grade point averages between the fall and spring semesters for both the groups were not reliably different than 0, even when zoomed in on non-honors and message-receiving students only. The correlation between differences in GPA and increases in parental login frequency was very nearly 0 as well. In effect, the messages appeared to have absolutely no detectable effect on student grades at all.

Discussion

Unfortunately, most of the survey responses did not change significantly. We will discuss in the Future Work section why we believe this could have been the result of a small sample size and a possible ceiling effect. The one question that did reliably change, however, was a very general and important one: “I feel I have a good understanding of what is going on in my student's math class (i.e. topics being covered, upcoming exams, etc).” A possible explanation for this is that all parents received the messages containing information about what was happening in class, while only a small subset of students received individualized feedback. This question maps directly to these more “global” messages, while the others are tied more to individual students. The number of parents who received individualized feedback about their students *and* checked their messages, filled out the pre-survey, and filled out the post-survey was extremely small—in order to get meaningful results on these other questions, teachers would likely have needed to send every parent several individualized messages, which was not feasible for this study.

Particularly interesting among the survey results was the fact that the frequency with which parents checked on their students’ homework and gave them consequences for poor performance decreased, though not quite significantly. This was perhaps the result of parents assuming that if they were not receiving messages about their student, then everything must have been in order. As one parent put it, “no news is good news.” This is an important point to consider and warrants further study, as there is the possibility that such a feature could actually *decrease* parental engagement due to a false sense of security given to parents by the system. Such a phenomenon would shift more responsibility from the parent to the teacher, which we

believe is not desirable. Ideally, the clerical burdens would be offloaded on the system, with some additional responsibilities shifted to the parent.

The results from analyzing the server logs appeared more conclusive than those from the survey. The data indicated that after parents started receiving messages from their students' teachers, they visited the reporting sections of the site more frequently. Combined with the results from the survey, this would seem to suggest our hypothesis was correct: messages home from a teacher reminded parents to log into ASSISTments and check on their students' progress, and these messages and increased log-ins may have caused parents to feel more engaged in their students' learning.

The lack of results from the student survey was disappointing, but not unexpected. Like the grades and homework completion rates, student perception of parent engagement is a leap down the causal chain from actual parental engagement, and thus harder to detect. As in many of the results, however, the informal trends hinted at a positive result, suggesting that perhaps a stronger future study could uncover them. The discrepancy between parental feelings of engagement and student perception was also interesting. Parents believed that they knew more about what their students were doing in class than their children believed they did, while students thought their parents knew more about *how* they were doing in class than parents believed they themselves did. The latter could simply have been students over-estimating how much their parents are checking up on them using ASSISTments. While students were well aware of the reporting capabilities of ASSISTments, we did not explicitly inform them of the messages their parents would be receiving, which could explain why parents believed they knew more about what was going on in class than their students thought they did.

The analysis of homework completion rates again only provided informal trends, but they as well showed promise for a future study, especially among the low knowledge students. It was surprising to find that those students whose parents received individualized messages (usually about homework) did not differ from the group at large, though by the time it was narrowed down to those particular students the sample size was less than 5. The one reliable result, however, was very promising. The data showed that there was a correlation (0.78, $p < 0.02$) between increases in on-time homework completion rates and increases in parent logins to ASSISTments (excluding the inbox). This supports the hypothesis that parents who logged in more frequently to the Summary page, which displayed when students have assignments due/late, put more pressure on their students to complete their homework on time.

The qualitative feedback from the study was also positive. The teachers found the parent notification feature useful and the experience of sending messages home via ASSISTments promising. The interface allowed them to send messages home efficiently and gave them the ability to contextualize those messages with real data. Most importantly, they did not have to worry about parents flooding them with responses—communication was still open at both ends, but one end had much higher bandwidth, making the prospect of sending a message home less daunting and encouraging them to do so more often. They continued to use this feature in their classrooms well after the study was completed.

Feedback from parents was also positive. The last question on the post-survey instructed parents to write down any thoughts they had about the system or the study. Most indicated they were happy to receive messages from the teacher informing them of their students' progress. Many remarked that the messages did in fact remind them to log in and check up on their students' performance. There was no negative feedback; at worst, some parents explained that

they did not gain any benefit from the messages or ASSISTments, stating that their students were very responsible and as long as they received good grades, their parents would let them be independent. In general, parents liked being more connected to their students' education and felt the parent notification feature was a positive step in that direction.

The program gives me the ability to observe the quality and quantity of nightly homework. I never have to worry about missing homework. Assistment is always available for past and future work.

I really liked the notes sent by the teacher telling us what they did in class and what you might want to talk about with your child. It gives one more thing to try to connect with them at the dinner table. Thanks.

It is a nice feature and helps us to know better the types of activities being done in class so we can discuss them with our children. I think this program is a positive step toward connecting families with the curriculum.

It is a very good program. In the least, the notifications help you remember your child's school work and I can be an active participant. Usually I wouldn't get involved unless there was a problem, and then it would be too late. This helps me track progress and interact as necessary. I only read the messages. I will look at other areas of the site.

Figure 4. Sample parent comments about parental notification from post-survey

One anecdote from the study is worth mentioning as it demonstrates the potential of the system in a way that cannot be captured in quantitative data. Throughout the spring one of the teachers sent 5 messages to one struggling student's parent in particular. While this was originally prompted out of genuine concern for the student's weak performance, it soon became obvious that this correspondence would make a great case study of the system's ability to connect with parents and effect positive change. The first two messages received by this student's parent were actually sent to the parents of several different students, warning them that their children were falling behind on homework completion. The next two were sent specifically to the one parent, informing her that her student had caught up with his work and had really

improved in class. The final message was another warning that the student had become overconfident and was beginning to slip again. While it cannot be known for sure, as this parent did not respond to requests for interview, it is plausible that this student's turn-around was brought about by pressure put on the student by his parent as the result of these messages.

11 Jan, 2010 - Subject: Over due Assignments

Good morning, I am writing to inform you that your child has some outstanding assignments. Please encourage them to come in for extra help if they are having difficulty mastering the work. Thank you, Courtney Mulcahy

To: Multiple recipients

25 Jan, 2010 - Subject: Outstanding Assignments

Your child has several assignments that are outstanding at this point. Please encourage them to be responsible and take initiative to complete assignments that are overdue. Additionally, encourage them to come and see me for extra help if they need clarification so that they can get caught up. Thank you, Courtney Mulcahy

To: Multiple recipients

06 Feb, 2010 - Subject: *****

***** has really had a positive turn around with his work effort and production this week. He is current with his Mastery Learning assignments and is demonstrating much more responsibility. Please continue to encourage him. I am happy with his week at school.

To: *****

22 Feb, 2010 - Subject: *****'s Math Work

Good morning, I just wanted to let you know that I am sitting with ***** right now for extra help during math buddies and he is doing very well. He has a great understanding of the material for Pythagorean Theorem and has an excellent attitude about getting his work done. I have noticed a significant change in his attitude, behavior and effort. Please encourage him to keep up the great work! Thank you, Courtney

To: *****

10 Mar, 2010 - Subject: *****'s Math

Hi *****, I just wanted to let you know that ***** is slowly slipping behind in his work on Assistent. He was all caught up and very proud of himself but is beginning to build a list of overdue assignments. Please encourage him to stay up to date. I don't want him to get too proud and then take it easy. He claims that he didn't know that they were assigned, but I am trying to teach the students accountability and have them respond to the due dates in addition to assigning them for HW. He is not too far behind yet, so it should be relatively easy to catch up. I want him to continue with his good efforts. Thank you, Courtney

To: *****

Figure 5. Series of sample messages from teacher to particular student's parent.

Conclusion and Future Work

As we stated in our introduction, the purpose of this study was largely exploratory. According to our prior research, no one had yet provided parental access to the fine-grained learning data collected by a true ITS. We suspected that providing this data would allow parents to become more engaged in their students' education, which the literature suggested was beneficial to student learning. At the very least, we hoped that providing such information would enable parents to make sure students were completing their homework, which has been shown in prior work to be beneficial as well, and thus be helpful in an indirect manner. However, doing so required the development and deployment of a completely new, untested software component. We were unsure how parents would respond to such a drastic increase in the amount and detail of information on their students' performance. We did not know how or even if they would utilize this data. These questions needed to be addressed before we could reasonably begin forming strong hypotheses and conducting experiments on this topic, which necessitated the work we did here.

The exploratory nature of the study meant that few of our results were statistically reliable, but we believe we were successful in answering many of the questions we set out to and providing clear directions for future research in this area. We hope that both ourselves and others can now conduct more definitive experiments by using what we learned in our study as a guideline. For example, we learned that providing access to data does not mean that it will be utilized. When we first piloted our new feature, participation was very low, despite what we perceived as almost universal support and excitement on the part of parents. Whether they were just too busy and forgot or were overwhelmed by the amount of new information available to them, parents were just not logging on. We found though that simply reminding parents, in the

form of messages from teachers that prompted them to log into the site, was enough to get them to check in on their students. These messages also provided some context to the data, perhaps helping them put it into a more meaningful perspective. We believe any future researchers would benefit from having a similar mechanism, or they may find themselves without sufficient data points. One possibility is to implement a system of automated messages sent by the ASSISTments system to parents. This would take the burden off of the teachers and allow for more frequent reminders—in the form of emails containing relevant data—to every student's parents rather than just a subset. This should generate considerably more data points, potentially allowing the detection of reliable experimental results.

Once we had parents logging in more often, our survey results showed some informal trends indicating that parents did feel more engaged in their students' education when given access to ITS data. We believe that parents have the ability and the desire to take advantage of this information, and that further, more definitive research on this topic is warranted. We recommend using surveys to measure parental engagement in future studies, and with a stronger experimental design and more data points it may be possible to detect reliable results. Our current study has convinced us that this is feasible and worth pursuing.

Finally, we have been assuming based on the literature that parental engagement is in and of itself a beneficial concept, in that it increases student performance or at least indirectly influences it through the development of better learning habits, such as increased homework completion rates. We have shown in this study that ITS make the measurement of metrics such as homework completion rates and performance (grades) fairly straightforward. Once parental engagement has been established, it is possible to verify whether this engagement was beneficial in the very same experiment. While we were unable to—and did not expect to—detect any

reliable results from these metrics, we believe more data points and a stronger design could allow for detection.

We also encountered a fair share of pitfalls that future researchers should seek to avoid. While we already discussed the infrequency with which parents logged into the system after signing up, it was also surprisingly difficult to get parents to even sign up in the first place or complete the online survey. This was particularly unexpected due to the fact that the school was located in an affluent community with almost ubiquitous access to computers and the internet. Yet, participation in the study, especially the post-survey, was extremely disappointing despite persistent efforts. Why this is the case and how to remedy it is unknown. It did, however, result in a very small sample size, which made obtaining statistically significant results difficult. Out of an original 86 parents, only 17 completed all parts of the study necessary to perform analysis.

In addition to the small sample size, the results could have possibly fell victim to a ceiling effect. Apparently, the middle school where our study was performed is quite notable for keeping parents informed about their students. The results from the pre-survey supported this, with parents indicating they felt relatively well engaged even before the intervention was introduced. On many of the questions, which were scored on a scale of 1-5, parents answered an average of approximately 4.0, leaving little room for improvement. Interestingly enough, the only question for which this was not the case, with an average of ~3.5, was the question found to have reliably increased after the intervention. Future studies might benefit from taking place at a school with a higher need for parent-teacher communication.

Finally, the authors are well aware that multiple tests for statistical significance were performed without using some sort of penalty to correct for it. Had this been done, it is likely that the few reliable results found would become unreliable. This is not a justification for choosing

not to use a penalty; it should simply be noted that there is a high possibility of that outcome. The reason for not using such a correction was that this was mainly an exploratory study. Most of the important results consisted of informal trends and qualitative feedback. As we have mentioned, a more robust evaluation would be warranted in the future.

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