Description and Evaluation of Reasoning
Mind’s 2003 Pilot Project

September, 2003
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*Reasoning Mind, Inc.*
Preface

This report discusses *A Web-Based Environment for Learning Math in Middle School*, the first pilot project of Reasoning Mind, Inc. In this project, a web-based learning environment was created, and students in two very different schools spent a semester studying ratios and proportions in the environment. Although statistics are employed in certain sections, this report is not a rigorous statistical evaluation. Rather, it is a document written from the subjective perspective of Reasoning Mind. As such, it offers not only numerical evaluation, but also qualitative information on the program implemented and the learning processes of the students involved; much of the evidence presented here is anecdotal, offering insight into the nature of the project.

The primary purpose of this report is not to demonstrate the effectiveness of Reasoning Mind’s educational intervention, although that certainly is one of the topics addressed. Instead, this document aims to give the reader an idea of how the pilot project was carried out and what Reasoning Mind learned from it. Among the many sources used to reach the conclusions presented here are emails written and attitude surveys filled out by students, questionnaires handed out to teachers and parents, the activities of students online, and – perhaps most importantly – the observations of Reasoning Mind staff members present in the classroom. It is sincerely hoped that this report will be both useful and interesting to all those concerned with the combined effort to improve our nation’s education.

Executive Summary

“It’s a better way of learning math.”
- From an RM student’s attitude survey

This report describes the Reasoning Mind pilot project, A Web-Based Environment for Learning Math in Middle School and analyzes the causes of certain phenomena observed either in the data collected, or by Reasoning Mind staff members present in the classroom. The report relies on standardized and in-house test results, parent and teacher questionnaires, student attitude surveys and correspondence from students to support the conclusions presented.

In the first stage of the project, a web-based environment for learning math was created. The programming work was done in Moscow, and a team of education experts created a curriculum for the study of ratios and proportions. The system had many different modes of learning, including Guided Study, where students were taught by an animated “genie,” Classroom Mode, where students received lessons from online tutors, and the Game Room, where they could compete playing problem solving games.

The pilot project was carried out at two schools, Hogg Middle School and Cypress Grove Intermediate. Hogg is a predominantly Hispanic inner-city Houston school where the majority of students are classified as at-risk. Cypress Grove is a school in College Station, Texas; the school is one of the best in the state. In addition, the students selected from Hogg were below-average for the school, while the students of Cypress Grove were nominated as the best in their math classes.

The pilot project at Hogg was set up as a pretest-posttest research experiment; thirty students worked with the system on a regular basis in addition to their normal math classes, and there was a control group to adequately measure student progress. At Cypress Grove, twenty students worked with the system during their regular math class, and only when the teacher allowed it; there was no randomly selected control group. At both schools, the project’s duration was one semester.

The educational impact of the project was remarkable. Students at both schools showed a significant improvement in knowledge of ratios and proportions – at Hogg, for example, the test group’s average improvement from the pretest to the posttest was 67%, while the control group only improved 6%. Moreover, the TAKS passing rate for the test group – which was initially of equal mathematical achievement with the control group – exceeded the control group’s by 20%. This effectively brought the passing rate up to within 1% of the average passing rate for white students in the state, 84%. In other words, only one semester of instructional intervention closed the achievement gap between the predominantly Hispanic students of Hogg and the average white student in the state of Texas.
Student attitudes towards every learning mode and towards the system in general were very positive. The overriding majority of students at both schools indicated that they liked the program, and most students at Hogg also indicated that they would prefer learning in the system to their regular math classes. At both schools, almost all students that had spent significant time* in the system reported that they learned at least as much from the system as from their regular classes, and the vast majority reported that in fact they learned more. Overall, the students at both schools reported an improvement in their attitude towards math in general as a result of their participation in the project.

<table>
<thead>
<tr>
<th></th>
<th>Hogg Experimental Group</th>
<th>Hogg Control Group</th>
<th>CGI Reduced Test Group†</th>
</tr>
</thead>
<tbody>
<tr>
<td>RM pretest score, average</td>
<td>8.6</td>
<td>7.1</td>
<td>13.2</td>
</tr>
<tr>
<td>RM posttest score, average</td>
<td>14.4</td>
<td>7.5</td>
<td>19.7</td>
</tr>
<tr>
<td>Percent increase in RM test score, average</td>
<td>67%</td>
<td>6%</td>
<td>49%</td>
</tr>
<tr>
<td>TAAS-2002 score (% correct), average</td>
<td>86%</td>
<td>87%</td>
<td>--</td>
</tr>
<tr>
<td>TAKS-2003 score (% correct), average</td>
<td>63%</td>
<td>52%</td>
<td>91%</td>
</tr>
<tr>
<td>Percent by which the experimental group outperformed the control group</td>
<td>20%</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>TAKS-2003 Objective #2, number of correct problems out of 10</td>
<td>6.6</td>
<td>4.9</td>
<td>--</td>
</tr>
<tr>
<td>Percent by which the experimental group outperformed the control group</td>
<td>35%</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>TAKS-2003 passing rate</td>
<td>83%</td>
<td>69%</td>
<td>100%</td>
</tr>
<tr>
<td>Percent of students that liked the program</td>
<td>80%</td>
<td>--</td>
<td>82%</td>
</tr>
<tr>
<td>Percent of students that indicated that after taking the RM class they liked math more than before</td>
<td>57%</td>
<td>--</td>
<td>33%</td>
</tr>
<tr>
<td>Percent of students that indicated they learned more math on the RM website than in their regular math class</td>
<td>70%</td>
<td>--</td>
<td>73%</td>
</tr>
</tbody>
</table>

Table 1. This table summarizes some of the primary results of the project

Several observations were made during the course of the project about the general nature of the students. Perhaps the single most noticeable weakness in the mathematical upbringing of all of the students was an inability to think in theoretical terms; instead, students had been conditioned to solve problems, and getting the right answer was much more important to them than understanding the solution. The correction of this shortcoming was one of the primary goals set before the online tutors, and there was a certain degree of success in the endeavor.

In terms of the state of knowledge of students, it was understandably in better shape for the students of Cypress Grove. However, the students at both schools had difficulty with such basic concepts as whole-number division and decimals. At Hogg,

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* A total online time of at least ten hours.
† See Part III: Cypress Grove Intermediate of this report or “reduced test group” in the glossary.
most students did not even know what a whole number was. The arithmetical skills of the students also left much to be desired.

Another point of interest is in the students’ attitudes towards the reward system. Under this system, everything a student did in the environment gave him or her points, which in turn could be exchanged for prizes. Students liked the prizes quite a bit, but not nearly as much as the points, which were a tangible mark of approval. Even more significantly, the attitude surveys yielded the result that quite a substantial proportion of the students at both schools – at least half – placed the benefits of learning on par with or higher than the other benefits of the system, such as prizes and animations. The lapses in learning that had been observed were clearly not due to any lack of motivation on the part of the students.

Finally, it was found that a fair amount of students at both schools not only had access to the Internet, but were willing to give up their free time to study or play games in the system. The general enthusiasm of students, however, depended heavily on the attitude that their teacher projected with regards to the system.

Reasoning Mind considers this pilot project a great success, for two primary reasons. First, the project has demonstrated the effectiveness of the company’s educational philosophy and approach to teaching, and second, it has provided the company – and all interested parties – with a wealth of information about learning, and Internet learning in particular. It is hoped sincerely that this project, as well as the ones that will follow, will contribute as much as possible to the joint effort to improve the nation’s troubled K-12 education system.
Part I: The Project’s Objectives and Organization

Objectives of the Pilot Project

There were several objectives set prior to the beginning of the pilot project; these objectives were (1) to demonstrate that students in America – in fact, all students in America – could be taught mathematics if the instruction was carried out correctly, (2) to demonstrate that such instruction could be delivered totally remotely over the Internet, and (3) to show that such Internet instruction – when implemented through a solid methodology,* uniting computer teaching with help from qualified tutors – could be effective. In the eyes of the RM management, these objectives were all met by the pilot project; moreover, the pilot project’s value extended beyond these objectives, since information was obtained both about the technical elements of the realization of such a system, and – most importantly – about the educational process in general, as well as in the specific case of the students exposed to RM’s educational intervention.

Organization of the Pilot Project

The pilot project was carried out in two phases: development – which took one year – and piloting, which took half a year. The first phase was primarily centered around Moscow, Russia, where RM’s development office is located, and the second phase around Houston and College Station, Texas, where middle school students in two different schools – Hogg Middle School and Cypress Grove Intermediate – spent a semester studying with the system.

By the beginning of Phase I, a good deal of work had already been done on the development of primary concepts and certain general ideas about the implementation; during Phase I itself, these ideas were transferred into detailed descriptions of how the RM educational system would be organized, supplemented with other conceptual ideas, refined, and finally used to create a working system. A team of highly qualified Moscow programmers worked to develop this system, solving many technical problems in the process. No less importantly, an external design studio was contracted to design the website, the “genie” character was planned and created (both as an animation and a character), and a methodology for ratios and proportions was designed by a team of Russian teachers highly expert in middle school education and adapted to the specifics of American education by two Houston-based Reasoning Mind staff members.

The programming team consisted of four full-time web programmers, a project manager, and a team of part-time undergraduate and graduate students hired to input

* For the highlights of RM’s math teaching methodology, please refer to Appendix F of this report.
curriculum material into the database. Besides writing code, the programmers solved technical issues on every level, making large-scale architectural decisions. The team often worked overtime to complete the enormous amount of work presented by the project.

Some of RM’s programming and management staff

The RM genie – who has by now become something of a mascot for the project – was a character designed to act as the students’ teacher-figure in the system. The genie’s personality, speech, and place in the system were carefully planned out by the management staff to give the system a face that would guide students in a positive way, give support and encouragement, and set an example of how mathematics learning – and learning in general – should be regarded. The genie’s appearance was designed by DEFA, the design bureau that did all of the system artwork; the genie had over 50 animations, congratulating students, telling them about something, or just “living its own life” – painting, bathing, watering flowers, and so on.

The RM genie, in one of its more lyrical moods
Mathematical Content

The curriculum design team created an enormous amount of mathematical content. Although no student saw every problem (or even came close), this variety of material was necessary to accommodate the needs of every individual student. Besides ten chapters of theory material – together with theory exercises, graphics and animations explaining theoretical concepts – there were 16 units of review material and over 6,000 problems in the database, with hints and detailed solutions. Around 100 math riddles of various difficulty levels were added to the system halfway through the semester. As an idea of the amount of work this represented, 50 man-weeks were required only to enter the already created static theory material into the database. Additional time was required to create interactive exercises – problems which asked students to color objects or drag things across the screen as a method of presenting their answer – and the interactive game “Dino Island” (discussed below).

The curriculum itself was created with great flexibility; the individuals comprising the team – among Moscow’s leading grade-school education experts – brought their knowledge to bear on the design of the learning algorithm. The result was a complex system capable of suspecting problems in theory comprehension, giving students diagnostic problems to verify or reject these suspicions, and then setting appropriate diagnoses and acting on those diagnoses – either suggesting that the student review some theory pages, or recommending the student for a lesson with a tutor.*

* A description of this teaching algorithm is available in Appendix G of this report.

The team of methodology experts hired by RM

The system had something for students at practically every level; the theory was written in a way that was understandable to all students, and more difficult theory material – namely on inverse proportionality – was available to students that wanted a
There were problems at three difficulty levels – level A, level B, and level C – and while the level A problems were accessible to everyone, level C problems challenged even the strongest students.

The System’s Modes and Functions

The system was designed with a variety of modes and functions to accommodate different types of learning. These modes, carefully integrated to work together, included various forms of viewing theory, solving problems, and playing games, as well as a virtual classroom mode in which students studied with tutors. The functions included an internal email system, a reference system (with a hyperlinked glossary), and a powerful collection of tools for viewing information about the progress of students.

The primary learning mode was called “Guided Study.” It was above all in this mode that students were exposed to RM’s methodology, viewing screens of theory (see Figure 1) and solving problems. The genie was always present on the screen, congratulating students on their successes and making suggestions relating to the students’ study. When viewing theory, students had the option of browsing back to view past material. When given a problem, students were required to enter both their answer and their solution; the system would not allow them to go on until something was entered into the solution box. Moreover, the great majority of problems were not multiple choice, but free numerical response. After every problem – regardless of whether it was solved correctly – the students were shown the system’s (or as they knew it, “the genie’s”) solution.

![Figure 1. An example of a Guided Study screen](image-url)
The second mode of learning offered in the system was Independent Study. In this mode, students could pick the topic over which they wanted to solve problems, as well as the difficulty level at which they wanted to work. Students could also browse theory or solve riddles in the mode.

When a student was unable to continue in Guided Study, that student was blocked from entering the mode, and the next available tutor would take the student into a virtual classroom. In the classroom, tutors could edit and send material from the system’s theory section to students via the blackboard, and students could communicate with tutors through the built-in chat. Tutors would show up to lessons prepared, having reviewed the student’s activities through special tools: the Diagnoses (which could be set by either the system or by tutors), Study History (a detailed tree showing the student’s complete history of learning in the system), and Activity Logs (a searchable database of all activities in any mode).

The final mode of study was the Game Room. Here, students had access to two types of games – a two-player game requiring students to solve problems and then criticize each other’s solutions, and a single-player interactive game called “Dino Island,” in which students dragged dinosaurs of two sorts onto an island in a specified ratio; the game had four difficulty levels.

To ensure that students used the system properly and optimally in every mode, “The Genie’s Rules” were handed out. These rules can be found in Appendix H of this report.

The Reward System

For everything the students did in the system, they were given points. The amount of points varied depending on the task completed; a more difficult problem was worth more points than an easy one, and using a hint lowered the point value of a problem. In Guided Study and Independent Study, students were always shown the number of points they had accumulated that session and the number of points scored for the last problem. Moreover, students could always visit “My Points,” an interface that presented their achievements broken down by mode.

Points encouraged students in two ways. First, they could be exchanged for prizes – pens, pencils, stuffed animals, play-slime, model cars (some even remote-controlled), miniature airplanes, and so on. Second – and this was perhaps even more important – points gave students immediate feedback on how well they were doing.
Some students at Cypress Grove Intermediate collect their hard-earned prizes

The other indicator of success in the system was the level achieved in every portion of the curriculum (ratios, rates, proportions). This level was determined by the difficulty of problems that students learned to solve and by a test administered in Guided Study at the end of every unit; there were three levels (Standard, Advanced, and Highest), and students were presented a certificate for every level achieved. It should be noted that in Hogg Middle School, certificates were presented in front of the entire class, allowing the students to celebrate their own and their peers’ achievements.

A student at Hogg proudly displays his certificate
Tutors

The intervention of trained tutors in virtual classrooms was one of the primary components of the RM system. There were about fifteen tutors recruited and trained for the project, although five dropped out early in the project due to conflicts with their main jobs. Of the remaining ten, three came from Houston, three from Moscow, two from College Station, one from Richmond, Virginia, and one from Boston. Among them were two high school students, three undergraduate students (MIT, Texas A&M, Moscow Finance Academy), two graduate students (University of Houston, Texas A&M), two IT professionals, and one housewife. Some of the tutors worked as volunteers, and others were paid between $12 and $15 an hour.

The tutors were selected through an interview process, the main criteria for selection being a basic knowledge of mathematics, sound logical skills, a desire to help children, and comfort with computers; these interviews were performed through online chat sessions. After a tutor was hired, a tutor manual was sent to her, and she participated in a mock classroom session with another tutor. In this session, the tutors would take turns pretending to be students and giving each other lessons.

The work of the tutors was organized by a “dispatcher.” The dispatcher monitored which students needed or had requested lessons, and then assigned them to tutors that were available. The dispatcher also monitored the genie’s account – in effect, the dispatcher was the genie for the duration of the class session, responding to typical emails from students by sending standard pre-prepared responses.

When a tutor was contacted by the dispatcher, he was told the name of the student he would be working with. The tutor would then review this student’s records – the problems this student was working on in Guided Study, the mistakes the student was making, the diagnoses set by other tutors or by the system, the student’s previous classroom sessions, the levels achieved by the student on every topic, and so on. When the tutor was prepared (usually he would be ready in less than five minutes), he set up a classroom and invited the student with an email. At the end of the session, the tutor gave the student points for the class, commented on the student's performance and knowledge, and reviewed diagnoses to see if any could now be marked as “remedied.”

Roles of RM Personnel and School Teachers

For the purposes of the pilot project, both school teachers and RM personnel present in the classroom refrained from giving instruction to the students. In the Hogg classroom, two RM employees were typically present, giving technical help with using the system and making sure that students followed the directions of the genie – a function originally prescribed for teachers. Since there were occasional technical issues at the beginning of the semester (discussed in greater detail below), RM personnel also acted as middlemen between the Moscow office – where the programmers were
supporting the system – and the Houston Independent School District officials, who controlled the Hogg network firewall.

RM personnel acted as disbursers of prizes, keeping track of the points each student had spent and allowing students to exchange their remaining points for prizes. In addition, certificates were handed out at regular intervals to students that had passed a topic (“Ratios,” “Rates,” or “Proportions”).

At Cypress Grove Intermediate (CGI), the situation was radically different. No RM staff members were present, and neither were any teachers – teachers would send their students to work with the system in a computer lab when they felt the students were not needed in the class – typically in the case of strong students, who could be sent out while the teacher reviewed with the rest of the class. Thus, while RM staff still distributed prizes several times during the semester, the only adults physically present during the class were CGI's technology facilitators.

**Plans for Measuring Student Achievement**

For evaluating the students, RM planned a combination of tests, including an internal pre- and posttest, the Stanford 9, and the TAKS. While Hogg's students took the Stanford 9 during the semester, very little time had passed since the students had begun their work with RM, and the hope was that a separate administration could be arranged after the project’s conclusion.

The RM pre- and posttest covered only the topics of ratios and proportions. The 32 problems making up the test ranged from simple questions requiring only basic acquaintance with ratios to problems that were very involved both conceptually and computationally. Independent evaluators reviewed the tests, determining that they were indeed accurate measures of ratios and proportions knowledge. Both tests as well as the comments of the independent evaluators can be found in appendices of W. A. Weber’s statistical evaluation.

To learn about the students’ attitudes towards the system and towards math in general, an anonymous attitude survey was given at the end of the class. The survey is referred to throughout this evaluation, and the questions of the survey can be found in Appendix I. The full collection of Hogg Middle School student responses to every free-response questions of the survey can be found in W. A. Weber’s report, *An Evaluation of the Reasoning Mind Pilot Program in Hogg Middle School*. 

*Reasoning Mind, Inc.*
Part II: Hogg Middle School

School Attributes

Hogg Middle School is an inner-city school in Houston, Texas. Hogg’s students are 91% Hispanic, 5% Black, and 4% White. Most of Hogg’s students are from economically disadvantaged neighborhoods, and 58% of Hogg’s students are classified as at-risk. The school is known for doing a superior job in serving students from disadvantaged backgrounds.

Student Selection

The students at Hogg Middle School were generally very weak in ratios and proportions; they had received practically no good instruction in math, and this was a concern in the process of selecting students. The primary issue was not that students should know ratios or proportions, but that they should know enough about certain prerequisite concepts in order to be able to study ratios and proportions. For this reason, 229 seventh grade students were given a pre-selection test, designed to test knowledge of multiplication, division, decimals, and other topics key to the study of ratios in the RM curriculum. Hogg Middle School also had criteria for selecting students – it was interested in primarily filling the group up with C-students, since the level of A- and B-students was already satisfactory in terms of test pass rates.

Combining the results of the pre-selection test with the list of students that Hogg was interested in including in the project, a final list of 62 students was created. Of these students, 30 were randomly selected for the test group, the remaining 32 making up the control group. Since only 26 of the 32 members of the control group showed up for the pretest, that was the final number of students in that group. It should be noted that the TAAS scores of the test and control groups, when compared to the average scores for the school, show that the students in these two groups were in fact below average (Hogg’s average sixth-grade TAAS percent in 2002 was 90%, while these groups' average was 86.8%).

Fractions Tutorial

The results of the prequalification test were very disappointing. All of the students’ knowledge of basic mathematical concepts, including common fractions, left much to be desired. For this reason, Ellen Winstead – a consultant with Project Grad – agreed to give a three-lesson tutorial on fractions to both the experimental and control groups. Ms. Winstead covered several basic concepts relating to common
fractions, making work with the system more realistic for the students, since this version of the system did not have a full middle school curriculum and therefore presupposed some knowledge of concepts prerequisite to ratios.

**Student Pretesting**

The students in the control and test groups were pretested separately. Each group was administered the test by an RM staff member. The students were told ahead of time that the test would be very difficult, and it would be graded on a curve.

The students were given 1.5 hours for the pretest. The presence of the RM staff members prevented cheating on the test; one student was caught copying, and that student’s test was marked and the student moved. Later comparison of the test with the test of the student from whom the copy had been made yielded the conclusion that the cheating did not influence the outcome, due both to the weakness of the second student and the inability of the first to copy most of the problems.

**Class Organization**

**Prior to beginning work with the system, the students received a two-day tutorial** on how to use the different modes, how to use email, and what the point of the system was. This tutorial included a presentation of work in the system with a projector, and practice working in the system at the end of the day; after the tutorial period, everyone’s points were taken away and they began work with the system from scratch (of course, the students were told of this at the beginning of the tutorial period).

**The students worked with the system about one and a half hours, two to three times a week.** They all sat in a single very large computer room, where RM staff members walked around asking if any help was needed with navigating the system. The staff members also made sure that students were staying on task, and were following the instructions of the genie and of tutors. When a tutor invited a student into a class and the student ignored the request, the staff was contacted and they prompted the student to enter the classroom – something that is much less enforceable remotely.
Students were encouraged to spend time in Guided Study, and the Game Room was unavailable to students that had not reached a certain level. Prizes could also only be purchased with points earned in Guided Study or classrooms, unless Guided Study was completed, in which case points from games and Independent Study could be spent. Outside of helping each other, students were not allowed to work together, since each one had a computer and an individual account, where information determining the student's optimal path of learning was collected and stored.

Overall, the students had 29 one and a half hour sessions with the system. Since students often had to miss the class, the average total time spent in the system was just over twenty-eight hours.

**Student Posttesting and Educational Impact**

The students were given the posttest at the end exactly as had been planned; everything was set up in the same fashion as for the pretest. Texas Assessment of Knowledge and Skills (TAKS) scores were secured for all of the students in the project, both overall and for TEKS objective 2. Unfortunately, it was not possible to administer the Stanford 9 at the end of the class due to logistical reasons.

The results of the pretest/posttest combination were of no surprise to the RM administration; the students in the test group showed a 67% increase in score, while the control group's increase was minimal – 6%. Moreover, the difference was in
problems of every difficulty level (see W. A. Weber’s report, An Evaluation of the Reasoning Mind Pilot Program at Hogg Middle School).

It is useful to consider a function that measures students’ improvement in terms of how much closer they got to a perfect score: divide the number of problems by which they improved by the number of problems by which they could potentially have improved. Thus, a maximal score is 1, while a minimal (positive) score is 0. The use of this function can offer some insight into the growth of students at all levels; by this function – from now on referred to as the “improvement index” – the average score for the test group was 0.25, while for the control group it was only 0.01. The improvement index will appear throughout this report.

While the pretest/posttest results were not unexpected, the Stanford 9 (administered less than halfway through the project – as discussed above, permission for later administration of this test was not secured) and the TAKS results were quite surprising. Not only were differences between the test and control groups very statistically significant (see W. A. Weber’s report for details), but in fact the test group’s TAKS scores were 20% higher than the control group’s. This is especially meaningful in light of the fact that the pilot project covered only ratios and proportions, which play a very minor role in this particular test – only three of the test's forty-eight problems specifically address these topics. If one considers the TEKS objective closest to ratios and proportions – Objective 2* – the percent by which the test group outperformed the control group was 35%. Although the scores for problems specifically addressing the two topics could not be secured, one can extrapolate already from the above results that they most likely reflect the progress as measured by the internal pretest/posttest combination.◊

Moreover, student improvement from the pretest to the posttest correlates to certain internal RM ratings of the student. The correlation between the student’s improvement index (see above) and the number of points earned is very strong, with the correlation coefficient $R = 0.475$ and $P < 0.008$.† A graph of this correlation is shown below in Figure 2.

* The Texas Education Agency defines Objective 2 as “patterns, relationships and algebraic reasoning.”
◊ This progression has been termed the "ripple effect."
† P-values are given throughout this report. Traditionally, a P-value less than 0.05 is accepted as indicating statistical significance.
There is also a strong correlation between the improvement index and the achievement index, which is a combined measure derived from the various levels achieved by students over the different topics. For this correlation, $R = 0.57$ and $P < 0.001$. A graph follows in Figure 3.

* Standard, Advanced, and Highest Levels are represented by the integers 1, 2, and 3, respectively. These levels are taken for all three topics covered by students, as well as for the tests over each topic. Then, the result is summed. The greatest achievement index is thus 18, and the smallest 0.
Beyond affecting TAKS scores, the RM program also raised TAKS pass rates. 83% of the students in the test group had a score that “met the standard” on the TAKS, compared to 69% for the control group. Comparing these results with passing rates for White and Hispanic students across the state, one finds that the students were raised from a level just above the average pass rate for Hispanic students (64%) to almost the average level of White students (84%). This is confirmed by the posttest-pretest combination – the test group’s posttest score average of 14.4 is higher than the Cypress Grove Intermediate experimental group’s pretest score of 13.2. In other words, RM’s intervention raised the ratios and proportions knowledge of average inner-city students to the level of privileged university-town students after only a semester of study, and for mathematics knowledge in general it closed the achievement gap between White and Hispanic students.

**Student Attitudes**

**Learning on RM**

When the students were first told about the program – specifically about the Internet aspects – the reaction was mixed. Understandably there was some enthusiasm, but also there was apprehension; several students asked if this would be like “that history program” that they described as “boring.” Apparently the students had already participated in an Internet learning project, from which they came away without particular enthusiasm.

By contrast, the students’ interest in the RM program only increased towards the end of the semester. There was a certain amount of disillusionment that some of the students experienced a few weeks into the semester when they realized that the system required work of them, but their interest (in almost every case) was then regained, except now it was directed more towards the mathematical content than towards the animations, games, etc. In particular, several students commented in response to questions by visitors to the class that they liked the fact that the system explained how to solve problems and do math. On the attitude survey, three students responded to the question “What did you like most about learning math on the RM website?” by indicating that they liked seeing solutions to problems, and not just answers. A fourth student responded, “I could understand it better than my teacher.”

This leads us to a startling fact evidenced by the attitude surveys: many of these students – despite the fact that they are only in the seventh grade – have a pronounced interest in learning for the sake of learning, placing the educational benefits of the system in many cases above such things as games, points, prizes, and animations. Among the answers to questions 5a and 5b of the attitude survey (which asked what students liked most about RM, and what else they liked), there were many comments on games and prizes, but exactly half of the students – fifteen out of thirty – wrote comments naming the tutors, the reference section, some specific element of theory (e.g., “Ratios”), seeing solutions, learning, or “being challenged” as their favorite
elements of the system. As one student wrote, “I loved the problems that they gave me & I also learned a lot by this system. If it wasn’t for this class I wouldn’t be this smart as I am now.”

Many students (in fact, fifteen out of the thirty) commented on the difficulty of some of the problems; however, based on their responses to a question asking which was more difficult, RM or their regular math class, the students as a whole found the two classes of equal difficulty.* One possible explanation of why these seemingly contradictory opinions were expressed by the students is that – while the RM problems were harder – RM explained how to do them and students felt generally less frustration with the learning process. As one student put it on the attitude survey, “[I like most] that they show you how you’re supposed to do it.”

What Factors Led Some Students to Dislike RM?

There was a certain category of students that had absolutely no interest in the system or in math; they surfed the Internet instead of working, and generally did practically nothing in the system. What was remarkable is that the number of these individuals decreased as the semester went on; at the end, there were 2-3 students still in this category, but the rest had taken an interest in the system. One in particular only made this transition when a couple of weeks remained in the semester; he began working frantically in the system to catch up with his peers. Another student had definite problems both with focusing on study and with discipline. The student was clearly very smart, but he was not capable of realizing his potential. A certain time after he took an interest in the system, his teacher commented that he had transformed from a C-student to an A-student in her class, and that she attributed this to his work in RM.

On the attitude surveys, twenty four of the thirty students – 80% – indicated that they either liked the system, or liked it “a whole lot.” Of the remaining six students, five stated that it was “O.K.,” and one that he/she “didn’t like it at all.” An analysis of the attitude surveys of these six unenthusiastic students is illuminating. Two of them indicated that they would prefer to learn math on the RM system in the future, and not in their regular math class (!). One indicated that he/she disliked “everything” about the program and liked “nothing.” The remaining three all indicated either the difficulty of the problems or the need to work all the time as the primary deterring factors.

Two students indicated that they would prefer to learn in their regular classrooms in the future rather than with RM. What is interesting is that both of these students indicated that they learned more in RM than in their regular classes, one even answering that he/she learned “a whole lot more” in RM than in his/her regular class (!). As before, the contradiction is resolved when one notices that both students found RM to be more difficult than their regular classrooms. Another moment of interest is that, when asked


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“Is there anything else you’d like to say about RM?” one of the two students wrote, “I wish I can take it next year.”

Twelve students – 40% of the total number – indicated that it did not matter to them where to learn math in the future. Excluding the student that wrote that he/she disliked “everything” about the system, 100% of these students indicated either the difficulty of the problems or the need to work the whole time as a primary negative factor of RM.

**These results support the conclusion that the primary factor leading some students to prefer their regular classrooms over RM is the extra work required by RM.** The immediate feedback system which some students liked so much is a double-edged sword; it is in fact a system of immediate accountability.

**Attitudes towards Math**

As evidenced by the attitude survey, there was a substantial shift among the students in their attitude towards mathematics in general. Seventeen of the thirty students – 57% – indicated that after the project, they liked math more or even "a whole lot more" than before. Twelve students indicated that they felt the same way about math, and one student reported that he/she now liked math “a whole lot less.” These results support the previously drawn conclusion that students are interested in learning for the sake of learning; they also indicate that students react positively to a proper, theoretically grounded mode of instruction.

![How Students Liked Math After the Project, as Opposed to Before](image)

*Figure 4. Student responses indicate that the project improved student attitudes towards math in general*
Bugs in the System

The students were generally very patient with the system when it was not working; this was especially common in the beginning of the project, when difficulties coordinating with the school district network center led to a block of the system website. Six students named bugs in the system when asked what they disliked on the attitude surveys, but five of these students – 83% – indicated that they liked the system “a whole lot” and the sixth that he/she liked the system. This percentage, compared to the corresponding percentages of the students as a whole (only 43% indicated they liked the system “a whole lot”), indicates that irritation caused by technical difficulties was a minor factor in the students’ experience with the system.

The Computer Factor

It is natural that students should like working on the computer because of the novelty of the experience; however, if this is the only factor of interest in the system, then the system is in a bad position indeed, for eventually novelty will inevitably wear off. Seven of the students mentioned computers as a major positive factor; however, only three of them mentioned computers as the most positive element of the system. It should be noted that three is still a fairly sizeable portion of the student body, since it comprises 10% of the total.

Unexpectedly, one student mentioned computers as a negative factor in RM. The reason was that prolonged work in front of a monitor hurt this student’s eyes. To avoid such problems in the future, more care should be taken to set low monitor brightness and maximize the use of flat-panel displays.

The Genie and Guided Study

The students all liked the genie. Many students wrote emails to the genie thanking the genie for its help, and there were quite a few emails inquiring about who the genie is, what it does, where it’s from, etc. Several students regularly wrote to the genie, and a couple even asked if they could continue writing to it over the summer. Students even came to the genie with their troubles – one complained about her math teacher, who was making her students keep a math journal the student thought was useless; the student asked the genie for advice about what she should do!

The general positive feelings the students experienced for the genie far exceeded the expectations of the RM staff; the students acted not like 7th grade students would be expected to act – they were more than willing to accept the “genie” myth. When there was a cake with the genie on it served at the end-of-semester party, several students expressed their concern that it wasn’t right to be eating the genie; of course, they ate the cake anyway, but their statements were telling of a certain attachment to the genie. One student’s conversation with a tutor on the last day of the semester is amusing and illustrative of this point:

Teresa: Are you a genie like the one we have in the system?
Mr. Zaharchenko: No, I’m just a tutor. The genie is a computer character, you know.

Teresa: Then the Genie lied to me because he said he was born in egypt [sic] and hey [sic] actually got paid. I cant [sic] believe that little thing tricked me!

The genie soon found out about the student’s doubt, both from this classroom and from an accusatory email she sent. Fortunately, the situation was resolved when the genie explained to her that it indeed was a computer genie, but that was just its current occupation. For a selection of messages written to the genie as well as for comments on the attitude surveys, please refer to Appendix B.

The genie also performed very well on the students’ attitude surveys – not a single student said anything negative about the genie, although it came up four times in positive context. Moreover, Guided Study – billed as the genie’s favorite mode, and where students interact most with the genie – was the mode marked useful and interesting by the highest percent of students (93%).

The genie takes its job seriously

Guided Study itself grew in popularity as the semester went on. Originally, the students were apprehensive about the mode, preferring to work in Independent Study, where they could solve simple problems for easy points. However, partially due to a small “advertising campaign” encouraging students to work in Guided Study, students began working more and more in the mode. This campaign included active encouragement of Guided Study over Independent Study by RM staff members present in the classroom; also, students were not given access to games prior to the completion of the first two topics in Guided Study (ratios and rates), and points earned in games and Independent Study could not be spent prior to the completion of all three topics of Guided study. At first, students did not like being forced into Guided Study. Dozens of emails poured in to the genie asking for permission to work in Independent Study, including attempts to outwit the animated character – one student wrote, “Genie I was wondering if I could work in independent study because I think that is where I can learn more about ratios.”
However, the genie categorically refused all requests to do Independent Study, and the students continued in Guided Study. As a result of their increased work in this mode, they developed more positive attitudes towards it. When they had completed the curriculum, several students expressed disappointment that there was no more Guided Study left.

At the end of the class, several students chose to write emails thanking the genie and saying goodbye. One such message, written by the same student as in the above conversation, follows.

Thanks to you too Genie. Thanks for being a super good friend and a super good helper. I'm going to miss you. Genie are we going to have the Rm next year? Well if we do see you there. And if we dont thanks for everything and good luck on being a genie.

Love
Teresa :)

Classrooms

One misconception that is apparently common in the educational community and that had been expressed to RM’s staff is that Hispanic schoolchildren culturally have a great deal of pride, and this prevents them from asking for help. In the course of this project, the opposite was shown to be the case – the students, who were predominantly Hispanic, sent dozens upon dozens of emails to the genie asking for help from tutors; several students commented on their attitude surveys about how much they liked the tutors, and almost all found the classrooms to be useful. The reason for their eagerness – and perhaps also for the typical misconception – was expressed by several students on the attitude survey and in emails to the genie: students seemed to prefer the genie and tutors to their ordinary teachers. Perhaps this is because of the novelty of online interaction, but a more plausible reason considering the data is that teachers are under-qualified and incapable of properly explaining things to students when they ask for help.

![Classroom Attendance Against Knowledge](image)

Figure 5. As can be seen from this graph, there was no correlation between student achievement and the number of classroom sessions attended.
Multi-User Games

Multi-User Games were very popular with students. Overall, the stronger students enjoyed them more, for two primary reasons: (1) they had more access to these games, since they completed the appropriate sections of Guided Study earlier and accordingly gained permission to play games earlier, and (2) they had a more developed critical mind and competitive impulse, two elements important for success in this sort of game. 73% of students liked games; it should be noted that not a single one of the remaining 27% reported logging into the system outside of class, despite the fact that three out of eight – 38% – of the students had access to a computer that worked with RM (compare this with the 64% average). This confirms what RM staff observed qualitatively – many of the students that accessed the system after school hours chose to play games, although this was not always possible, since late at night there could be only one student online, and you can’t play multi-user games alone; one student sent an email to the genie at midnight on Saturday complaining that there was no one online to play games with.

Dino Island

The students were very divided about the interactive game “Dino Island.” Students seemed to either really like the game, or to really dislike it (only 55.2% of students found the game “useful/interesting”); many students used it as a way of getting easy points. One explanation of the mixed response to the game is that some students do not like learning through games as much as others; in fact, 38% of the students that did not like Dino Island also did not find Multi-User Games interesting, compared to just 18% for students that liked Dino Island. Another possible reason lies in Dino Island’s repetitive nature – being the first interactive game designed by Reasoning Mind, there were certain limitations on the game’s flexibility and scope imposed by limited time and resources. A sample screen from the game is given in Figure 6.

Figure 6. A typical screen from the interactive game “Dino Island”
**Teacher Attitudes**

Although there were only two teachers for this project, an analysis of their questionnaire responses shows that they both had a positive perception of the project, and that their observations were for the most part in line with RM’s. The exact answers to the questionnaires can be found in Appendix C of this report.

Both teachers indicated that the students were on task with the system, and one mentioned that she believed some of the students had noticeably improved in their math classes as a result of the program’s intervention. The teachers confirmed that students liked the genie and the tutors in virtual classrooms.

As far as the usefulness of the system, the two teachers saw the system from slightly different angles. One commented on the system’s usefulness for gaining the interest of weak and unmotivated students, so that then their teachers could have greater ability to teach these students in conventional classrooms. The other teacher believed that the system’s primary weakness was in its limited usefulness for weaker students, since they “will not benefit from this type of program because they can’t stay focused.” The contrast of these responses indicates that different teachers may choose to use the system in different ways: it is a tool for teachers – whether their aim is to generate interest, or give additional room for growth where interest is already present.

An added observation is that the teachers did not take much interest in gaining first-hand experience with the system. Although both of them had accounts, neither chose to log in and explore the environment. However, both teachers spent time observing their students at work with the system.

**Tutor Comments and Observations**

The tutors were given questionnaires to fill out at the end of the course. In these questionnaires, they were asked about the knowledge levels of students, effectiveness of learning modes, and possible improvements in the system from a tutor’s perspective. Those comments made by tutors with regard to students more often refer to Hogg students than to Cypress Grove students, since relatively few lessons were given to CGI students compared to the total number (53 out of 240), and most of these by a single tutor, who had been assigned to CGI.

Common observations made about the students include that students were engaged by the system (this was attributed usually to the game-like approach and the point system). The comments of the tutors also confirm the RM staff’s observation that many students lost interest upon realizing that work was required of them, but most (all but two or three) regained interest shortly. In terms of reading theory, tutors pointed out that (1) the interest level of students drops significantly when they are asked to read theory, and (2) students that spend even minimal time reading theory do considerably better than those who do not. When students are confused, they usually
begin to guess at the answer blindly, since they place the emphasis not on the solution, but on the answer.

Tutors commented on the excessive computational difficulty of problems in the curriculum; the problem was compounded by students’ weak arithmetical skills, especially where large numbers or decimals were concerned. Tutors also suggested that more examples be added into the theory material.

The tutors agreed with students on the usefulness of Guided Study. It was written that the combination of Guided Study and Classroom Mode was especially effective. Independent Study, by contrast, was criticized as too easy to take advantage of; one tutor wrote that students at this age were not capable of assigning themselves challenging problems when easier problems were available.

What RM Learned from the Project at Hogg

Knowledge of Prerequisite Topics

When the students began work with the system, their knowledge of mathematics was in a very bad state. Most students did not even know what a whole number was, and practically none actually understood the concept of decimals. Even simplifying fractions was a problem, and unit conversions all the more; the students had no idea of how to convert between square and cubic units, and the metric system was poorly known. Even in the customary system, many students made mistakes and practically all were reluctant to use the conversion tables.

The first unexpected problems addressed were the students’ lack of knowledge of whole numbers and decimals. Special units covering these topics were added to the reference, and tutors gave lessons to students on these two topics. Unfortunately, there was no chance to cover square and cubic units, so most students still do not understand the significance of these topics, although problems involving the units are accessible through use of the conversion tables.

It should be noted that – based on student scores on the prequalification test – student preparedness had practically no correlation to knowledge of ratios and proportions as measured by the pretest. However, student improvement was possibly correlated to preparedness, although the relatively small size of the test group as well as the importance of other factors – for example motivation to learn and interest in the system – prevent the correlation from being statistically significant ($R = 0.27, P < 0.15$).
Figure 7. Relationship of student improvement to student preparedness. Please note that the apparent correlation is not statistically significant, perhaps because of the small sample size.

This weak relationship of student ability to solve problems over ratios and proportions and knowledge of prerequisite concepts (Figure 8) leads to the conclusion that students are traditionally taught math not from a perspective of theory and true understanding, but rather from algorithms for solving standard problems. This is supported by the students' initial inability to grasp the importance of theoretical knowledge (see “Understanding Theory” below).

Figure 8. Student ability to solve problems over ratios and proportions had practically no connection to their understanding of prerequisite concepts.
Writing Full Solutions

One of the largest problems experienced during the project was that **students would avoid writing full solutions**, preferring to enter the answer in the solution box. Every so often, all of the students’ records would be reviewed, and emails from the genie sent, typically suggesting that students write more complete solutions. The strongest students soon started writing better solutions, although occasional reminders from the genie were necessary. The weaker and average students either ignored the request altogether, or wrote solutions along the lines of “The solution is 5.” In greatest likelihood, the cause of this was not a lack of understanding of what a full solution was (since the system solution to every problem was shown), but either an inability to express mathematical thoughts or an unwillingness to cooperate (thereby losing time and valuable points).

Understanding Theory

At the beginning of the project, students were reluctant to read theory. Practically all of the students skimmed over the theory pages, and several students even inquired as to what the word “theory” meant (!). **The students had been oriented by their previous mathematical experiences towards solving problems, and not towards understanding the concepts behind the solutions.** One student wrote to the genie, “I need the answer to problem RAM20_6.” The genie of course responded, “You don’t need the answer. You need to UNDERSTAND how this type of problem is solved.”

Tutors also had enormous difficulty explaining things to students in classrooms, since the students would say they understood the theory without even having read it
carefully, and then would repeat statements to the effect of “Give me a problem! Give me a problem!” Tutors were instructed to keep to theory in such situations, making sure students actually understood it before giving problems. It is to a large extent the result of the combined work of tutors and of the Guided Study algorithm that towards the end of the project, the students began to realize the importance of reading theory and took more time on the theory screens. This was especially valuable in the “Proportions” section of the curriculum, where the theory material was considerably more difficult than in “Ratios.”

A student ponders a theory screen towards the end of the semester

Online After School: Students at Work from Home

The very first day that a tutorial was given to students on RM, a student logged on at night. Imagine the shock of the RM staff when, at 10:00 PM, there was a student solving problems in Guided Study! The student steadily continued solving problems for over an hour, and then logged off for about twenty minutes. Then, she returned and worked until midnight. From that time until the end of the project, hardly a weekend passed that students did not log in, often late at night.

According to the attitude survey, fourteen students had access to a computer that worked with the RM website outside of school. Of these, nine students indicated that they logged into the system from time to time. Since in greatest likelihood most of the Internet connections of these students were modem connections, the website must have worked very slowly from their homes, since it was intended for high-speed connections. If the students had access to faster connections, it is likely that the time they spent online would have drastically increased.
An interesting and unexpected fact is that students that liked RM “a whole lot” were much more likely to have access to RM than students that did not like RM or were less enthusiastic. For these students, almost 70% had access to RM from outside of school, compared to 29% for other students. There are two possible explanations that come to mind for this difference. The first is that students that like RM are more likely to seek out computers that work with the system – as one student put it, “I have a friend that has a computer & when I go to her class I always go to RM to have more points.” Another explanation is that students that have access to RM are more likely to develop a positive attitude towards the system, since students without access from home (and especially without computers) could feel a certain resentment towards the system, since their friends can log on, while they can’t. The first reason is much more likely to be a major factor, but both should be taken into account.

Figure 10
Part III: Cypress Grove Intermediate

School Attributes

The students in Cypress Grove Intermediate were stronger than those at Hogg; they had been the beneficiaries of the educational system of one of the best schools in the state of Texas. The 2002 TAAS math passing rate for Cypress Grove was 97.1%. The ethnic composition of the school is 68% White, 12% Black, 11% Hispanic, and 9% Asian.

Student Selection

Students in Cypress Grove Intermediate were not selected randomly. Instead, students from four advanced math classes were nominated by their teachers to work with the system; thus, it was the best twenty-one students of these classes that worked with the system. Nomination was not a function of pretest performance, and was determined prior to administration of the pretests. In addition to the twenty-one selected students, twenty-three were chosen to form a "control" group. Note that the test and control groups were thus not randomly selected, and the control group is not a true control group, but rather an approximate reference point.

Another consideration is that one of the twenty-one students was unable to take the posttest. For this reason, he is not counted as a member of the test group, which is thus for all practical purposes reduced to twenty students. This student did however take an attitude survey; two of the other students in the test group did not take an attitude survey. Overall, this gives nineteen attitude surveys.

A major difference from Hogg is that students did not work with the system in addition to their normal math class, but rather were sent by their teachers to a computer lab to work with the system during class time. Thus, teachers used the system as a tool for keeping stronger students occupied while they reviewed with their weaker students. Another difference is that students at CGI studied ratios and proportions in their regular classes concurrently with their work in RM, while students at Hogg had studied these topics a semester earlier.

The Participant Group and Reduced Test Group

Prior to any intelligent discussion of the students’ test results and attitude surveys, it is necessary to address the issue created by a teacher who was not supportive of the RM system, for reasons which the management is unable to determine. It is not known exactly how this teacher influenced her students outside of refusing to let them spend time in the system from class, but both the students’ interest in the system and time they
spent working with it varied radically from the group of her students to the other test students. For this reason, all but one of her students (who chose to spend quite some time with the system from home) failed to complete the study of ratios in the system, thus not even reaching the beginning of proportions; this is the case for only one of the students of the other two teachers. Consequently, the students that had not reached some level in ratios were placed in a separate group, called the “participant” group, and the remaining students called the “reduced test group;” the students in these groups took the attitude survey separately, so that while the surveys remain anonymous, they are divided into two separate groups.

As the reader will see below, the participant group was markedly less enthusiastic about the system, and spent much less time with it – the average time spent in the system by members of the participant group is only 4.7 hours. The improvement indices of the participant group were much lower than of the reduced test group (0.16 as compared to 0.35). Recall also that one student did not take the posttest, but did fill out an attitude survey as a participant group member.

**Student Pretesting, Posttesting, and Educational Impact**

The pretest was administered in Cypress Grove by the students’ teachers and the posttest by RM staff. Just like at Hogg, the students were given one and a half hours, although practically none used the entire time. All forty-three students in both groups took both of the tests, but only the twenty nominated students subsequently worked with the system.

The analysis of system effectiveness for Cypress Grove Intermediate students must necessarily differ from that at Hogg. The reason for this is that the time spent by students in the system varied radically. Even among the twenty students selected for work with the system, only twelve spent what could be considered substantial time logged on (at least ten hours). Four students even spent less than three hours. In addition – as written above – students cannot be divided into proper test and control groups, since the selection of these twenty students from the forty-three was not random – the twenty were the strongest students. For these two reasons, the statistical method used will be correlation analysis, both for the forty-three students and the twenty students in the so-called test group, although the later will be emphasized for the reasons given above.

The first correlation noted will be that between time spent in the system and improvement from the pretest to the posttest. The improvement index used in previous sections will again appear here, since individual improvement – and not just posttest score – is the primary criterion by which effectiveness should be judged.

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* Note that from this point on in the document, the test group student that did not take the posttest will not be counted. Thus, there are forty-three students in total, and twenty test group students.
Figure 11. Students spending more time in the system showed greater improvement from the pretest to the posttest.

The correlation coefficient $R$ is 0.41 and $P < 0.07$. A linear regression yields $I = 0.012 \cdot t + 0.14$, indicating that for a student spending no time in the system, an improvement index of 0.14 is to be expected, while for a student having spent 20 hours in the system, the expected index is 0.38, a 170% difference.

Thus, the educational impact of the RM system was extremely significant: even a relatively small time in the system could drastically improve students' knowledge of ratios and proportions. This is supported by the difference in improvement index for the reduced test group, participant group, and control group (see Figure 13).

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* Certain $P$-values given in this report exceed 0.05. Due to the low power of the test, caused by the small size of the CGI test group, Reasoning Mind has taken $P < 10\%$ as a valid indicator of statistical significance for this section. The reader is of course free to either accept or reject results that fall into this category.
Figure 12. Note that all students improved, since the classes were all studying ratios and proportions concurrently with the RM curriculum. However, the improvement for the reduced test group was significantly greater than for the participant group.

Figure 13. The average improvement indices for the groups further demonstrate the effectiveness of RM’s instructional intervention.

While the twenty-three students that were not selected for work with the system were weaker than the twenty that were, it should be noted that the total time that both groups spent learning math in class was the same, including time spent on RM; in addition, the students had the same teachers and therefore the same lessons. Thus, it makes sense to analyze the entire group of forty-three students; whether the results of
such an analysis are accepted is up to the reader, but they are presented here for any additional insight they might offer, and without pretense of scientific rigor.

![Improvement Against Time in System — 43 Students](image)

**Figure 14. The same graph as in Figure 11, but for all 43 students that took the posttest**

The correlation here is considerably stronger: $R = 0.55$ and $P < 0.00009$. The linear regression is also steeper: $I = 0.017 \cdot t + 0.064$. It is likely that the cause of this steeper slope is that weaker students show less improvement simply by virtue of not being able to keep up in their regular math class. Another possible cause is the outlier that is visible at coordinate (2.88, 0.64) of Figures 11 and 14; this student’s progress – clearly not the effect of RM’s intervention – heavily weakens the twenty-student results due to the small size of the test group (see Figure 11). The addition of the twenty-three students not selected for participation in RM offsets this effect.

It should here be noted that, while posttest scores are correlated with time spent in the system, there is practically no correlation between previous student achievement (as measured by the pretest) and time spent in the system; in other words, student interest did not depend on previous knowledge.
Students’ previous knowledge did not influence how much time they spent online (see Figure 15); factors that were major influences included the students’ interest in the system, their parent’s influence over their studies, and whether students had access to computers that worked with RM from home (15 out of 19 said they did). But perhaps the single most important factor was the influence of the students’ teachers. Much depended on whether a student’s teacher provided the opportunity to work on RM during class, and also on the attitude towards RM that the teacher projected to his/her students. One teacher in particular was not supportive of the system – unfortunately, she taught almost half of the twenty students selected for work with the system (this situation is discussed in greater detail below).

Just as with Hogg, certain internal measures used by the system strongly correlate with student improvement as measured by the improvement index, derived from the pretest-posttest combination's results. The achievement index, which reflects the level students achieved in each topic covered, is one such measure. $R = 0.44$ and $P < 0.051$; if all 43 students that took the posttest are considered, $R = 0.54$ and $P < 0.0002$.

For the relationship between total points earned by students and their improvement index (taken just for the twenty test students), $R = 0.41$ and $P < 0.071$. The correlation of the total number of problems solved correctly in the system to the improvement index yields $R = 0.41$ and $P < 0.076$.

100% of the students at Cypress Grove passed the TAKS. But what is unusual is that the pretest results of the participant group are significantly lower than of the test
group, despite the fact that the participant group has a slightly higher TAKS average (93 as opposed to 91). The TAKS results confirm what RM staff was told about the students of the uncooperative teacher – namely, that they were on average stronger than the other teachers’ students. The pretest results, however, are not in line with this. The RM management has been able to think of only three explanations: first, that the students in the participant group had not yet spent as much time on ratios as the other teachers’ students, second, that the teacher’s negative attitude towards the system came across in the manner in which the pretest was administered, and third, that the small amount of students in the participant group that took the TAKS (only six) skewed the results.

![Spring 2003 TAKS Scores for CGI Students](image)

*Figure 16. Note that the participant group in fact outperformed the reduced test group on the TAKS.*

### Student Attitudes

#### Learning on RM

Overall, the students had very positive attitudes towards learning on RM. Twelve out of nineteen students – 63% – wrote that they liked RM or liked it “a whole lot.” This proportion increases for the students outside of the participant group, where nine of eleven – 82% – indicated they liked or strongly liked the system. Eleven students – among them three (!) participants – indicated that they learned more on the RM system than they did in their regular math class. All but three students found RM to be more difficult than their regular class.
Figure 17. Student attitudes indicate that most were very positive about the system.

Despite the fact that these students were considerably stronger than the students at Hogg, they found learning on RM to be both challenging and difficult. One student, when asked on the attitude survey what he/she liked most about RM, responded “The problems were challenging.” The same student, when asked what he/she liked least, wrote “Some of the problems were so hard that I screamed & cried.”

All nineteen students found RM to be at least of equal difficulty with their regular classrooms, and sixteen found it more difficult. It is a testament to the flexibility of the
curriculum designed by RM’s methodology experts that students among the weakest in the state could learn from it, while students among the strongest found in challenging.

Figure 19. CGI students found RM to be more difficult than their regular classes. Note that not a single student indicated their regular class as more difficult than RM.

Besides finding the system to be difficult, the students also found it highly educational (see Figures 20-22). As one student put it, “It taught you stuff very extensively.” Not a single student in the reduced test group felt that she learned more in her regular class than in the system. Even in the participant group – and recall that the average time spent online is under five hours for this group, and no student in the group spent over 8.03 hours in the system – almost half of the students said they learned more in RM than in their regular class (!).

Figure 20. The nineteen students as a whole felt that they learned more in RM than in their regular classes.
Figure 21. None of the members of the reduced test group felt they learned more in their regular classes.

Figure 22. Even in the participant group, many students felt they learned more from RM than in their regular classes

In the reduced test group, four students wrote that they would prefer to study in RM in the future, four that they would prefer the regular classroom, and three that it did not matter. This is significant, since it shows that students who (1) have the benefit of one of the best classroom experiences the public school system has to offer and (2) did not have the full benefit of games, classrooms, and messages from the genie that students at Hogg did, still prefer RM on par with their standard classrooms, despite the fact that they consider it harder. Of course, the participant group had a more negative attitude
towards RM: only two students preferred RM, two said it did not matter, and four preferred the traditional classroom.

Since, unlike the Hogg students, the CGI students were never all online simultaneously – and in fact most of the time spent with the system was from home – access to multi-user games was limited for lack of partners. Classroom access was also limited, since there were tutors online only during school hours. These factors show up in students’ appraisal of how “interesting/useful” certain modes are. While 100% of the nineteen students found Guided Study useful/interesting, only thirteen (68%) felt the same way about classrooms. For games, only ten students – 53% – felt that the mode was useful/interesting. The experience with Hogg demonstrates that stronger students usually like games; the low approval percentage for the mode among CGI students is most likely a result of their decreased familiarity with the mode (none of the participants ever had access to games, since they had not gotten far enough in Guided Study), and limited access to partners for playing the games. Another factor could have been that several Cypress Grove students were “busted” for cheating on games.

**Attitudes towards Math**

The students of the participant group did not indicate a change in attitude towards math. Six of the eight students wrote that they felt the same towards math, one that he/she liked it more after the project, and one that he/she liked it less after the project. In the reduced test group, however, there was a marked improvement in attitude. **Four of eleven students – 36% – indicated that they now like math more than before,** while the remaining seven indicated no change in attitude. It is noteworthy that fewer than twenty hours of difficult instruction could significantly alter the attitudes of such a substantial number of students.

**The Genie and Guided Study**

The genie was popular with the Cypress Grove students, although to a lesser extent than with the students of Hogg. There were no negative feelings for it, and five of the nineteen students named it as a favorite element of the system. However, the college station students were less eager to make friends with the genie, perhaps because their work with RM was entirely voluntary at all times, and where Hogg students might write email to the genie to kill time, this was not an issue for CGI. **The CGI students did however adopt a more familiar tone with the genie, and some treated it more as a peer than as a mentor.** The students at CGI also tended to be more demanding of the genie, and less tolerant to mistakes in the system – often, emails informing the genie of mistakes they had found in problems had a slightly rude tone, despite the fact that the mistakes were usually not the system’s but the students’. Eventually, these problems were corrected, as the students saw the genie demonstrate its authority by removing points from students caught cheating in games.

As mentioned earlier, **100% of students at Cypress Grove found Guided Study “useful/interesting.”** A couple of students raced through the mode with incredible
speed, spending up to three hours per day online. Inevitably, they soon ran out of material in the mode, and had to wait several weeks until the third unit – material over proportions – was added to the system. Once this happened, the students again jumped into the mode. One student wrote to the genie, “It says that I am done with proportions, but I only worked for three days.” As the reader can verify both from the amount of material created for the system and from the time spent by other students to complete the curriculum, the student’s rapid completion of “Proportions” in Guided Study was not for lack of substance in the unit.

**Learning for the Sake of Learning**

Of the students in the reduced test group, eight of eleven named something related to learning as a primary positive component of the system. Examples include seeing solutions, moving at your own pace, and “Inverse Proportionality.” Even in the participant group, five of eight students fall into the same category. Thus, the students of CGI are as a whole even more consciously oriented towards learning than the students at Hogg, for which the corresponding figure was fifteen of thirty (still an impressive amount for this age group).

**Teacher Attitudes**

There were three teachers at Cypress Grove. Only one of these teachers filled out a questionnaire; of the other two, one wrote two messages in which he praised the program, and the other – and this is the same teacher that significantly limited her students’ work in the system – did not provide any feedback.

Even among the two teachers that did give feedback, opinions were varied. One teacher did not feel that the RM program had benefited her students. She wrote, “Only two out of five kids continued to participate consistently. It was very difficult to keep the others motivated to continue using the program… My Advanced students who participated in the RM program were already more experienced with ratios, before they started the program, compared to the rest of my class.” This opinion is partially corroborated by the data for student achievement; this teacher’s students spent less time in the system compared to other students in the reduced test group (around 13 hours average as compared to 18 hours), and their average improvement index was 24% less than the average for the other reduced test group students. However, this teacher’s conclusion is not corroborated by the student attitude surveys, which show all four of this teacher’s students that took the attitude survey indicated that they learned at least as much from RM as they did in the regular classroom, despite the fact that some spent as little as eight hours logged on.

The other teacher had a very positive impression of RM. He wrote, “[I] know that my students have greatly enjoyed and surely benefited from the Reasoning Mind

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* For complete responses to the teacher questionnaire and for original correspondence from teachers, refer to Appendix D.
program.” All but one of his students finished the entire Guided Study curriculum, and the one student that did not was very close to finishing. This teacher's students also showed a significantly higher improvement index than the students of other teachers.

These results indicate that the RM program’s success depends heavily on what teachers make of it. If a teacher does not give his or her students enough time to work with the program, the program’s benefit will be minimal. If a teacher takes a neutral attitude to the system, there will be sure benefits to the students. Finally, if a teacher succeeds in encouraging his/her students to work in the system, then the results can be very positive and significant for every student.

As in Hogg, none of the teachers chose to log into the system with their accounts. Thus, none of them had any first-hand experience with the system's educational processes.

Karin Horn, the Technology Facilitator of Cypress Grove Intermediate School as well as of the College Station ISD participated in the project, helping RM both with administrative and technical issues as they related to the project at CGI. Ms. Horn took an active interest in the project, and frequently checked in on students while they worked with the system. While she was not the classroom teacher of any of the students, Ms. Horn had the advantage of being able to observe students while they were at work in the system – something their teachers were not able to do, since the students worked with RM during class time. Her questionnaire was very positive; Ms. Horn wrote, “I believe the RM system is an excellent tool for addressing the individual needs of students. The RM system can challenge not only those who are ready to excel, but also help those who might need extra time with a particular objective. As a classroom teacher, I would welcome a system like Reasoning Mind as an additional resource for math, or any academic subject.” Ms. Horn also mentioned that computers were a very positive factor, helping gain students’ interest.

**Cheating and Loopholes**

Cheating was minimal in the system. This was the case for two reasons: (1) the system did not afford many opportunities for cheating, since almost every answer was checked, and (2) all activities of students were visible via the activity logs and Study History tools. Nevertheless, some cheating was observed in multi-user games, where the system did not require answers, expecting students to check each other’s work.

Students were encouraged to report loopholes that they found to the genie. Just as they would receive points for uncovering mistakes in problems, the finding of loopholes and ways of earning “easy points” was rewarded. This led to an especially interesting sequence of events involving the game “Dino Island.” These events are discussed below.

**Cheating on Multi-User Games**
One shortcoming of the system was that the multi-user games counted on students to carefully examine each other’s answers and solutions, finally deciding on who was right and who was wrong (to make this decision, students had access to the system’s solution to the problem in question). This meant that two students who were friends could simply agree that the answers were always right, thereby accumulating points without actually correctly solving problems. Indeed, this loophole did not take long to come up – students from Cypress Grove were soon caught cheating. “Caught” is a somewhat misleading word here; it was not very difficult to “catch” cheaters, since everything they did showed up in the activity logs, which were regularly perused by RM staff and tutors.

The genie sent emails to the offending students, first warning them, and then – upon the second offense – removing all points earned for games. Such disciplinary action was only applied several times, since the students quickly stopped cheating, either having had points removed or seeing their cheating peers lose points.

**The Dino Island Hack**

In the game “Dino Island,” the system used a method in higher levels to determine a limit on the number of dinosaurs of each type available to students; this method depended on the number of dinosaurs needed to solve the problem, and gave the largest number of dinosaurs that it was possible to give without allowing for more than one solution to the problem. The students at CGI were able to use this dependence to find “shortcuts” to solving Dino Island. The interesting story that ensued began with the following email message to the genie:

*Genie*

_In Independent Study, I can't get any problems except for maybe Level A in Ratio Basics. I've tried everything else and all I can do now is Dino Island, which Level 4 is easy because of this: take a T-Rex (or a brontosaurus) group off the pile and hold it there, okay, and you divide the remainder by 2, then you add the group you took off and that's the number you need to put on for your answer. It's tried and true!! (except for times when you can still make the number smaller.)_

Of course, the RM staff was intrigued by this message, although it took quite an effort to figure out exactly what was meant. The first part was simple enough – the student was reporting a perceived technical problem that was keeping her from Independent Study. In the second part, she was describing a “cheat” that had been created, and which was not only incredibly intricate, but also quite random – it involved removing a group of dinosaurs from a pile, seeing how many were left, dividing them by two, and then adding to that the number of dinosaurs in the original group removed! Going back to the formulas used for generating the Dino Island data sets, the staff saw

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*In the messages given in this section, spelling and capitalization errors have been corrected in those places where they detracted from readability without enhancing the content. Grammar and syntax has not been changed.*

*Reasoning Mind, Inc.*
that the hack was indeed valid, and dependent on the generation of the dinosaurs in the pile. The algorithm was changed, and the genie wrote back:

Hi Rachel!

I checked the Dino game and discovered that you are absolutely correct. Thanks for letting me know! This is a very smart shortcut for finding correct solutions! I want to award bonus points to the student who found it. Please let me know if that was you or somebody else. In addition I'll be awarding bonus points to you for reporting this shortcut. Also, I'll have to disable the shortcut, since it was not supposed to be there in the first place.

Best,
The Genie

Not much time had passed when the genie received both a response from Rachel and a message from the hack’s other (and, as it was determined, primary) creator:

Genie,
I only figured out part of the solution. Unfortunately, I can’t remember the name of the person who figured it out too. I wish I did remember, though. I would rather be honest and only get some points instead of being dishonest and getting all of them. But now I will be really ready for the test!
[Rachel]

Rachel told me that she sent you about the dino island method that was figured out by me. I just wanted to tell you because she said that you might give her some points so please give me the points thank you very much.
Sincerely, boy who wants points,
Ali E________

Points were awarded – in fact, 100 points to Ali and 70 to Rachel* – and it seemed that the situation had come to an end. However, the surprises continued, as one day later messages were received from Rachel and Ali with another method, which worked with the new data set generation algorithm that had been set up. Apparently, the students were alternately working together and against each other in a race to find the new loophole. The color seen in Rachel’s email is original – the students often used the system’s highlighter tool to add some flavor to their messages.

I found a new cheat for Dino Island. On Level 4, you do the old cheat for the T-Rex, but on the brontos, you take off a group and divide the remainder by 2, but DON’T add the group you took off back.
I have also been told by my fellow students not to tell you this.
Rachel

The first number, take one unit away and the number left, divide by two and add by 5 and the second number, take away one unit and divide the remaining number but what is

* As an idea of the value of a point, a typical problem of average difficulty is worth around 5 points, and the cost of prizes ranges from around 200 points to over 1,500.
different than the first is that you do not add that one unit when you divide by two on the second number unlike the first. That is what I did to find it out.
Ali E_____,
the bell rang, talk tomorrow.

Needless to say, the genie was very impressed with the students’ game-cracking abilities. More points changed hands, and a random number generator was attached to the Dino Island algorithm to ensure that no more hacks could be found. Rachel commented on this when her and her peers’ attempts to find a third loophole ended in (inevitable) frustration:

Boy, you sure did a good job of getting rid of the cheats. I haven't found a single one through my careful nit-picking! Oh well. I wish there still was. I could use a few points!
Rachel F.

This sequence of events serves to demonstrate several interesting facts both about the RM system and the students of Cypress Grove Intermediate. First, students are willing to do practically anything for points. The points bring in prizes, but above all they are a numerical indicator of approval. A student with points is comfortable that he is doing what is required of him. Secondly, many students are more than willing to look past the constraints of formal educational systems and explore other aspects of systems, be they mental constructs or actual computer systems like the Dino Island algorithm. The RM point system showed its incredible flexibility in relation to such situations: student exploration can be rewarded, and moreover it can be rewarded proportionately to the effort expended and result reached.

The third fact that these messages bring to light is that while many students are very bright and imaginative, they are weak at expressing their mathematical and procedural thoughts. Ali’s second message presents both sides in stark contrast: on the one hand a description of an intricate scheme for generating general solutions, and on the other a redundant, unclear, and poorly organized description of that scheme. It goes without saying that an ability to express mathematical thought is key to the development of abstract reasoning faculties, and therefore must be given greater importance in middle school education.

Another fact that an analysis of the emails given here suggests and that the entire body of emails to the genie makes all too obvious is that the students of CGI – to a much greater extent than those of Hogg – partake of an informant culture. Quite a few emails came in to the genie with explicit denunciations of specific students in addition to more vague references, such as Rachel’s “I have also been told by my fellow students not to tell you this.” Whether this informant culture is a good thing or a bad thing is subject to discussion, and opinions are varied. Nevertheless, its presence is a fact that must be documented.
Since participation in the RM program was entirely voluntary at Cypress Grove, it was intended for parents to play a more important role than at Hogg. A meeting was held in January where most of the nominated students and their parents were given a presentation of the system and told what they could expect from it. All of the nominated students agreed to participate in the project. Exactly half of the parents indicated at a later time that they were interested in receiving information about the progress of their child in the system. This information was in the form of (1) occasional emails from RM staff and (2) an account under which parents could view the activities of their children with RM’s report tools.

Most parents – to the best knowledge of RM – did not take advantage of their accounts, since only two explicitly stated that they had used the accounts, and none of the other parents entered any modes. It cannot be determined how many parents logged on, since only activities in modes are recorded by the system. One parent, who did log on, found the website useful. The parent wrote, “Thank you for developing the site for the parents. It looks good. I can already see where Elyssa is having some problems.” Three other parents filled in the questionnaire at the end of the class. All three perceived RM as a very positive influence on their children, although they did not spend very much time monitoring their children’s progress – one parent explained, “Emily normally is so motivated that I don't have to push her as I do some of my other kids.” One parent wrote, “Math has always been one of my favorite subjects, and I have taught Nathan at home to supplement the school curriculum. However, he hasn't particularly enjoyed it – until now.”
One student, Johanna, spent practically no time in the system at first; close to the end of the project, her parents learned this from an email from the RM staff detailing her progress. They then took an active interest in Johanna’s work in the system, and her mother wrote on the questionnaire: “It seemed to take Johanna a while to get going on it. Possibly because they didn’t always have a set time in class when they were going to do it? It was only when she set aside time to work on it at home that she really got going with it. Then she really enjoyed it and also enjoyed being able to track her own progress.”

Despite the limited amount of data on the subject, certain conclusions can be drawn about the role of parents in the project. It can be seen that parents are usually interested in receiving information about their child’s progress, although they do not always have time to spend on sorting out this information or on acting on it. Also, parental involvement, where it is present, can have a very powerful influence over a student’s work in the system. The exact responses to the parent questionnaire as well as correspondence from parents can be found in Appendix E.
Hogg and Cypress Grove: Similarities and Differences

Friends with the Genie

Students at both schools made friends with the genie. The friendships at Hogg were often somewhat closer than at Cypress Grove, but this is likely due to the fact that students at Hogg are mostly disadvantaged and do not have as many toys; the genie was a highly unusual experience for them, while it was less of a surprise for the CGI students. Another reason is that students at Hogg had much more time to bond with the genie, since they had regular classes in the system. Finally, students at Cypress Grove were much more goal-oriented; when they were in the system, they knew exactly what they wanted out of it: to play games, to learn ratios, to get points, etc. Thus, they viewed the genie more as a means, and not as an end in itself.

Educational Impact and Attitude

Beyond a doubt, the educational impact at both schools was very strong. However, what is not immediately obvious is that the impact as measured by the pretest/posttest combination was even stronger for the reduced test group of CGI than it was for the students at Hogg – compare the average improvement indices of 0.28 and 0.25, respectively. The reason for this is probably twofold: (1) the CGI test group consisted of students that were mostly motivated to learn and (2) the students at CGI were more prepared for the study of ratios. As can be shown by correlating the improvement index to the prequalification test score for Hogg students (see “What RM Learned from the Project at Hogg”), students that were more prepared going into the program came out with more knowledge of ratios. However, it should be noted that Hogg students were taught much by tutors that did not fall under the subject of ratios, since many prerequisite topics had not been studied. This sort of knowledge is not measured by the improvement index, since the pretest and posttest cover exclusively ratios and proportions.

Attitudes at both schools were very positive, but at Hogg they were even stronger than at CGI. In particular, more students at Hogg indicated that they preferred RM over their regular classrooms. It is likely that this is caused by the better learning experience of students at CGI. Nevertheless, the key indicator in the eyes of Reasoning Mind is how much students learn. In both schools, students unambiguously reported learning more in the RM system than in their regular math classes.

It should be noted that certain modes met with success in both schools. Guided Study, for example, was extremely popular. Games were also very much in demand, and students from both schools asked for a greater variety of games to be included in the system.
What the Students Know and What They Are Like

While there are many differences between the learning attitudes and states of knowledge of the students at the two schools, some very important qualities can be observed in both groups. One such similarity is a lack of familiarity with theoretical knowledge as a concept. **Students at both schools found reading theory material and thinking in terms of “why” as opposed to “how” to be very difficult.** Students at both schools wanted problems, not concepts. In addition, both groups of students placed a very high value on *speed* as opposed to accuracy. The average percent accuracy at Hogg was 60%, and at Cypress Grove 71%. While it is true that the point system in the current implementation inadvertently worked to encourage speed, that encouragement only served to amplify the students’ fundamental attitude.

The system was challenging for both groups of students. Many of the advanced Cypress Grove students commented on the difficult problems, and indeed level C problems could be very involved. As mentioned previously, one student at Cypress Grove felt that some of the problems were so hard that they made him/her “scream & cry.” Consider, for example, the following level C problem over rates:

Brian was thirsty for coffee. He made two 100 mL cups, and put sugar into both. In the first cup, the concentration of sugar was 0.29 grams per mL, and in the second it was 0.09 grams per mL. Brian tasted the second cup, and decided it was not sweet enough. He drank $\frac{1}{10}$ of the coffee in this cup, and then filled it up again from the first cup. What is the new concentration of sugar in the second cup?

Some students were understandably offset by the difficulty, and these students chose not to work on level C problems, instead completing the curriculum at level A. In both schools, there were examples of students that did this, only to ask that they be returned to a previous point in Guided Study so that they could repeat the material at level B or C.

On the pretest, there were eleven level C problems. Collectively, all thirty students in the Hogg test group solved exactly that number – eleven – level C problems. However, several students at Hogg completed *the entire curriculum* at level C, which entails a certain proficiency in solving problems like the one given above. It is therefore no surprise that on the posttest, the students collectively solved 71 level C problems, and there were students that solved up to eight (!).

One major difference between the Hogg and Cypress Grove students was the required number of tutors. Four to five tutors were usually necessary to service a Hogg session. In Cypress Grove by contrast, where students knew prerequisite topics better, one tutor was kept online at first, and then none when it was realized that this tutor was not in demand.
Working from home was far more common for the Cypress Grove students. Many of them worked primarily after school hours, compared to only a few at Hogg. One reason for this is that the nominated CGI students were more likely to take an interest in math outside of compulsory studies. However, a greater role was probably played by the fact that CGI students in their majority had access to the RM website from home, while Hogg students did not.

**Classroom Setup**

The ways in which the Hogg Middle School and Cypress Grove Intermediate students worked with the system were radically different. The Hogg students sat for a fixed period of time in a class under the direct supervision of teachers and in addition to their normal studies. The CGI students, by contrast, worked with the system when they were released from their normal class for that express purpose, and also from home. They were not under the supervision of any teacher, and their grades in no way depended on success in the system. Moreover, Cypress Grove students’ sessions were usually just fifteen or twenty minutes, compared to the one and a half hour sessions of Hogg students. Another major difference is that Hogg’s students had already completed their school study of ratios, whereas CGI students studied ratios concurrently with work in the Reasoning Mind system.

The radical difference in the learning setups clearly did not heavily influence the outcome; the incentive system and other factors led both groups of students to work productively in the system. This fact is confirmed by a comparison of the students’ improvement indices.

**The Reward System**

Points were cherished – and guarded – equally by students in both schools. The genie regularly found itself replying to emails wondering about where a point or two had gone,* or why a problem had yielded fewer points than other problems of the same sort. Moreover, this infatuation with points seemed to be only very loosely related to a desire to obtain prizes, which – although it was certainly present – played only a secondary role in maintaining the students’ interest. Only three of nineteen students at CGI and nine of thirty students at Hogg named prizes as a major positive factor in the system.

An interesting observation made by RM staff members was that there was a fundamental difference in how boys and girls approached prizes: girls bought small prizes as soon as they had enough points. Boys however preferred to store up their points until they had enough to buy a single big prize, such as a remote-controlled car (these

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* Recall from earlier that the least expensive prizes – for example gel pens – were typically worth around 200 points.
were quite popular). This occurred despite an effort on RM’s part to obtain prizes suitable to both sexes at all value levels.
Conclusion

Reasoning Mind has judged its 2003 pilot project a success. The project has served a twofold purpose: first, it has demonstrated the effectiveness of Reasoning Mind’s educational philosophy and approach to teaching, and second, it has provided the company with a veritable wealth of information about learning, and Internet learning in particular. The lessons that the company has extracted are already influencing development decisions for Reasoning Mind’s next web-based environment.

Reasoning Mind would like to urge the reader to examine W. A. Weber’s report, *An Evaluation of the Effectiveness of the Reasoning Mind Pilot Program at Hogg Middle School*, if this has not been done already. That report offers an important objective view of the project, and complements the opinions and conclusions drawn in the present document.

Reasoning Mind understands the vital importance of the joint effort to improve the nation’s education system. It is hoped sincerely that this project, as well as the ones that will follow, will contribute as much as possible to this truly critical effort.
Glossary of Terms Used in the Report

An Evaluation of the Reasoning Mind Pilot Program at Hogg Middle School – An external statistical report created by W. A. Weber. The report analyzes educational impact and student attitude with a rigorous scientific approach.

Achievement Index – An index from 0 to 18 determined by the level of mastery a student reached on the three topics (ratios, rates, and proportions) addressed in the RM curriculum.

Activity Logs – Records of all activities in every mode. The activity logs are searchable and were used extensively by tutors and administrators.

Attitude Survey – A questionnaire given to all participating students at the end of the semester, to determine their attitudes towards the system, the system's educational impact, and towards math in general.

CGI – Cypress Grove Intermediate, one of the two Texas schools at which the pilot project took place. See also “Cypress Grove Intermediate.”

Classrooms – Virtual classrooms, in which students received lessons from online tutors.

Cypress Grove Intermediate – A strong intermediate school in College Station, Texas, the home of Texas A&M University. Twenty students at Cypress Grove participated in the pilot project.

Diagnoses – Set either by tutors or by the system, diagnoses catalogued observed lapses in knowledge.

Dino Island – An interactive game where students dragged dinosaurs onto an island. The game developed mechanical ratios skills.

Game Room – The mode in which students could play games – namely, Multi-User Games and Dino Island.

The Genie – An animated character that guided students through the learning process.

Guided Study – A mode where students read theory material and solved problems, led by the system. The genie was present at all times in this mode.

Hogg – Hogg Middle School, one of the two Texas schools at which the pilot project took place. See also “Hogg Middle School.”
**Hogg Middle School** – An inner-city, predominantly Hispanic Houston school. Thirty students at Hogg participated in the pilot project.

**Improvement Index** – A value between 0 and 1 determined based on a student's pre- and posttest scores. The improvement index is the number of problems by which a student improved, divided by the number of problems by which the student could have improved.

**Independent Study** – A mode where students could choose which topics they wanted to study, and what difficulty level problems they wanted to solve.

**Level C problems** – The most difficult category of problems available in the system, level C problems taxed the abilities of even the most able students.

**Multi-User Games** – In multi-user games, students took turns solving problems and checking each others' solutions.

**Objective 2** – TEKS Objective 2 is defined by the Texas Education Agency as "patterns, relationships, and algebraic reasoning." Hogg students in the test group outperformed the control group on this objective by 35%.

**Participant Group** – A group of eight Cypress Grove students that did not spend sufficient time in the system.

**Points** – Points were given to students for everything they did in the system, and could be exchanged later for prizes.

**Posttest** – An internal test given to students at the end of the semester to determine their knowledge of ratios and proportions. The posttest was basically just another version of the pretest.

**Prequalification test** – A test given to 229 Hogg Middle School students to determine their knowledge of concepts prerequisite to the study of ratios and proportions. Partially based on the results of this test, sixty-two students were selected to form the test and control groups.

**Pretest** – An internal test given to students prior to study with the system to determine their knowledge of ratios and proportions.

**Reasoning Mind** – A non-profit Internet education company. This report describes Reasoning Mind's first pilot project.

**Reduced Test Group** – A group of twelve Cypress Grove students that spent considerable time in the system. The remaining eight students in the test group did not spend sufficient time, and thus comprise the "participant group."
Reference Section – A section of the system where students had access to theory material, a glossary, unit conversion tables, and divisibility rules.

Reward System – The system by which students earned points, which they could later redeem for prizes.

Riddles – Problems requiring creative or non-standard thought. Riddles were accessible to students through Independent Study or through Multi-User Games.

RM – See "Reasoning Mind."

The RM Genie – An animated character that guided students through the learning process.

Stanford 9 – A standardized test given to students at Hogg Middle School less then halfway through their work with the system.

Study History – A tool used for viewing the history of a student's progress through the RM curriculum.

The system – The web-based learning environment created and piloted by Reasoning Mind.

TAKS – See "Texas Assessment of Knowledge and Skills."

TEKS – See "Texas Essential Knowledge and Skills."

Texas Assessment of Knowledge and Skills – The standardized state-mandated test that recently replaced the TAAS (Texas Assessment of Academic Skills).

Texas Essential Knowledge and Skills – The Texas state-mandated curriculum guidelines that establish what every student in the state should know.

Tutors – A geographically and professionally diverse group of individuals that gave online lessons to students in virtual classrooms.
Appendices

Appendix A: Photographs Taken in the Classroom

Students at Cypress Grove play Dino Island
A student at Hogg works in Guided Study

Some students from Cypress Grove present their achievement certificates
A Hogg student receives an achievement certificate from an RM staff member

Some CGI students on prize redemption day
A CGI student ponders a problem in a Multi-User Game

A student solves problems in Guided Study
A CGI student works in Guided Study next to her new achievement certificate

Some Hogg students at work
A student helps her friend with a problem

Hogg students at their computers
A student uses her notepad to solve a problem. All students were given notepads, and these were used quite extensively.
Appendix B: Student Quotes*

There were many wonderful quotes that came up either in messages to the genie, in classrooms, or on the attitude surveys. Since only a few could be used in the body of the report, some selected quotes have been placed in this appendix. The quotes are grouped thematically.

About the RM System

Hi genie I just wanted to say hello. I have learned a lot from this program if it wasn't for this I wouldn't be that good on math. Thank you.

-Carmen R.

***

“It taught me a lot of new material in a fun way.”
- A student’s response, when asked what he/she liked most about the system

***

“You would be encouraged to do math because of the points.”
- A student’s response, when asked what he/she liked most about the system

***

“It was cool!!!!!!!!!!!”
- From a student’s attitude survey

***

“It was fun and great to miss class.”
- From a student’s attitude survey

***

“When the genie after the question gave me a solution so that I could understand it better.”
- A student’s response, when asked what he/she liked most about the system

***

* Some of the names presented in this report have been changed to protect the privacy of the students.
“I hope that it continues on and on so that other kids could have as much fun learning as we did.”
   - From a student’s attitude survey

***

“We only have 1½ hours of class.”
   - A student’s response, when asked what he/she liked least about the system

***

“That they show you how you’re supposed to do it!”
   - A student’s response, when asked what he/she liked most about the system

***

“I loved the problems that they gave me & also learned a lot by this system. If it wasn’t for this class I wouldn’t be this smart as I am now.”
   - From a student’s attitude survey

***

“RM is a really cool website and it really help me in my math. I got to learn many things. I had a great time.”
   - From a student’s attitude survey

***

“I liked the games, animations and the most interesting thing was the points.”
   - A student’s response, when asked what he/she liked most about the system

***

“I liked that there were references to look up instead of asking. The tutors were the best because they helped me with problems.”
   - A student’s response, when asked what he/she liked most about the system

***

“I learn a lot of stuff about RM like that helps kids on math.”
   - A student’s response, when asked what he/she liked about the system

***

Hello Genie,
I was just sitting here doing my math problems when the question struck me. Are we going to be able to log on to rm in the summer time? It would keep our minds fresh and we wouldn't have to start all over when school starts again. You should think about it. write back asap.

Thanks,
-Lisa

The Genie

dear rm genie,

thank you for your encouragement I will try my best to pass guided study thanks again

[Ramon V]

***

Dear Carlos,

You’ve been doing a great job lately, and I’m very proud of you! I’m especially impressed by the great solutions you’re writing to every problem. Nice work! :)

Your friend,
The Genie

Thanks. I been trying my best to write good solutions. There getting pretty hard and I don't mind getting some advice on rates. Maybe I should try not to consitrate so much on the problems. I got to relax every once in a while, I guess. What do you think?

[Carlos]

***

Say genie wuz up. I’m writing you to tell you that if you can give me 0.2 points. The reason I want those points is so I can have a whole number of points. If you can do this thanks.

Sincerely; Mario H.

Hi Mario!
You've done a great job lately! I am really proud of you. You also know what a whole number is. For all of this I believe you deserve to get the extra 0.2 points. Enjoy and keep up the great work you are doing!

Your friend,
The Genie

***

Genie,

Thank you for your good advice and I hope that I pass the test because I really want to finish guided study so I can play games and a lot of fun things on your website. Thanks for everything and for having patience on everything that I did wrong. Your a wonderful Genie keep up the good work. I would be glad to keep writing to you during the summer. At home. Well let me go because I want to work a little bit on Independent study or guided study before the test.

Thanks for your advice,
Rita R_____

***

dear genie
I request you make problems a little easier for me on guided study
Hector

***

Dear Teresa,

You get three chances to solve each exercise. If you get it the first time, you get 2 points and move on. If you answer correctly the second time, you get 1 point and move on. If you answer correctly the third time, you move on, but you don't get any points. I hope this answered your question! :)

Best,
The Genie

Genie,
I get the concept but that's a rip off. (no offense)
-Teresa

***
if you're so smart figure this out 987.32547 ÷ .3258474 + 987.2548 x 3.1417927 =
send me the answer now!!!!!!!

[Jared R.]

Hi Jared,

I am the Genie, not a speedy calculator. My training and knowledge have been in a different domain. I am sure that you are smart enough to understand this.

Best,
The Genie

***

Genie,
I want to get 1,000 more points before the end of the year. Is there a way that you could help me reach this goal?
Sincerely,
Nathan C_______

***

Genie,
Is there any food that I could eat that would stimulate my brain?
Nathan C_______

A Conversation with the Genie

Hello Genie,

HOW ARE YOU DOING TODAY? ARE YOU HAVING FUN INSIDE THE COMPUTER? HOW DOES THE COMPUTER LOOK FROM THE INSIDE? ARE YOU REALLY A SMART PERSON? DID YOU WENT TO SCHOOL OR WERE YOU JUST PROGRAM TO HELP US WITH OUR WORK? GENIE DO YOU THINK YOU ARE THE SMARTEST PERSON IN THE WHOLE WORLD?
-Teresa

…

Hi Teresa,

I didn't have the chance to answer all of your questions in my last e-mail, so I've sent this one. It's kind-of tough being in the computer, since there isn't much room, but it's fun teaching you guys. As far as your question if I am really smart, you have to remember
that I'm not a normal person, but a genie. So of course I'm smarter than any people are, but about average as far as genies go. I got my education in a genie college, in Egypt (that's where most genies come from).

Best,
The genie

...

Can I go to college in Egypt so I can be as smart as you?
-Teresa

...

Hi Teresa!

Sure you can go to college in Egypt! I can help you learn ratios and proportions, so eventually you can go to college anywhere you want! :) But you know, Egypt is very far away -- are you sure you would want to go to college that far away from home?

Your friend,
The Genie

...

Of course I would like to go to a college that far! Are you asking me because you don't want me to go to that college?
-Teresa

...

Hello Teresa!

No, I think that it would be great if you went to college in Egypt. The climate is hot, but there's lots of interesting stuff around, like the pyramids and the Nile.

There's a city in Egypt called Alexandria that used to be the most important city in the world for learning things. That's where I'm from; it's on the Mediterranean Sea, so there are lots of beaches, and the views are beautiful!

Best,
The Genie

...
Ok Genie I'll tell my mom if she allows me to go to college that far away from home.
-Teresa

...

Hello Teresa!
That's good! Maybe someday, you can become a genie like me! :)
-The Genie

...

That would be so good, but I am not as smart as you are. I will try to be as smart as you but is almost imposible. Genie have you been smart all your life?
-Teresa

...

Thanks Genie you are so nice. Are you enjoying yourself and having a good time?
-Teresa

...

Hi Teresa!

Of course I'm enjoying myself -- I get to teach smart kids like you! And it's not true that you're not as smart as I am. It's just that I'm much older -- I've been around for five thousand years, in fact. I think, though, that you're definitely genie material. Just keep learning things, and you'll be as smart as me!

-The Genie

...

Genie exactly how old are you? I'm 13.
-Teresa

...

Hi Teresa!

I'm 5,764 years old. Although that seems like a lot, it's actually pretty young as far as genies go. However, I've only worked as a computer genie for about thirty years; before that, I was a regular (lamp) genie. :)

Your Friend,
The Genie
How old has the oldest genie been?
Your Friend
Teresa

Hi Teresa,

I don't think anyone knows for sure; it was very, very long ago. I would say definitely at least 10,000 years, and probably even more. Most of the really old genies still live in Egypt or in Persia, working out of lamps for sultans. Some young professional genies, like myself, have moved to Europe or to the U.S.A.

Best,
The Genie

Do you ever plan to go back there? Do you have family members over there?
-Teresa

Classrooms

Dear Genie,

I went to a classroom and learned more about ratios. Thank you for advising me.

bye,
Veronica

***

Dear Genie,

Hi, how are you doing? I am fine I just need to ask to send me a tutor so they can help me with the problems I am doing about finding the density of something or the volume. I don't really understand how to do this I need a little push.

Rita R_____
“Yes, that I’ll miss the program and the teachers.”
   - A student, asked on the survey if there was anything he/she would like to add

***

“The way we can get tutors if we don’t understand.”
   - A student, asked on the attitude survey what else he/she liked about the system

***

“That there were tutors there to help us.”
   - A student’s response, when asked what he/she liked most about the system

***

**Students Ready for More…**

Genie,

Can you sent me a player for the gameroom please. I am bored and I want to play in the
game room.

Rita R_____

Friday, 11:48 P.M.

***

dear genie,

I want to do proportions on guided study but it says I have been taught all the theory material that I can be taught.

Lisa

***

It says that I am done with proportions, but I only worked for three days.

Dillon

[What this student failed to mention in the email is that he averaged about three hours online per day…]

***
Boy, you sure did a good job of getting rid of the cheats. I haven't found a single one through my careful nit-picking! Oh well. I wish there still was. I could use a few points! Rachel F.

Hi Rachel!

Why thank you, I'm flattered! :)
Don't look for cheats so hard you forget about ratios... :)

Good luck,
The Genie

Like I could EVER forget about that! };p
Rachel

***

Dear Genie

I'm sending you this letter because I want to get a head start on proportions and I was wondering if you could send me something to study on for the next week.

sincerely,
HECTOR D
Appendix C: Hogg Middle School Teacher Questionnaires

Teacher A

1. *In your opinion, were the students engaged and interested in the RM class? Please explain.*

I found that the students were engaged and eager to work with the system. They seemed especially fond of the genie and many enjoyed working with the tutors. There was very little off-task behavior because the students were engaged and motivated with the program.

2. *Do you think RM is good for the students? Do you believe it could be a useful tool for teachers like you?*

I think anything that captures students’ interests and gets them excited about Math is a good tool. It is good for teachers because it is a way to “hook” those students that are hesitant about doing Math and challenges them once they are working in the program.

3. *Is there anything else you'd like to say about RM?*

RM is a unique program that grasps the students attention and gets them motivated to work challenging Math problems.
Teacher B

1. In your opinion, were the students engaged and interested in the RM class? Please explain.

Most of the students were actively engaged and interested in the RM Program. I noticed that some of the students improved in their regular math class which I believe stems from the RM Program.

2. Do you think RM is good for the students? Do you believe it could be a useful tool for teachers like you?

I think it is a great program. However, I don’t feel it is a program for all students. The students that lack motivation and/or drive will not benefit from this type of program because they can’t stay focused.

3. Is there anything else you’d like to say about RM?

Great concept, great program!
Appendix D: Cypress Grove Teacher Questionnaires

Teacher A

1. In your opinion, were the students engaged and interested in the RM class? Please explain.

I do not believe that a majority of my kids were interested in RM. Only two out of five kids continued to participate consistently. It was very difficult to keep the others motivated to continue using the program.

2. Do you think RM is good for the students? Do you believe it could be a useful tool for teachers like you?

Overall, I did not see RM as a useful tool in my classroom. My two students who continued the program were already motivated to learn on their own. The program only focused on “Ratios” at all levels. It did not contain enough 6th Grade TEKS.

3. Is there anything else you'd like to say about RM?

RM needs to use all 6th grade TEKS in its program. It was very difficult to see the progress with just one objective, “ratios”, throughout the semester. My Advanced students who participated in the RM program were already more experienced with ratios, before they started the program, compared to the rest of my class.

Teacher B

I […] know that my students have greatly enjoyed and surely benefited from the Reasoning Mind program. Thank you for all of your hard work and I wish your program success in the future.

I think my students have really enjoyed working in the Reasoning Mind program and have benefited greatly from it…..Once again I thank you for your time and hope that the Reasonging Mind program continues to expand.
Technology Facilitator

1. In your opinion, were the students engaged and interested in the RM class? Please explain.

Each time I observed students working in the Reasoning Mind system, they were engaged in the online activities and/or discussing the subject with each other. Several students chose to work in the system outside of their regular class time, which indicates they found it interesting enough to give up their free time.

2. Do you think RM is good for the students? Do you believe it could be a useful tool for teachers like you?

I believe the RM system is an excellent tool for addressing the individual needs of students. The RM system can challenge not only those who are ready to excel, but also help those who might need extra time with a particular objective. As a classroom teacher, I would welcome a system like Reasoning Mind as an additional resource for math, or any academic subject.

3. Is there anything else you'd like to say about RM?

Because the RM system is delivered via the Internet, on computer, I believe it has built-in motivation for students. Technology is the method of choice for many of our students, especially gifted and at-risk! Given the opportunity to do pencil/paper or computer projects or testing, the students prefer the computer, which gives the Reasoning Mind program a tremendous advantage in helping students learn and succeed.
Appendix E: Cypress Grove Parent Feedback

Parent Questionnaire: Mrs. B______

1. In your opinion, was your child engaged and interested in the RM class? Please explain.

It seemed to take Johanna a while to get going on it. Possibly because they didn’t always have a set time in class when they were going to do it? It was only when she set aside time to work on it at home that she really got going with it. Then she really enjoyed it and also enjoyed being able to track her own progress.

2. Do you think RM was good for your child? Do you believe it could be a useful tool for parents like you?

I think so. I think it’s good to challenge children by offering them material in a variety of ways. Most children like to use computers anyway and it’s a fun medium to learn in. All three of our children are advanced and we are always glad when they are offered extra challenges – so yes it is a useful tool for parents like us.

3. Have you logged into the RM website to track your child's progress? Did you find it useful for this purpose?

I had trouble logging in with my own password so I just used Johanna’s. I don’t know if I was able to get the full gist of it that way – if there was extra information on the parents’ log-in, or not. But I do think it’s very important for parents to have access to what their children are doing.

4. Is there anything else you'd like to say about RM?

I think it is interesting and quite well done. Johanna was frustrated a few times when she saw more than one solution, because something was not specified. So, one improvement that we may suggest, is making sure that questions are not ambiguous in any way. All in all we enjoyed it. Thank you very much.

Will you continue working with students at Cypress Grove? We have a 5th Grader there this coming school year.
Parent Questionnaire: Ms. H_______

1. In your opinion, was your child engaged and interested in the RM class? Please explain.

I think Emily was engaged and did find the class interesting. Emily has always been a student who enjoys learning independently of the classroom, so this pilot project was "right up her alley". She also enjoyed the rewards for reaching certain goals.

2. Do you think RM was good for your child? Do you believe it could be a useful tool for parents like you?

I do think the RM was good for Emily. It can only help a student to learn extra information outside the classroom, even if they occasionally miss parts of their normal work. It could be a useful tool for a parent, but I did not use it as I probably should have.

3. Have you logged into the RM website to track your child's progress? Did you find it useful for this purpose?

I did log in once. Just didn't follow up. I think it is useful. Emily normally is so motivated that I don't have to push her as I do some of my other kids. Therefore, I did not check on her progress as much as I probably should have.

4. Is there anything else you'd like to say about RM?

I appreciate your work and that Emily was included in the pilot.
A letter from Mrs. C______

Dr. Khachatryan,

Thank you for the update on Nathan's progress in the Reasoning Mind project. Nathan has enjoyed the math very much, and we appreciate the opportunity given him to participate. Math has always been one of my favorite subjects, and I have taught Nathan at home to supplement the school curriculum. However, he hasn't particularly enjoyed it – until now.

I'm sorry he hasn't been able to participate from home. We are in the midst of building a home and continuing to get settled here after moving last year. Our rental does not have the best access available, nor do we have the latest software. We do plan to be current shortly; would Nathan be able to access the site during the summer?

Thanks again for the opportunity.

Regards,

Karen C______

A Letter from Dr. T______

Alex-

Thank you for developing this site for the parents. It looks good. I can already see where E______ is having some problems. Thanks again and all the best!
Appendix F: Highlights of RM’s Math Teaching Methodology

1. The RM Environment is a collection of tools supplementing, not replacing, regular classroom and home practices. It can be used in class and/or at home as directed by a teacher. The tools can be employed to master selected topics or to study the entire curriculum.

2. An automated tutor using artificial intelligence technology (AI Tutor) controls the learning process. The AI Tutor selects the path and pace of learning, tailored to the individual characteristics of each student. This is accomplished through the continuous analysis of students' performance on assignments given by the Tutor.

3. Key learning tool: an extensive database of exercises and problems. Exercises target the acquisition of solid skills in applying basic rules in the manipulation of numbers and of other mathematical objects. Problems combine practicing these skills with the development of the logical, non-standard, and creative thinking required for understanding mathematical concepts.

4. The AI Tutor enforces the main objective of the achievement of a minimum (required) level of knowledge by all children. Students will continue to practice every essential rule/topic until they meet the minimum requirements for math proficiency. The "Failure is not an option" principle will be exercised in a firm fashion with regard to minimum requirements. The RM project's methodology holds the belief that the basics can and should be mastered by all students.

5. No student will be artificially held back in their drive to master more complex notions and further develop mathematical and logical thinking skills. The Tutor gradually raises the level of academics complexity, ensuring that every student is challenged according to his or her interests and talents.

6. The AI Tutor implements a "spiral" path of learning, which has proven its effectiveness in the history of K-12 education worldwide. All concepts and skills learned at the earlier phases of the course are continuously practiced and reiterated throughout the entire school year. This is accomplished through the inclusion of such exercises as subproblems in problems given when studying more advanced topics.

7. The RM curriculum emphasizes teaching how to think and reason, as opposed to just learning "plug-and-play" methods for solving simple standard problems, thus building the foundation for children's intellectual development. This is accomplished by requiring that students explain how they arrive at solutions to exercises and problems as well as through offering special problems that practice reasoning techniques. The testing of students' progress through multiple-choice exams is minimized. Mental math is given priority over the use of calculators.
8. **Comprehensive reference system to math theory** including (1) rules for performing math operations as well as (2) methods for and examples of solving problems is available through Internet links. The system allows for a topic-by-topic review mode as well as a hypertext-based reference index accessible from all exercises and problems.

9. All educational materials offered by the Environment are in strict **compliance with the Texas Essential Knowledge and Skills (TEKS)** for Mathematics standards.

10. Learning is not fun in itself. **Learning is hard day-to-day work**, and children in 6-7 grades are prepared to face this reality. However, learning can and should be made fun as long as having easy fun does not become student's prime motive. To make the process of learning more exciting and enjoyable, much of the problem solving is performed in game settings. **Problem-solving (academic) games** specially designed for this purpose add a new dimension to the studying process. Children compete with their peers either individually or in teams, creating an **interactive learning environment.** Student-to-student interaction is a powerful pedagogy that is brought back to our teaching practices.

11. **Effective Tutoring.** Automated computer-based learning has its limits. When it comes to answering students' questions or aiding the comprehension of a math notion, live tutoring is the only solution. RM's Web-based system will make teacher-performed tutoring more focused by helping with the early diagnosis of problems. Also, an organization of tutors recruited from college students, parents, and retired professionals is created to monitor student's performance, answer questions, and assist with overcoming difficulties in understanding concepts. Tutors communicate with students over the Internet through e-mails and live sessions. Each student has an assigned tutor (a mentor) who observes the student's progress and gives help when needed.

12. **Ratings and Awards.** Students' performance is measured by a specially designed rating system – an assessment tool seamlessly integrated into the learning process. Ratings serve as a powerful means for the monitoring of students' progress and effort and present a comprehensive **multidimensional** picture of students’ academic proficiency, logical and reasoning skills, ability to learn, and teamwork skills. The key point behind the rating system is that **anything** a student does in RM adds to his/her rating. Since ratings never decrease, students can only improve the indicators of their learning by doing more work in RM. Minimum targets in various topics, as measured by ratings, are required of everybody. The AI Tutor will rely on ratings in creating an individual path of learning for each student. Besides bringing such new dimensions into teaching practices, ratings combine the best features of grades and test scores, overcoming some of their deficiencies. First, ratings are built over time and encourage an individual pace of learning thus reflecting not only the achieved level of knowledge but also the cumulative effort put in by the student. Second, ratings (as opposed to school grades) have no ceiling and will provide for a more
detailed contrast between different track records. Third, ratings are measured with a common yardstick and are independent of each teacher's grading system and biases.

To provide for additional incentives in learning math, Awards will be established and issued by RM and businesses sponsoring the project. The award system will be a direct extension of the rating system. Rewards will be given for many different types of accomplishments and designed to acknowledge not just top performance but also progress made in an area of study. The Reward System will feature certificates of recognition, prizes in the form of commercial products (books, CDs, etc.). Parents will be strongly encouraged to establish their own reward systems for stimulating their children’s participation in RM programs.

Implementing the above principles will ensure results on the ultimate two-fold objective of the RM math curriculum – effectively teaching basic computational skills and developing reasoning and non-standard thinking abilities as opposed to memorizing standard methods for solving simple problems.
Appendix G: Condensed Guided Study Algorithm

The system is based on modules, which are also called tasks and, sometimes, blocks. The student’s performance in each module determines the next module (task) given to him/her.

The course is divided into topics (“Ratios,” “Proportions”), parts (there are two parts in the topic “Ratios” and one part in the topic "Proportions"), and paragraphs (there are 2-3 paragraphs per part). The sequence of modules is focused primarily around the paragraph unit, although there may be rare exceptions.

Tasks Comprising a Paragraph

For a paragraph, the first module is the Introductory Review. This is a short sequence of explanations and problems, covering review material essential to the theory in the paragraph. The student always passes these modules and moves on to the Theory Module, regardless of his/her performance on the Introductory Review.

In the Theory Module, the student gets the crux of the material. Interspersed in the sequence of explanations, examples, and definitions are simple exercises to test whether the student is understanding the material. If the student incorrectly answers an exercise, he/she is advised to review the theory material just covered. From there, the student re-reads the material and again tries to do the exercise (the numbers may be changed, but aside from minor variations it is basically the same exercise). Please note that the system does not make the student review the material – tutors have to enforce this whenever it is appropriate. In such a fashion, the student is given three attempts at solving the exercise. If he/she is unsuccessful, he/she is sent to the Diagnostics Module (explained below), and then to a tutor. "Being sent to a tutor" means that the following occurs:

- A automatic message is sent to the RM Dispatcher (referred to as "The Genie") notifying him that the student needs help and is awaiting a tutor
- An automatic message is sent to the student notifying him/her that help is on the way (that a tutor will contact the student shortly)
- The student is locked by the system, i.e. he/she will not be able to continue working in the Guided Study mode. However, all other modes will remain open to the student.

After the student gets a lesson from a tutor, the tutor should "unlock" the student, which will allow him/her to continue working in guided study. Please refer to the Tutor Manual for details on "unlocking" students.

If the student succeeds in passing the theory section, he/she goes on to the Problem Module.
In the **Problem Module** also referred to as **Block of Problems**, the student is usually given 12-20 problems (depending on the module) provided that all problems are solved correctly. Incorrect solutions lead to the assignment of additional problems: students are given three (3) attempts to solve each problem (again, there are variations in the problem formulations for each attempt, but the knowledge required for solving the problem will be the same). If the student fails all three attempts, the system moves to the next problem. Thus, it is actually possible for there to be around 60 problems in the module. Once the student reaches the end of the Problem Module, the system analyses the results and issues diagnoses when necessary. All diagnoses are recorded in the Diagnoses Section of the student's Study History. If a student's performance on the problems in a Problem Module does not provide sufficient information to determine the specific gaps in the student's knowledge, the system sends the student to one or more Diagnostics Module (explained below). Based on the results of the diagnostics the student may be given one or more Review Module (explained below).

If the student passes the Problem Module, then after the Diagnostics and Review Modules he/she goes on to the next paragraph (so the next thing the student will see is an Introductory Review module). If the student does not pass the Problem Module he/she is sent to a tutor, along with whatever diagnoses the system came up with. In some cases, although the system does not lock the student up (i.e. the student is not sent to a tutor), a recommendation is given to the student to talk to a tutor, but this is voluntarily.

In each **Diagnostics Module**, the student is given problems to determine which skills/concepts are giving him/her trouble. If a diagnosis is issued, it is recorded in the Diagnoses Section of the student's Study History. Diagnoses can be viewed/edited by tutors. Depending on the position in the algorithm, the student may afterwards be sent to a tutor or to a Review Module. A list of the Diagnostic Modules available in the RM system is given in the Appendix.

A **Review Module** is a small section of theory material explaining some concept, with examples of how to solve problems. A list of the Review Modules available in the RM system is given in the Appendix.

One cycle through all of these modules represents the successful completion of a paragraph.

**Student Levels and Testing**

When a student has completed a part (2-3 paragraphs), he/she is given the opportunity to raise his/her level of achievement. There are three levels – Standard, Advanced, and Highest; if a student opts to go for a higher level, he/she is given a special Problem Module corresponding to this level. If the student fails a Problem Module at a higher level, he/she is given the option to give it another try (but just once). Afterwards, regardless of whether the student opted to raise his/her level, he/she is given a test, the difficulty of which corresponds to the level the student is at. If the student fails a test at
the higher level, he/she is given a test at a lower level. After failing the test at the Standard Level, the student is sent to diagnostics and to a tutor.

The student achieves a certain level in a part before taking a test. The results of the test cannot take this level away from the student. Thus, for the tutor's purposes the student's achievement is characterized by a pair of data – the Level Achieved, and the Level of Test Passed. Although important, tests are not given much weight in the overall RM assessment. For that reason they are rather small – 5 problem each.

It should also be noted that all problems are divided by difficulty into three categories: A, B, and C (A is the easiest, C is the hardest). These categories correspond to the achievement levels, and they are used to determine the difficulty of tests, Problem Modules, etc. The second letter in the problem ID, e.g. "B" in RBC1_1, indicates that this is a level-B problem.

A test at the Standard Level is made up of five problems of the following difficulty levels AAAAB
A test at the Advanced Level ..................................................       ABBBC
A test at the Highest Level ....................................................     ABCCC
Appendix H: The Genie's Rules

**Rule #1.** Take your time reading theory material, and don't rush. Make sure you understand everything shown on each screen before you move on to the next one. Follow the instructions I give you. If I recommend something – do it.

**Rule #2.** Always provide a *detailed* solution to the problem in the "Your Solution" box before writing an answer in the "Your Answer" box for every problem.

**Rule #3.** Always read my solution to all problems – that's why I give them to you, after all!

**Rule #4.** If there's something you don't understand or just have a question, send me an e-mail. Never panic. There is not a thing that you can't understand and master. And tutors are always here to help you out.

**Rule #5.** If you think there is a mistake in the problem, or in my solution to the problem, send me an e-mail giving the problem name and the time when you were solving the problem. You get extra points for finding mistakes in problems!
Appendix I: Student Attitude Survey

1. Did you like learning math on the RM system?
   A. I liked it a whole lot
   B. I liked it
   C. It was O.K.
   D. I didn't like it at all

2. In the future, where would you like to learn math most?
   A. On the RM website
   B. In my regular math class
   C. It doesn't matter

3. Which class was harder this semester?
   A. The RM class was much harder than the regular class
   B. The RM class was harder than the regular class
   C. They were about the same
   D. My regular math class was harder than RM
   E. My regular math class was much harder than RM

4. Where have you learned more math this semester?
   A. I learned much more in RM than in my regular class
   B. I learned more in RM than in my regular class
   C. I learned about the same
   D. I learned more in my regular class than in RM
   E. I learned much more in my regular class than in RM
5. What did you like **most** about learning math on the RM website?

What else did you like about RM?

6. What did you like **least** about learning math on the RM website?

What else did you dislike about RM?

7. How much time did you spend with the RM system outside of class?  
   (You don't have to answer with a number.)

Do you have access to a computer outside of school that works with RM?

8. How did your liking of math change after the RM class?
   
   A. Now, I like math **a whole lot** more than before
   
   B. Now, I like math more than before
   
   C. I like math the same as before
   
   D. Now, I like math less than before
   
   E. Now, I like math **a whole lot** less than before
9. Which of the following activities on the RM website did you find useful or interesting? Check all that apply.

<table>
<thead>
<tr>
<th>Useful/Interesting</th>
<th>Not Useful / Not Interesting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guided Study</td>
<td>□</td>
</tr>
<tr>
<td>Independent Study</td>
<td>□</td>
</tr>
<tr>
<td>Classrooms</td>
<td>□</td>
</tr>
<tr>
<td>Problem Solving Games</td>
<td>□</td>
</tr>
<tr>
<td>Dino Island Game</td>
<td>□</td>
</tr>
<tr>
<td>E-mails to and from the Genie</td>
<td>□</td>
</tr>
</tbody>
</table>

10. Is there anything else you'd like to say about RM?