Design experiments consist of a thoughtfully sequenced series of research projects that culminate in a defensible theory of instruction and effective instructional materials (Brown, 1992; Burkhardt & Schoenfeld, 2003). The distinguishing feature of the design experiment approach is the accumulation of findings from each step and the use of a variety of research methodologies matched to the requirements of each research question (Schneider, Carnoy, Kilpatrick, Schmidt, & Shavelson, 2007). The sequencing involves qualitative changes in the goals addressed by each research activity, following a stage theory of Research & Development (i.e., needs assessment, product development, implementation and evaluation). Design experiments also include progressive tweaking of the final product through a serial process of development, assessment and revision.

In September 2006, the Ontario Ministry of Education contracted, through the Council of Directors of Education, with the Kawartha Pine Ridge District School Board and researchers from the University of Toronto and Trent University to develop a set of CLIPS to improve the mathematics achievement of students in grades 7-10. A CLIPS (Critical Learning Instructional Paths Supports) is comparable to a learning object (i.e., an activity, frequently involving multi-media, which presents a learning activity for students that addresses a specific course expectation). The investigators were asked to:

- Gather input from students on content areas where CLIPS should be developed by a technical team.
- Develop and field test grade 7-10 CLIPS.
- Gather evidence of the effectiveness of CLIPS from the perspectives of students and teachers.

1 Funding for the study was provided by the Ontario Ministry of Education. The views expressed in the report are not necessarily those of the Ministry. John Ross is Professor of Curriculum, Teaching, and Learning at the University of Toronto. Cathy Bruce is Assistant Professor of Education and Professional Learning at Trent University. Susan Scoffin is a graduate student at the University of Toronto. Tim Sibbald is a doctoral candidate at the University of Toronto. John Ford of the Kawartha Pine Ridge District School Board contributed to the design and refinement of the CLIPS. Garth Scott of the Kawartha Pine Ridge District School Board and Carolyn Brioux of the University of Toronto contributed to the data analysis.
In this report we summarize the findings from the project as it evolved through six stages, as shown in Table 1.

Table 1
*Stages in CLIPS Research & Development*

<table>
<thead>
<tr>
<th>Stage</th>
<th>Purpose</th>
<th>Research Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Identify specific learning expectations to be addressed by the CLIPS</td>
<td>Systematic needs assessment</td>
</tr>
<tr>
<td>2</td>
<td>Develop CLIPS</td>
<td>Application of research on technology supported learning</td>
</tr>
<tr>
<td>3</td>
<td>Formative assessment using a few classrooms</td>
<td>Qualitative observation</td>
</tr>
<tr>
<td>4</td>
<td>Revision of CLIPS</td>
<td>Application of research on technology supported learning</td>
</tr>
<tr>
<td>5</td>
<td>Assessment of CLIPS effect on student outcomes</td>
<td>Randomized field trial with implementation study</td>
</tr>
<tr>
<td>6</td>
<td>Assessment of CLIPS in different instructional contexts</td>
<td>Randomized field trial with implementation study</td>
</tr>
</tbody>
</table>

*Stage 1 Needs Assessment*

Since we addressed this stage in our interim report (Ross & Ford, 2006) and a subsequent publication (Ross, Ford, & Bruce, 2007), we will only briefly summarized our procedure and findings.

In a review of 125 needs assessments conducted in educational settings, Witkin (1994) identified multiple deficiencies: mono-method bias (use of a single data source to identify needs), confusion between solutions (instructional actions) and needs (gaps in student performance), use of unsystematic procedures, and over-reliance on data from a single group. We attempted to avoid these problems in selecting the focus for the CLIPS by applying systematic needs assessment procedures (Witkin & Altschuld, 1995). Figure 1 summarizes our strategy.
Step 1: Link to a formative assessment system.

We framed CLIPS development within a formative assessment system to ensure that the CLIPS fit the structure of the curriculum and meet the criteria for formative assessment (Black & Wiliam, 1998). Fit means that (1) there is a diagnostic procedure for placing students on a developmental continuum; (2) the CLIPS provide instruction for moving students from one level of the continuum to another; (3) the instructional strategy embedded in the CLIPS complements Standards-based mathematics teaching (NCTM, 2000).

We used the grade 6 diagnostic tests of PRIME - Professional Resources and Instruction for Mathematics Educators (Thomson Nelson, 2005). These tests place students on a developmental continuum for mathematics that has been empirically validated using samples of Canadian students (Small, McDougall, Ross, & Ben Jaafar, 2006). PRIME provides a conception of the curriculum organized around a small set of concepts and skills (e.g., for the Number and Operations strand there are five organizing concepts and three organizing skills). For each curriculum outcome there are five phases of performance. For each level of the continuum, PRIME provides examples of developmentally appropriate instructional strategies to be used with Standards-based texts (Small, 2005a; 2005b).

Step 2: Select learning objectives that are poorly achieved.

In 2005-06 we collected data from underachieving grade 7 and 8 students (Ross, Ford, and Xu, 2006). We identified 21 problem types for Number & Operations in which student
achievement was consistently low. All problems involved fractions. It is not surprising that fractions were identified as problematic for students since previous research clearly points to this same finding (Moss & Case, 1999). The National Assessment of Educational Progress report shows that fractions are "exceedingly difficult for children to master" (NAEP, 2005, p. 5).

Step 3: Select learning objectives that students believe they need to learn.

We assembled pairs of examples for each of the 21 problem types. Students used a 1-6 scale to show how confident they were about their ability to solve each pair of problems. The scale was anchored by not confident at all (1) and very confident (6). Each pair of problems was flashed on an overhead. It was essential that the problems not be visible on the screen for so long that students could actually solve them. What we were measuring was students’ self-efficacy beliefs (i.e., their expectations that they could solve each problem type (Bandura, 1997)). Following Schunk (1996), we started with a two second display but this was not enough time to process both items in the pair. After considerable experimentation we found that the time taken by the teacher to read each pair aloud was sufficient for students to determine whether they could successfully complete the problem pairs.

We conducted an exploratory factor analysis (principal axis with varimax and promax rotation) on 405 grade 7-10 student responses. There was a single factor solution: the first eigenvalue=12.541, accounting for 60% of the variance; second eigenvalue=0.984. We concluded the 21 items were measuring a single construct (“confidence in solving fraction problems”), rather than a cluster of themes. We calculated the mean confidence level for each item pair for the total sample, for students who were in the lowest quartile of self-reported mathematics ability, and for males and females. We found that mean confidence levels were very high for all students, including those in the lowest quartile. Confidence was higher for males than females, even though there were no gender achievement differences in Ross et al. (2006b).

Step 4: Select learning objectives that teachers believe to be important

We focused on two dimensions of teacher knowledge: (1) Teachers’ pedagogical content knowledge: which areas of the curriculum were most likely to cause learning problems and generate misconceptions. We provided 33 grade 7-10 teachers with the same set of problem pairs rated by students and asked teachers “How much difficulty do students in your course have in mastering the learning expectation shown in this pair of items?” (2) Teachers’ disciplinary knowledge: knowledge of mathematics content and the substantive structure that organizes this content. We asked them to estimate for each problem pair “How important is it to produce additional CLIPS to help students master the learning expectation shown in this pair of items?”

We added the two teacher scores together to rank the problem pairs from highest to lowest priority. Teachers rated the top ten problem types in exactly the same order for difficulty and importance. In contrast, there were substantial differences between students and teachers. For example, the item rated as the highest priority by students (i.e., they were least confident about their ability to deal with problems of this type) was only the tenth highest priority for teachers.
Step 5: Set CLIPS Agenda.

A team of eight expert teachers used the teacher and student data to identify the learning objectives to be addressed by the CLIPS. The decision making process was not a straight forward application of an algorithm but a thoughtful discussion of all the sources of information. In general, the teacher team started with the teacher results and then factored in the student confidence results. After exploring several ways of combining the data, the team decided that the Number and Operations CLIPS would focus on two themes: representing fractions and equivalent fractions.

Lessons Learned in Stage 1

In Stage 1, the needs assessment procedure provided a rigorous foundation for CLIPS development that avoided the deficiencies identified in previous studies by Witkin (1994). Stage 1 also had other benefits: teacher ownership increased by participating in the data collection; we discovered that students, especially boys, over-estimated their competence in solving fractions; and the 21 problem pairs provided items for the summative evaluation of the CLIPS.

Stage 2 Development of CLIPS

The needs assessment provided a rank ordered list of the most urgent student learning needs. In the second stage, this list was transformed into an integrated learning agenda that prescribed an instructional sequence designed to overcome student deficits. A technical team contracted by the Ministry of Education used this system to construct CLIPS as multi-media learning objects that address specific curriculum expectations. The technical team worked with John Ford and his team of expert teachers to ensure that the CLIPS provided classroom tools that were perceived to be feasible by teachers and were tightly linked to the identified needs.

Stage 3: Formative Assessment of CLIPS

Methodology

In the third step, the CLIPS were implemented in two classrooms. We closely observed pairs of students in these two classrooms using the CLIPS in order to assess the functioning of the CLIPS and to generate detailed recommendations for revising them. These classrooms were purposefully chosen based on the teachers’ skills and reputation as effective math teachers using best practices. Students were selected to participate based on their limited understanding of fractions. They were then paired with a similarly struggling peer. One pair of students was of the same gender (female) and the other pair was of different genders (one male and one female). In all cases, the teacher made the selection based on prior student achievement and information from PRIME diagnostic data.

Data collection methods included informal teacher interviews as well as detailed observations of pairs of students in math class before, during and after the use of CLIPS. Our goals were to understand: (1) the context of the lesson including expressed purpose of the lesson, teacher input/directions, instructional materials, student tasks assigned; (2) how the student’s
mathematical thinking emerged through the lesson; and (3) which aspects of the lesson (especially the CLIPS components) hindered and/or facilitated student affect (e.g., self-efficacy, anxiety, effort, engagement, beliefs about math and math learning) and understanding.

Researchers observed teachers and students on nine occasions in each of the two classrooms. Two observations occurred prior to CLIPS implementation, five observations were completed during CLIPS implementation and two occurred upon completion of CLIPS use. These observations consisted of field note taking on whole class introductions (minds-on warm-up) as well as student activity in the classroom. Then the researchers focused in on specific students using the CLIPS to enhance their limited level of conceptual understanding of fractions. The researchers interacted with the students to probe their thinking while using the CLIPS and after completion of specific CLIPS (as opposed to classroom activities) activities to determine how confident the students were that they had increased their level of understanding of fractions.

In addition to the case studies, a focus group of expert teachers was brought together in the spring of 2007 for extensive interviews about the content and technical components of the CLIPS prototypes. The goal of this series of interviews was to gather explicit feedback on the functioning of the CLIPS as a method for increasing student understanding of fractions.

Researchers followed six sequential steps of coding: 1) Initial reading of text data; 2) Division of text into segments of information (segments based on utterances); 3) Labeling of each utterance with codes; 4) Reduction of overlap and redundancy of codes; 5) Collapsing codes into themes (Creswell, 2005); and 6) Pattern matching of themes to the theoretical model being tested (Mark, Henry, & Julnes, 2000).

Results

From these case studies the researchers were able to develop a list of highly specific recommended changes to the CLIPS Alpha version. The case studies also provided important information on how students could be successful with the CLIPS. Mastery experiences (i.e., student perceptions of being successful with meaningful mathematics tasks) were a major contributor to self-efficacy. Students with higher self-efficacy demonstrated greater effort and had a decreased fear of failure. In the four cases, there were some excellent examples of student mastery experiences both on-line and off-line. Four examples of positive mastery experiences using the CLIPS Alpha version are summarized as examples in Table 2.

<table>
<thead>
<tr>
<th>CLIP</th>
<th>Student</th>
<th>Detail</th>
</tr>
</thead>
</table>
| 1    | Andrea  | Action: Visual representations of fractions
“*I am going to make the line into eighths and go across 3. It said make 3/8.*” Andrea attempted once, making fifths, realized this was incorrect and then tried again, this time successfully making eighths. |
3 Mandy  Action: Equivalent fractions task (Splitting Parts into Two or More Equal Parts)

Mandy realized that she had to perform the same operation on the numerator as on the denominator to make it equivalent. She doubled a numerator of 3 to get 6, then doubled the denominator of 4 to get 8. “3 plus 3 is 6 and I got 8 by using the same thing”. She then successfully chose 8/10 as an equivalent fraction to 4/5. At this point Mandy was more engaged in the task and was keen to move on.

4 Brad  Action: Using fraction strips

He went on to the fraction strips, tried three examples and got each one correct. When asked about his strategies for the task Brad offered the following explanation: “when the numbers are even they can be divided by two. They can’t be divided by three or five so I divided the numerator and denominator by two.” He was then able to reach the conclusion and confidently select the correct answer. “Sweet!” was his reaction.

5 Sarah  Action: Halves, Thirds, Fourths and Sixths

Sarah and her partner worked through these tasks independent of direction form the researcher. Sarah appeared to be getting the correct answers consistently and when asked what she was thinking as she was working through the tasks she was able to articulate her strategies in simple mathematical terms, “two boxes were full so I knew the whole number is two. Then there were two more in a box that holds four so it was two and two fourths.” Interestingly, when asked to represent the fraction numerically by selecting numbers. Sarah wrote the whole number first, then the numerator and then selected the denominator last. Sarah was highly successful in this task and agreed with the researcher’s assessment that she had mastered the activity.

Observations in the classrooms after students had had mastery experiences with the CLIPS indicated that the students were more likely to participate in whole group discussions and to engage more fully with tasks presented in class. It was anticipated that increases in student achievement would follow for those students who experienced positive influences on their functional beliefs about learning math and increased self-efficacy.

A series of recommendations were made at the end of stage 3. They were:

- CLIPS learning objects should be revised with consideration of the evidence detailed in this report based on interviews and observations with the teacher expert group and the students. There are both technical and content based revisions required.

- The revised CLIPS should be then tested in two ways: A fifth and sixth qualitative case study should be conducted simultaneously with the quantitative study scheduled for the Fall of 2007.
A manual for teacher implementation should be developed. The manual for teacher implementation of CLIPS should include explicit lesson ideas for supporting the conceptual ideas in focus in each of the CLIPS learning objects.

Stage 4: CLIPS Revision

In the fourth stage, researchers, teachers and technical developers gathered together for an intensive re-working of the CLIPS storyboard based on detailed charts of suggested revisions to each activity and the overall recommendations. The goal of the revisions was to maintain the strengths of the CLIPS Alpha version while attending to deficiencies. This work began in June 2007 and continued through to September 2007.

Stage 5: Randomized Field Trials

The fifth step consisted of a systematic assessment of the effects of CLIPS on student achievement and motivation. In this stage of the research we attempted to make causal claims about the effect of CLIPS on student outcomes. This fifth stage also included one additional qualitative case study classroom (one teacher and four students). Nine observations were conducted following the same process that was employed in stage 3. The four students were identified by the teacher as struggling students, who were particularly challenged in understanding basic fractions concepts. We will begin this section with the quantitative study and then report the qualitative study.

Theoretical Framework

Our theoretical framework for anticipating that CLIPS would contribute to higher student achievement is based on social cognition theory and formative assessment theory. The placement test used to assign students to CLIPS enabled teachers to assess the specific needs of their students in terms of the developmental maps of the PRIME continuum. Having identified students’ levels, we predicted that teachers would target specific concepts and skills, using the CLIPS and the examples of strategies from the PRIME maps (Small 2005a; 2005b). PRIME links curriculum, assessment, and instruction, thereby meeting the four criteria for an effective feedback system: (a) data on the actual level of a measurable attribute, (b) the reference level of the attribute, (c) mechanisms for comparing the actual performance to a meaningful scale and generating information about the nature of the gap, and (d) specific strategies for altering the gap (Black & Wiliam, 1998).

We anticipated that there would be two paths from CLIPS instruction to achievement. In the first path, we expected that CLIPS would reduce dysfunctional beliefs about mathematics and its learning (for example, that mathematics problems are solved quickly or not at all) and enhance functional beliefs (e.g., about working in math discussion groups). Math beliefs contribute to student achievement (Muis, 2004; Schommer-Aitkins, Duell, & Hutter, 2005). The second path predicted that if the CLIPS were targeted on students’ individual needs, students would experience success. Mastery experiences (i.e., student perceptions of being successful on meaningful mathematics tasks) are a major contributor to self-efficacy, defined as students’ expectations that they will be able to complete similar tasks in the future (Pajares, 1996).
theory predicted that students with higher self-efficacy would exert greater effort (Bandura, 1997) and would have lower fear of failure (Meyer, Turner, & Spencer, 1997; Turner, Meyer, Midgley, & Patrick, 2003), both factors that contribute to higher mathematics achievement.

Research Questions

The first three research questions examined the effects of CLIPS on student outcomes. However, the effectiveness of CLIPS is dependent upon how they are implemented. The second set of research questions examined these implementation issues.

1. Did CLIPS contribute to the mathematics achievement of underachieving students in grades 7-10?

2. Did CLIPS contribute to improved student affect about mathematics and mathematics learning?

3. Did the number of CLIPS used by students moderate the effects of CLIPS on student achievement and beliefs?

4. What factors influence teacher decisions to assign particular students to CLIPS?

5. How reliable are teacher interpretations of the CLIPS placement test?

6. What conditions contribute to or inhibit effective CLIPS use?

Methodology

We addressed these questions using a combined quantitative and qualitative approach (Creswell & Plano Clark, 2007). The quantitative design was a randomized field trial; the qualitative design was an extension of the observational studies conducted in stage 3.

Table 3 displays our quantitative research design. Teachers were randomly assigned, within schools, to early and late treatment conditions. The table shows that all students were tested on three occasions. Occasions 1 and 2 provided a CLIPS versus control group comparison (i.e., early versus late). Occasions 2 and 3 provided a comparison of immediate (for the late treatment group) and delayed (for the early treatment group) effects of CLIPS. The strength of the design is that all teachers who volunteered for the project had equal opportunity to implement the CLIPS. The design provided the rigor of a true experiment for testing causal claims without the negative effects, such as demoralization of the control group and denial of treatment to students who could benefit from it. The top row show the intended dates of implementation.
Table 3

*Research Design for Field Test*

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Early Treatment</td>
<td>O₁</td>
<td>X</td>
<td>O₂</td>
<td></td>
<td>O₃</td>
</tr>
<tr>
<td>Late Treatment</td>
<td>O₁</td>
<td>O₂</td>
<td>X</td>
<td>O₃</td>
<td></td>
</tr>
</tbody>
</table>

O₁ = achievement pretest and attitude measures
O₂ = achievement posttest and attitude measures
O₃ = delayed achievement posttest

*Sample*

Invitations to participate in the research were extended to all grade 7-10 mathematics teachers in the district. Thirty teachers volunteered. They were randomly assigned within schools to early and late treatment groups, producing 14 teachers (15 classes, N=383 students) in the early treatment group and 16 teachers (16 classes, N=404 students) in the late treatment group. Table 4 shows that 73% of the students were in the elementary panel and 37% were in secondary. The table also shows that the students were unequally divided in the secondary panel with the majority of grade 9 students in the late treatment group and the majority of grade 10s in the early treatment group [χ²(4)=78.89, p<.001]. The student sample was 51% male.

Table 4

*Student Grade Distribution by Experimental Condition*

<table>
<thead>
<tr>
<th>Grade</th>
<th>Early Treatment</th>
<th>Late Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grade 7</td>
<td>102</td>
<td>117</td>
</tr>
<tr>
<td>Grade 8</td>
<td>152</td>
<td>204</td>
</tr>
<tr>
<td>Grade 9</td>
<td>37</td>
<td>70</td>
</tr>
<tr>
<td>Grade 10</td>
<td>91</td>
<td>12</td>
</tr>
<tr>
<td>All Grades</td>
<td>383</td>
<td>404</td>
</tr>
</tbody>
</table>

*Treatment*

CLIPS are multi-media learning objects focused on fractions. Students begin by viewing a video which shows why students should care about fractions. Students are presented with a menu of five sets of activities (CLIPS A, B, C, D, E): representing simple fractions; forming and naming equivalent fractions; comparing simple fractions; forming equivalent fractions by splitting or merging parts; and representing improper fractions as mixed numbers. Within each
set of activities there are introductory instructions, interactive tasks, consolidation quizzes and extension activities.

For example, CLIPS A has an introduction activity on representing simple fractions. There is a voice over with area models presented on the screen. In the second activity students are asked to describe a fraction by entering the numerator and denominator and showing what the fraction looks like in an area model. There are three additional mini-sets of activities. The student is given a quiz on representing simple fractions. Students drag their answers to a box and receive immediate feedback. If incorrect, they are given an explanation. The final component of CLIPS A is a “show what you know” screen which suggests five different activities (e.g., a fractions card game) students could do as consolidation. The same structure is repeated for each of the five CLIPS.

Student Instruments

Student Achievement was measured on three occasions. Test 1 consisted of 10 items on fractions that were drawn from the PRIME placement tests for Number and Operations (PRIME, 2005). Tests 2 and 3 each consisted of the 21 items generated in stage 1 of the study. In the needs assessment stage John Ford’s team of expert teachers constructed pairs of items for each problem type. In stage 5 of the study, each item in the pair was randomly assigned to Test 2 or Test 3, creating two parallel assessment forms. All items on the student achievement tests produced a score ranging from 0-2. Test 1 was marked by teachers and independently by a trained marker. Tests 2 and 3 were marked only by the trained marker. Inter-rater reliability data of the teachers and the trained marker will be presented in the Results Section. Student achievement was operationalized at each test occasion as the mean score assigned by the trained marker. In some analyses, see Results section, we used the total Test 1 score assigned by the student’s teacher.

Student achievement was measured on three occasions, as shown in Figure 2. However, the student affect measures derived from our theoretical framework were administered only at test occasions 1 and 2. We did not administer the affect measures on test occasion 3 because we were concerned about student fatigue and distortion of results due to students’ recalling previous responses.

Math self-efficacy consisted of six Likert items measuring expectations about future mathematics performance (from Ross, Hogaboam-Gray, & Rolheiser, 2002; e.g., “as you work through a math problem how sure are you that you can…explain the solution”). There were six response options, anchored by “not sure” and “really sure” for each item. In previous administrations, alpha=.91 (Ross et al., 2002), .84 (Ross, Bruce, & Hogaboam-Gray, 2006a), and .87 (Ross et al., 2006b).

Functional beliefs about mathematics learning focused on students’ motivation for participating in discussions in mathematics class. We selected from Jansen (2006) eight statements made by grade 6-8 students about their motivation in participating in mathematical discussions. We converted these statements into Likert scales; e.g., “If you are there throwing out your ideas, you could find a new way of doing a math problem.” There were six response options, anchored by “strongly agree” and “strongly disagree” for each item. We added to these
items three more from Schoenfeld’s (1985) student beliefs survey that predicted achievement in PRIME (Ross et al., 2006b).

**Dysfunctional beliefs about mathematics learning** consisted of eight items adapted from Schommer-Aitkins et al. (2005). These items measure belief in quick/fixed learning (i.e., that learning occurs quickly or not at all and that intelligence is fixed rather than incremental); e.g., “If I cannot understand something quickly, it usually means I will never understand it.” In our study there were six response options, anchored by “strongly agree” and “strongly disagree” for each item. In Schommer-Aitkins et al. (2005) this scale predicted student beliefs in effortful math, useful math, math confidence, and understanding math concepts. The scale also predicted achievement in mathematics problem solving. The original ten item scale was reliable (alpha=.77) in a large middle school sample. We selected for our study all items that loaded in Schommer-Aitkins et al. (2005) factor analysis at least .40 on this scale (actual range .40-.67) with no cross-loadings (N=8). These items were all worded negatively. We did not recode; i.e., we anticipated that the scale would be a negative predictor.

**Fear of failure** consisted of six items (e.g., “I worry a lot about making errors on my math work”) from Turner et al. (2003). There were six response options, anchored by “not at all true” and “very true” for each item. This scale measures students’ fear of failing, a powerful inhibitor of mathematical motivation. In previous administrations, alpha=.79 (Turner et al., 2003) and .84 (Ross et al., 2006b).

**Effort** was measured with eight items (e.g., “how hard do you study for your math tests?”). There were six response options, anchored by “not hard at all” and “as hard as I can” for each item. In previous administrations, alpha=.88 (Ross et al., 2006b).

**Number of CLIPS** completed (0-5) was generated from data provided by teachers. We used these responses to construct the variable CLIPS user (1=user, 0=not) which indicated whether students had completed any CLIPS.

Students were also asked to identify their grade (7, 8, 9, 10) and gender.

**Teacher Instruments**

After administering CLIPS in their classrooms, teachers completed an implementation survey consisting of 12 open and fixed response items. The survey asked teachers how they assigned students to CLIPS (e.g., in pairs or individually), the amount of time spent on CLIPS, perceptions of the adequacy of time allotted, where students worked on CLIPS (e.g., the classroom, the library, at home), perceptions of student like/dislike of the program, perceptions of student success, difficulties in accessing CLIPS software and whether the teacher was able to resolve technical problems, strategies used by the teacher to interact with students while working with CLIPS and to debrief them after completion, whether teachers felt the right students had received CLIPS, whether they would use CLIPS again, and fractions topics taught during CLIPS implementation. In addition to the survey, teachers marked achievement test 1 and indicated how many (0-5) CLIPS each student completed.
All student and teacher instruments are contained in the Appendix. There were slight differences between the instruments used in the two groups; i.e., teachers recorded the CLIPS that they used in achievement Test 1 if they were in the early treatment and in achievement Test 2 if they were in the late treatment.

**Analysis Procedures**

After establishing the reliability of the measures used in the study, we applied univariate and multivariate procedures of General Linear Modeling. The dependent measures for the student data were the posttest achievement and affect scale scores; the covariates were the corresponding pretest scores on the same measures; and the independent variable was experimental condition (treatment or control group). In some analyses we introduced additional controls such as and grade and gender and conducted additional analyses to be described below. We used logistic regression to identify predictors of teacher decisions to assign CLIPS to particular students.

**Results**

There was a great deal of missing data—too much for us to be able to use Missing Values in SPSS. The amount of missing achievement data ranged from 9% on Test 1 to 22% on Test 2 to 36% on Test 3. Affect data were missing from 13% of students on the pretest and 24% on the posttest. The main explanation given by teachers for not completing assessments was that they dropped out of the study because they were unable to get the CLIPS software to work in their classrooms.

The developers recommended that teachers assign CLIPS to the six lowest achieving students in their class or assign CLIPS if students scored 50% or less on the two parts of Test 1 (i.e., if students scored below the criterion on items 1-5, they should complete CLIPS 1 and 2; if below criterion on items 6-10, they should complete CLIPS 3, 4, and 5). Neither rule was followed consistently. Only 14 teachers (nine in the Early group and five in the Late group) had students complete one or more CLIPS, even though all teachers had at least one student who was below criterion on achievement Test 1.

Teachers reported that 91 students (18% of non-missing cases) completed at least one CLIPS. However, there were four teachers who reported in the implementation survey that their students completed CLIPS at home. These teachers did not identify which students these were, possibly because they did not know. Three of the four teachers reported that their students were successful but we were not able to include any students from these four classrooms in the CLIPS user analysis. Table 5 shows that the percentage of students who completed no CLIPS was very high in both treatment groups.
Refinement of Scales and Estimation of Reliability. A single marker assessed all the student achievement data. Inter-rater reliability was calculated on three occasions. For Test 1, we selected a random sample of 200 items (drawn from 20 tests) which were independently marked by a second marker. There was perfect agreement on 93%, producing a Kappa (i.e., chance adjusted) score of .86 (Kundel & Polansky, 2003). The standard error for Kappa was .033 giving a 99% confidence interval of .80 to .93 (using the approximation of Cohen, 1960). For Test 2 we randomly selected 210 items for which there was 96% perfect agreement, producing Kappa=.92. The standard error for Kappa was .0006 giving a 99% confidence interval of .918 to .922. For Test 3 we randomly selected 210 items for which there was 94% perfect agreement, Kappa=.88. The standard error for Kappa was .033 giving a 99% confidence interval of .84 to .91. The inter-rater reliability on all three achievement tests was excellent according to the criteria identified by Bakeman and Gottman (1997). We also conducted inter-rater reliability statistics for items marked by the field test teachers and the external markers—these statistics are shown below for research question # 5.

The Appendix contains a comparison between CLIPS, PRIME, and the student achievement tests. The comparison shows that the tests contained items that were not addressed by the CLIPS. We reduced the achievement scales to six items for Test 1 and to 16 items for each of Tests 2 and 3 in order to increase statistical power.

We conducted an exploratory factor analysis of the affect items from the pretest student survey using principal axis extraction and promax rotation. The optimal solution contained five factors explaining 43% of the variance. The mean item loading on the factors ranged from .49 to .71. Each item loaded at least .46 on a single factor—there were no cross loadings at .35 or higher. Table 6 displays the factor structure. We moved two of the items (#5 and #10) from the mathematics beliefs scale to the self-efficacy scale based on their factor loadings and deleted four items (#4, #6, #8, #9) from the mathematics beliefs scale because they did not load on any factor.
Table 6
Factor Structure of the Student Affect Items [main factor loadings bolded]

<table>
<thead>
<tr>
<th>Survey Variables</th>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
<th>Factor 4</th>
<th>Factor 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>pre_v28</td>
<td>0.673</td>
<td>0.003</td>
<td>-0.079</td>
<td>0.032</td>
<td>-0.026</td>
</tr>
<tr>
<td>pre_v29</td>
<td>0.646</td>
<td>-0.075</td>
<td>0.009</td>
<td>0.059</td>
<td>-0.152</td>
</tr>
<tr>
<td>pre_v30</td>
<td>0.730</td>
<td>-0.009</td>
<td>-0.003</td>
<td>0.075</td>
<td>0.083</td>
</tr>
<tr>
<td>pre_v31</td>
<td>0.729</td>
<td>-0.060</td>
<td>-0.015</td>
<td>-0.018</td>
<td>0.027</td>
</tr>
<tr>
<td>pre_v32</td>
<td>0.800</td>
<td>-0.013</td>
<td>0.052</td>
<td>-0.065</td>
<td>-0.010</td>
</tr>
<tr>
<td>pre_v33</td>
<td>0.713</td>
<td>0.020</td>
<td>0.020</td>
<td>0.018</td>
<td>0.035</td>
</tr>
<tr>
<td>pre_v34</td>
<td>0.750</td>
<td>-0.029</td>
<td>0.015</td>
<td>-0.081</td>
<td>-0.041</td>
</tr>
<tr>
<td>pre_v35</td>
<td>0.758</td>
<td>0.051</td>
<td>0.095</td>
<td>-0.047</td>
<td>0.108</td>
</tr>
<tr>
<td>pre_v01</td>
<td>-0.143</td>
<td>0.895</td>
<td>-0.008</td>
<td>-0.016</td>
<td>0.005</td>
</tr>
<tr>
<td>pre_v02a</td>
<td>-0.090</td>
<td>0.851</td>
<td>-0.003</td>
<td>0.010</td>
<td>0.022</td>
</tr>
<tr>
<td>prev_02b</td>
<td>0.057</td>
<td>0.739</td>
<td>0.019</td>
<td>-0.003</td>
<td>0.023</td>
</tr>
<tr>
<td>pre_v02c</td>
<td>-0.112</td>
<td>0.846</td>
<td>0.027</td>
<td>0.010</td>
<td>-0.006</td>
</tr>
<tr>
<td>pre_v02d</td>
<td>0.123</td>
<td>0.628</td>
<td>0.022</td>
<td>-0.022</td>
<td>0.049</td>
</tr>
<tr>
<td>pre_v02e</td>
<td>0.084</td>
<td>0.560</td>
<td>-0.005</td>
<td>0.087</td>
<td>0.080</td>
</tr>
<tr>
<td>pre_v05</td>
<td>0.073</td>
<td>0.429</td>
<td>0.013</td>
<td>0.048</td>
<td>-0.086</td>
</tr>
<tr>
<td>pre_v10</td>
<td>0.061</td>
<td>0.501</td>
<td>0.018</td>
<td>-0.060</td>
<td>-0.094</td>
</tr>
<tr>
<td>pre_v14</td>
<td>0.132</td>
<td>-0.034</td>
<td>0.515</td>
<td>-0.065</td>
<td>-0.214</td>
</tr>
<tr>
<td>pre_v15</td>
<td>-0.138</td>
<td>-0.009</td>
<td>0.482</td>
<td>0.076</td>
<td>-0.052</td>
</tr>
<tr>
<td>pre_v16</td>
<td>-0.028</td>
<td>-0.042</td>
<td>0.645</td>
<td>0.013</td>
<td>-0.013</td>
</tr>
<tr>
<td>pre_v17</td>
<td>-0.042</td>
<td>-0.010</td>
<td>0.675</td>
<td>0.006</td>
<td>0.141</td>
</tr>
<tr>
<td>pre_v18</td>
<td>0.071</td>
<td>0.192</td>
<td>0.481</td>
<td>-0.044</td>
<td>-0.094</td>
</tr>
<tr>
<td>pre_v19</td>
<td>0.084</td>
<td>0.003</td>
<td>0.656</td>
<td>-0.059</td>
<td>-0.077</td>
</tr>
<tr>
<td>pre_v20</td>
<td>-0.072</td>
<td>-0.023</td>
<td>0.618</td>
<td>0.070</td>
<td>0.056</td>
</tr>
<tr>
<td>pre_v21</td>
<td>0.044</td>
<td>0.013</td>
<td>0.680</td>
<td>0.052</td>
<td>0.044</td>
</tr>
<tr>
<td>pre_v22</td>
<td>0.007</td>
<td>0.111</td>
<td>0.030</td>
<td>0.527</td>
<td>-0.088</td>
</tr>
<tr>
<td>pre_v23</td>
<td>-0.108</td>
<td>0.091</td>
<td>0.031</td>
<td>0.602</td>
<td>-0.015</td>
</tr>
<tr>
<td>pre_v24</td>
<td>0.127</td>
<td>0.133</td>
<td>-0.037</td>
<td>0.684</td>
<td>0.138</td>
</tr>
<tr>
<td>pre_v25</td>
<td>0.098</td>
<td>-0.077</td>
<td>-0.054</td>
<td>0.698</td>
<td>-0.040</td>
</tr>
<tr>
<td>pre_v26</td>
<td>-0.067</td>
<td>0.014</td>
<td>0.019</td>
<td>0.778</td>
<td>-0.030</td>
</tr>
<tr>
<td>pre_v27</td>
<td>-0.109</td>
<td>-0.256</td>
<td>0.058</td>
<td>0.584</td>
<td>-0.022</td>
</tr>
<tr>
<td>pre_v03</td>
<td>-0.178</td>
<td>-0.109</td>
<td>0.068</td>
<td>-0.028</td>
<td>0.448</td>
</tr>
<tr>
<td>pre_v07</td>
<td>0.067</td>
<td>0.060</td>
<td>0.072</td>
<td>-0.150</td>
<td>0.457</td>
</tr>
<tr>
<td>pre_v11</td>
<td>-0.059</td>
<td>-0.143</td>
<td>-0.034</td>
<td>0.018</td>
<td>0.496</td>
</tr>
<tr>
<td>pre_v12</td>
<td>0.084</td>
<td>0.148</td>
<td>-0.051</td>
<td>-0.011</td>
<td>0.491</td>
</tr>
<tr>
<td>pre_v13</td>
<td>0.084</td>
<td>0.111</td>
<td>-0.142</td>
<td>0.045</td>
<td>0.499</td>
</tr>
</tbody>
</table>

We used Cronbach’s alpha to assess the reliability of the student scales. Table 7 shows the reliability based on the total sample. The table also summarizes the revisions made to the scales. The three achievement measures had high reliability, as did four of the five affect scales on each test occasion. The lone exception was the pretest functional math beliefs scale which at alpha=.61 was slightly below the .70 criterion. The reliability of the student measures on the
CLIPS only sample (i.e., students who had received at least one CLIPS) was similar, although the reliability of the mathematics beliefs scale was even lower, suggesting that it should be interpreted with caution. Means, standard deviations, and alphas for all student outcome measures for students who completed CLIPS are shown in the Appendix.

### Table 7
**Means, Standard Deviations, and Cronbach’s Alpha of Student Survey Instruments**

<table>
<thead>
<tr>
<th>Scales</th>
<th>N</th>
<th>Items</th>
<th>Mean</th>
<th>SD</th>
<th>Alpha</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Math Self-Efficacy (Pre)</td>
<td>662</td>
<td>8</td>
<td>4.09</td>
<td>0.91</td>
<td>.88</td>
<td>Items 5 and 10 were added.</td>
</tr>
<tr>
<td>Math Self-Efficacy (Post)</td>
<td>579</td>
<td>8</td>
<td>4.08</td>
<td>0.91</td>
<td>.88</td>
<td>Items 5 and 10 were added.</td>
</tr>
<tr>
<td>Beliefs about Math (Pre)</td>
<td>678</td>
<td>5</td>
<td>3.73</td>
<td>0.89</td>
<td>.61</td>
<td>Items 3, 7, 11, 12, 13 were used.</td>
</tr>
<tr>
<td>Beliefs about Math (Post)</td>
<td>588</td>
<td>5</td>
<td>3.70</td>
<td>0.97</td>
<td>.71</td>
<td>Items 3, 7, 11, 12, 13 were used.</td>
</tr>
<tr>
<td>Quick/fixed Learning (Pre)</td>
<td>662</td>
<td>8</td>
<td>2.39</td>
<td>0.94</td>
<td>.82</td>
<td>Okay</td>
</tr>
<tr>
<td>Quick/fixed Learning (Post)</td>
<td>576</td>
<td>8</td>
<td>2.39</td>
<td>1.01</td>
<td>.88</td>
<td>Okay</td>
</tr>
<tr>
<td>Fear of Failure (Pre)</td>
<td>675</td>
<td>6</td>
<td>3.09</td>
<td>1.09</td>
<td>.81</td>
<td>Okay</td>
</tr>
<tr>
<td>Fear of Failure (Post)</td>
<td>586</td>
<td>6</td>
<td>3.13</td>
<td>1.11</td>
<td>.84</td>
<td>Okay</td>
</tr>
<tr>
<td>Effort (Pre)</td>
<td>676</td>
<td>8</td>
<td>4.04</td>
<td>0.96</td>
<td>.89</td>
<td>Okay</td>
</tr>
<tr>
<td>Effort (Post)</td>
<td>581</td>
<td>8</td>
<td>4.03</td>
<td>0.95</td>
<td>.88</td>
<td>Okay</td>
</tr>
<tr>
<td>Fractions 1</td>
<td>727</td>
<td>6</td>
<td>1.31</td>
<td>0.54</td>
<td>.75</td>
<td>Items 2, 3, 5, 10 were removed.</td>
</tr>
<tr>
<td>Fractions 2</td>
<td>617</td>
<td>16</td>
<td>1.33</td>
<td>0.47</td>
<td>.87</td>
<td>Items 4, 6, 15, 16, 17 were removed.</td>
</tr>
<tr>
<td>Fractions 3</td>
<td>502</td>
<td>16</td>
<td>1.32</td>
<td>0.39</td>
<td>.82</td>
<td>Items 4, 6, 15, 16, 17 were removed.</td>
</tr>
</tbody>
</table>

All student outcome variables were normally distributed: skewness and kurtosis were <1.0 on all variables on all test occasions. The number of CLIPS used was not normal: skewness=2.28, kurtosis=3.94.

**Research Question 1. Did CLIPS contribute to the mathematics achievement of underachieving students in grades 7-10?**

The analysis for this research question was based only on students who had completed one or more CLIPS at some time during the study (N=91, with missing data deleted pairwise). We conducted a univariate analysis of variance using GLM in SPSS. The dependent variable was achievement Test 2; the covariate was achievement Test 1 (using the expert marker’s assessments); the independent variable was experimental condition. In this analysis the Early Treatment received CLIPS and the Late Treatment did not. Student use of CLIPS had no statistically significant effect on student achievement for students in the Early Treatment group [F(1,83)=.410, p=.524]. Although the model explained 46% of the achievement variance,
virtually all this variance was attributable to the pretest score \([F(1,83)=7.873, p<.001]\). Students who performed poorly on the achievement pretest continued to perform poorly on the posttest, regardless of whether they had completed CLIPS.

The results for the Late Treatment group were more positive. In the second univariate analysis of variance, the dependent variable was achievement Test 3; the covariate was achievement Test 2; the independent variable was experimental condition. In this analysis the Late Treatment received CLIPS and the Early Treatment did not. Students who received CLIPS between test occasion 2 and test occasion 3 had higher achievement than students who did not receive CLIPS during this time period \([F(1,80)=7.302, p=.008]\). CLIPS accounted for 8.4% of the achievement variance \((\text{Cohen’s } d = .33)\). Although Early Treatment students had not used CLIPS in the second round, they continued to improve \([t(82)=-4.374, p<.001]\). In contrast, students who did not complete CLIPS at any time during the study had significantly lower scores on Test 3 (mean=1.37) than they had on Test 2 (mean=1.42) \([t(402)=2.681, \ p=.008]\). Figure 2 shows the achievement test means for each group on each test occasion.

![Student Achievement by Test Occasion](image)

*Figure 2. Student achievement by Test Occasion and Experimental Condition.*
We re-analyzed the achievement data, separating students who received CLIPS into three groups on the basis of their pretest score (as marked by their teachers): 29 CLIPS using students scored 0-7 (out of 20); 36 scored 8-11; 25 scored 12 or more. There were no differences for the Early Treatment group: CLIPS did not contribute to higher achievement for any of the groups. For the Late Treatment group we found that CLIPS had a statistically significant positive effect on the middle group only \( F(1,32)=4.915, p=.034 \). The pattern was the same but not statistically significant for students with low \( F(1,23)=3.047, p=.094 \) and high \( F(1,19)=1.931, p=.181 \) scores on the pretest. This finding suggests that CLIPS is of greatest value to moderately low performing students (i.e., who were correct on 40-55% of the items) and are less useful to very low performers (i.e., who scored 0-40% on the pretest) or high performers (i.e., who scored 60-100% on the pretest). The proportion of the variance explained by CLIPS ranged from 12% (low) to 13% (medium) to 9% (high). Unfortunately the number of cases was especially low in the low and high categories, which severely weakened statistical power.

Research Question 2. Did CLIPS contribute to improved student affect about mathematics and mathematics learning?

The analysis for this research question was based only on students who had completed one or more CLIPS at some time during the study. The affect instruments were administered only at Test Occasions 1 and 2. We conducted a multivariate analysis of variance using GLM in SPSS. In this analysis, the Early Treatment group had received CLIPS and the Late Treatment group had not. The dependent variables were the posttest scores on the five affect variables used in the study (math self-efficacy, functional beliefs about math discussions, belief in quick and fixed learning, fear of failure, and effort). Table 8 shows the pretest and posttest scores for each of the two experimental conditions. There were no statistically significant differences between students who received CLIPS and those who did not \( F(5,67)=.941, p=.523 \). The univariate models explained 37-52% of the variance in the five affect variables; however almost all of the variance was explained by the pretest affect scores. This finding matches the finding that there were no achievement effects of CLIPS in the Early Treatment group. Our design did not enable us to determine whether CLIPS contributed to affect improvements comparable to the improvements in achievement.

Table 8
Pretest and Posttest Means and Standard Deviations on Affect Variables by Experimental Condition

<table>
<thead>
<tr>
<th>Affect Variable</th>
<th>Early Treatment Group</th>
<th>Late Treatment Group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Pre</td>
<td>Post</td>
</tr>
<tr>
<td>Math self-efficacy</td>
<td>3.41 ( .81)</td>
<td>3.59 ( .86)</td>
</tr>
<tr>
<td>Functional beliefs about math</td>
<td>3.82 ( .62)</td>
<td>3.80 ( .66)</td>
</tr>
<tr>
<td>Quick/fixed learning</td>
<td>2.61 ( .91)</td>
<td>2.52 ( .84)</td>
</tr>
<tr>
<td>Fear of failure</td>
<td>3.06 (1.18)</td>
<td>2.96 (1.22)</td>
</tr>
<tr>
<td>Effort</td>
<td>3.94 (1.10)</td>
<td>3.85 ( .98)</td>
</tr>
</tbody>
</table>
Research Question 3. Did the number of CLIPS used by students moderate the effects of CLIPS on student achievement and beliefs?

The analysis for this research question was based only on data from students who completed at least one CLIPS. To examine the effects of number of CLIPS on student achievement, we split the file into Early and Late Treatment data. For the Early Treatment group, we examined whether the number of CLIPS completed affected achievement growth from Test 1 to Test 2. For the Late Treatment group, we examined whether the number of CLIPS assigned affected achievement growth from Test 2 to Test 3. We found that the number of CLIPS completed had no significant effect on the achievement of students in the Early $[F(4, 38)=.883, p=.483]$ or the Late $[F(4, 37)=1.091, p=.375]$ Treatment groups.

Research Question 4. What factors influenced teacher decisions to assign particular students to CLIPS?

In this question we searched for variables in our data that predicted whether or not a student would complete one or more of the CLIPS. Earlier we noted that a relatively small proportion of all students (18% of non-missing cases) completed one or more CLIPS.

We addressed this research question using logistic regression on the students in classrooms taught by teachers who assigned at least one CLIPS to one of their students ($N=369$ after listwise deletion of cases). We began by searching the database for multicollinearity. We conducted a multiple regression on CLIPS use (i.e., all students who completed at least one CLIPS versus students who did not use CLIPS). We entered into a multiple regression the following potential predictors of CLIPS use: gender, grade, pretest self-efficacy, pretest math beliefs, pretest math as quick/fixed learning, pretest fear of failure, pretest effort, and achievement Test 1. We found low tolerances, indicating multicollinearity, for pretest self-efficacy and pretest math beliefs. These two variables correlated highly $r=.574$. Since there were reliability issues for the pretest math beliefs, we deleted it and kept pretest self-efficacy. In the second multiple regression, we re-entered the reduced set of predictors. We found low tolerances for pretest self-efficacy and pretest effort, two variables that were highly correlated $r=.408$. We decided to retain effort because it had a higher tolerance score than pretest self-efficacy which was deleted. In the third multiple regression there was no evidence of multicollinearity.

We entered into the logistic regression the following potential predictors of CLIPS use: gender, grade, pretest math as quick/fixed learning, pretest fear of failure, pretest effort, and achievement Test 1. When all six predictor variables were in the equation, 39% of the variance in CLIPS assignment was explained. Four of these variables were statistically significant predictors of CLIPS use when considered in isolation: fixed/quick learning pretest ($p=.042$), pretest effort ($p=.001$), achievement pretest ($p<.001$), and gender ($p=.041$). Students were more likely to be assigned CLIPS if they had low pretest achievement, dysfunctional attitudes toward math learning, reported exerting low effort on mathematical tasks or were male.

However, when all the predictors were entered into the model simultaneously, only the achievement pretest score was statistically significant as shown in Table 9. The table shows that the odds of being assigned CLIPS decreased for every unit increase of the achievement pretest
(i.e., low achieving students were more likely to be assigned CLIPS). The model predicted 43% of those who were assigned CLIPS (up from 16%) and 95% of students who were not (up from 86%).

Table 9

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>Sig.</th>
<th>Odds Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre quick/fixed learning</td>
<td>-.019</td>
<td>.915</td>
<td>.98</td>
</tr>
<tr>
<td>Pre fear failure</td>
<td>-.058</td>
<td>.683</td>
<td>.94</td>
</tr>
<tr>
<td>Pre effort</td>
<td>-.158</td>
<td>.349</td>
<td>.85</td>
</tr>
<tr>
<td>Achievement Test 1</td>
<td>-.326</td>
<td>.000</td>
<td>.72</td>
</tr>
<tr>
<td>Gender</td>
<td>-.444</td>
<td>.152</td>
<td>.64</td>
</tr>
<tr>
<td>Grade</td>
<td>.220</td>
<td>.237</td>
<td>1.25</td>
</tr>
<tr>
<td>Constant</td>
<td>4.006</td>
<td>.000</td>
<td>54.91</td>
</tr>
</tbody>
</table>

The median score on the achievement pretest for all CLIPS users was 9 out of 20 (teacher marking). The proportion of students who received CLIPS declined from 40% of those given low scores on the pretest (0-7), to 29% of those with medium scores (8-11), to 8% of those with high scores (12-20). However, that still left a lot of non-users with scores that were similar to those who received CLIPS.

Finally, we examined how teachers used the achievement pretest data to assign CLIPS. We suggested two alternative strategies to teachers: assign the full set of CLIPS to the six lowest achieving students based on their total score or assign either CLIPS 1-3 or CLIPS 4-5 based on student pretest scores (i.e., if a student scored less than 50% on items 1-5, assign CLIPS 1-3; if the student scored less than 50% on items 6-10, assign CLIPS 4-5). Inspection of a matrix of students X CLIPS completed by each teacher produced a confusing pattern that appeared to be heavily influenced by student absences (e.g., a student might complete CLIPS 1, skip CLIPS 2 and 3, then complete CLIPS 4 and 5). In addition, the outcome of the strategies would be identical if a student was among the six lowest performers and scored less than 50% on both sets of items. This likely occurred because scores on items 1-5 and items 6-10 were highly correlated with the total score ($r=.905$ and $.923$ respectively). We found some support for the notion that teachers were assigning CLIPS on the basis of students' total score: for students who started with CLIPS 1, the correlation between total score and CLIPS assignment was higher ($r=-.401$) for the total score than for items 1-5 ($r=-.376$) The same pattern was found for students who started with CLIPS 4: the correlation between total score and CLIPS assignment was higher ($r=-.275$) for the total score than for items 6-10 ($r=-.253$). However, the differences were very small—we would have had better information if we had just asked the teachers what they did.
Research Question 5. How reliable are teacher interpretations of the CLIPS placement test?

A key element in the program theory underlying CLIPS is that there be a good fit between student need and CLIPS content. If teachers over-identify students for CLIPS assignment, students who have already mastered the content will be spending about 50 minutes (if they complete all five CLIPS) unproductively. More serious are under-identifications; i.e., students who could benefit from receiving CLIPS who do not receive them. The placement test (achievement Test 1) involves relatively high inferences. We were concerned that teacher marking might be unreliable. For example, Cousins, Ross, and Prentice (1993) found statistically significant differences between expert markers and classroom teachers even after training.

Table 10 shows the proportion of perfect agreement between trained markers and classroom teachers on the placement test. For seven of the ten items there was 95% agreement or better. Chance adjusted agreement was excellent (Kappa=.80s-.90s). Agreement was much lower on three items than the others: perfect agreement was in the 62-70% range and chance adjusted agreement was only fair (kappa=.40-.50s). The items for which there was high agreement were low inference: the items called only for an answer. The other three items were high inference because they demanded an explanation (written for items 1 and 2, a drawing for item 7). In a workshop following the completion of the study, teachers quickly reached agreement on how to mark Item 7. The rubric (in the Appendix) required that the two figures showing the fractions 1/2 and 2/4 be in identical positions on the shapes drawn by the student. Although some teachers disagreed with this criterion, once it was established as a policy teachers had no difficulty recognizing it. However, the marking of items 1 and 2 which called for an explanation continued to be problematic, even after fairly lengthy discussion.

Table 10
Percent Perfect Agreement and Kappa Scores of Teachers and Expert Markers (N=715-725)

<table>
<thead>
<tr>
<th>Item Number</th>
<th>Percent Perfect Agreement</th>
<th>Kappa</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>62%</td>
<td>.43</td>
</tr>
<tr>
<td>2</td>
<td>70%</td>
<td>.54</td>
</tr>
<tr>
<td>3</td>
<td>97%</td>
<td>.87</td>
</tr>
<tr>
<td>4</td>
<td>98%</td>
<td>.95</td>
</tr>
<tr>
<td>5</td>
<td>95%</td>
<td>.93</td>
</tr>
<tr>
<td>6</td>
<td>98%</td>
<td>NA</td>
</tr>
<tr>
<td>7</td>
<td>70%</td>
<td>.42</td>
</tr>
<tr>
<td>8</td>
<td>98%</td>
<td>.96</td>
</tr>
<tr>
<td>9</td>
<td>96%</td>
<td>.94</td>
</tr>
<tr>
<td>10</td>
<td>99%</td>
<td>NA</td>
</tr>
</tbody>
</table>

NA=Kappa cannot be calculated if one of the three categories of response is empty for one of the markers
We also found that teachers were more generous than the expert markers. Scores were significantly higher on four of the ten items as shown in Table 11. In the table, items ending with ‘t’ (e.g., “r1v01t” are scores awarded by teachers) and items not ending with ‘t’ (e.g., “r1v01” are scores awarded by the expert markers). We attribute the higher scores awarded by teachers to teachers being better able to interpret what students meant than external markers who had no prior experience with these students.

Table 11
Comparison of Mean Scores Assigned by Teachers and Expert Markers

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>N</th>
<th>SD</th>
<th>t-tests</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pair 1</td>
<td>r1v01t</td>
<td>1.08</td>
<td>723</td>
<td>.83</td>
</tr>
<tr>
<td></td>
<td>r1v01</td>
<td>1.00</td>
<td>723</td>
<td>.84</td>
</tr>
<tr>
<td>Pair 2</td>
<td>r1v02t</td>
<td>1.19</td>
<td>723</td>
<td>.79</td>
</tr>
<tr>
<td></td>
<td>r1v02</td>
<td>1.03</td>
<td>723</td>
<td>.80</td>
</tr>
<tr>
<td>Pair 3</td>
<td>r1v03t</td>
<td>1.79</td>
<td>725</td>
<td>.53</td>
</tr>
<tr>
<td></td>
<td>r1v03</td>
<td>1.79</td>
<td>725</td>
<td>.54</td>
</tr>
<tr>
<td>Pair 4</td>
<td>r1v04t</td>
<td>1.44</td>
<td>723</td>
<td>.82</td>
</tr>
<tr>
<td></td>
<td>r1v04</td>
<td>1.43</td>
<td>723</td>
<td>.83</td>
</tr>
<tr>
<td>Pair 5</td>
<td>r1v05t</td>
<td>1.23</td>
<td>723</td>
<td>.72</td>
</tr>
<tr>
<td></td>
<td>r1v05</td>
<td>1.23</td>
<td>723</td>
<td>.72</td>
</tr>
<tr>
<td>Pair 6</td>
<td>r1v06t</td>
<td>1.85</td>
<td>723</td>
<td>.50</td>
</tr>
<tr>
<td></td>
<td>r1v06</td>
<td>1.83</td>
<td>723</td>
<td>.56</td>
</tr>
<tr>
<td>Pair 7</td>
<td>r1v07t</td>
<td>1.65</td>
<td>715</td>
<td>.63</td>
</tr>
<tr>
<td></td>
<td>r1v07</td>
<td>1.43</td>
<td>715</td>
<td>.73</td>
</tr>
<tr>
<td>Pair 8</td>
<td>r1v08t</td>
<td>1.18</td>
<td>721</td>
<td>.93</td>
</tr>
<tr>
<td></td>
<td>r1v08</td>
<td>1.17</td>
<td>721</td>
<td>.93</td>
</tr>
<tr>
<td>Pair 9</td>
<td>r1v09t</td>
<td>1.03</td>
<td>723</td>
<td>.93</td>
</tr>
<tr>
<td></td>
<td>r1v09</td>
<td>1.04</td>
<td>723</td>
<td>.94</td>
</tr>
<tr>
<td>Pair 10</td>
<td>r1v10t</td>
<td>1.09</td>
<td>719</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>r1v10</td>
<td>1.09</td>
<td>719</td>
<td>1.00</td>
</tr>
</tbody>
</table>
Research Question 6. What conditions contribute to or inhibit effective CLIPS use?

This question was addressed through the implementation surveys and in the case studies. In this section we will report only the survey results, holding the richer detail for the case study report at the end of the quantitative section.

The database is limited: only 18 teachers completed the implementation survey. We found three related themes in the survey.

Very Serious Technology Implementation Problems

The problems were varied but fell along two axes: hardware issues in the school and software issues. Examples of hardware issues were: issues with sound (“lost audio”), inability to launch the program (“CD ROMs on computers didn’t work”) and sporadic problems running the program (“screen froze”). The diversity of hardware issues suggested that the system requirements of CLIPS pushed the limits of the hardware available in the schools. Examples of software issues were: it was slow when many students were accessing the web version, students were “unable to open the disk”, “program did not run”, “one disk didn’t work” (appears to have been one disk among several since this issue was resolved).

The issues described by the teachers suggest that the system requirements may be a significant issue. However, most teachers would be unable to check this (it is clear that one teacher relied on their students to run the software, for example). It is recommended that the software be modified to have automatic checking of basic system requirements (does system have a sound card, is the computer sufficiently fast, etc.). Lastly, it was noted by one researcher that the software requires Flash software and that an automatic installation routine on the OAME website did not install the software properly. The researcher resolved this issue by installing the Flash software directly from the Adobe website but this availability was likely not known by the teachers who experienced problems.

These technology problems are not unique to the school district in which we conducted the research. One of the researchers involved in the data analysis reported that his district had to make changes to meet software licensing arrangements. Access to all software was moved to centralized control where the copyrights and licenses are maintained. This way the software vendors can audit the entire board without going to each computer. The catch is that individual teachers, or even computer administrators in schools, cannot install any software. They have to request the software be installed centrally in order that the board can verify the license. This increases the burden on teachers and decreases the likelihood that they will access the software.

All but one of the 18 teachers reported major difficulties regardless of where they had students work on the CLIPS. Ten teachers reported they had resolved the problems to some degree; the remainder said they had not. The most likely explanation for the major attrition through the study was the inability of teachers to solve the technology problems.
Insufficient Support and Supervision

Teachers reported using CLIPS in a variety of locations. Of the 27 locations (the 18 teachers checked as many as applied), in only ten cases was the mathematics classroom the site of CLIPS use. Other locations were the special education room (N=2), the library (N=5), students’ homes (N=4), the computer room (N=3), and other (N=3, not identified). The reasons teachers relied on non-classroom sites were lack of equipment in their homerooms, school policies that assigned computers to non-classroom locations and difficulties in accessing the program from the school. In these non-classroom locations students were either unsupervised (e.g., home use) or monitored for behaviour only (i.e., if students appeared to be working on the program, even if they were not using it as intended, there would be no intervention by the librarian or supervisor of the computer room). Several teachers expressed concern about their inability to monitor CLIPS use when students were not in the classroom. For example, one teacher reported “program did not run and I was not notified”. The lack of supervision was particularly consequential because students who were assigned to CLIPS were more likely than students not so assigned to be low achievers (as described above), have weaker self-efficacy \(F(483)=5.814, p<.001\) and report that they exert low effort in math class \(F(481)=2.235, p=.026\).

Of the 18 teachers who responded to the survey, 12 either did not interact with students at all when they were working through the CLIPS or observed students solely for classroom management purposes. Six teachers reported interacting with students as they worked by checking to see that students were ready to move from one CLIPS to the next, by identifying student thinking, and by providing additional help. These three practices were highly correlated \(r=.570-.723, p=.001\). Most teachers (12 of 18) reported that they had a conference with students to review their work in CLIPS. Two other teachers reviewed students’ written work. Of the remaining four who had no follow up to the CLIPS, three did not interact with students while they were working with the program.

The program developers recommended that students be assigned to CLIPS in pairs so that they could help each other and engage in explanation sharing—the latter is a strong predictor of student achievement (Ross, 2008). However, only five teachers had students work in pairs all the time and one teacher had students working in small groups. The remainder had students work alone for all or part of the time, perhaps because they felt that placing two low achievers together in a relatively unsupervised context would lead to behaviour issues.

Given the technical difficulties students encountered, the lack of supervision and support while completing CLIPS, and the cognitive and affective needs of students, there is considerable doubt that students completed the CLIPS as intended. For example, it is possible that some students entertained themselves by manipulating the flashier aspects of the program without engaging in serious learning.

Integration of CLIPS with Other Math Teaching

Seven of the 18 teachers taught fractions during the period of CLIPS implementation as part of their regular mathematics program; the remainder did not. The teachers who had a good fit of CLIPS with their curriculum were more likely to interact with students as they worked on
CLIPS. Teachers who were teaching fractions concurrently with CLIPS use were particularly likely to observe CLIPS activity in order to identify student thinking ($r=.570$, $p=.001$). Those for whom CLIPS were not a good curriculum fit were likely reluctant to allocate the time required for the program, especially when technical impediments emerged. The developers told teachers that each CLIPS could be completed in about 10 minutes, which was the case for able students, but higher needs students took longer. One third of the teachers found students were talking 11-15 minutes per CLIPS; one third reported 16-20 minutes; and one third reported more than 20 minutes.

Given the problems that teachers and students encountered while working with the program it may come as a surprise that a majority of teachers who completed the survey said that they would use CLIPS again. This group indicated that they would allocate more time to each student and would involve a greater proportion of their class. However, we have no data on the 12 teachers who did not complete the implementation survey. It is reasonable to suggest that their implementation problems were more severe and/or their capacity to deal with these problems was weaker than those who had students who completed one or more CLIPS.

Qualitative Results

**Methodology**

Case Study School (all names are pseudonyms) is centrally located at the intersection of two main roads in a city in the district. There is a range in the socio-economic backgrounds of the families as well as a number of families where English is a second language. The student population is 650 students from junior kindergarten to grade 8. The school was designated as a “turn around school” and a full-time Child and Youth worker is on site for the large number of students who require support.

We constructed student profiles for Adam, Hillary, Reg and Annette. They were in a grade 7/8 class. All four students attended class regularly. Adam was an IEP for language. He was selected to gain more exposure to math terms in English and to provide an opportunity to showcase his strong computer and technology skills to other students. He was a very motivated student who was observed to consistently participate in class.

Hillary was selected to work on CLIPS to gain more exposure to basic concepts about fractions. Hillary was very quiet and shy. She was never observed to participate in whole class discussion. On one occasion the teacher called on her to answer a very simple sum that Hillary got correct. In in-class group assigned tasks Hillary was observed to consistently depend on the other members of her group to do the tasks. At times she was seen to be off task, for example doodling on her partner’s binder.

Reg was selected to participate in CLIPS because ‘he just needs a break in life’. Reg also has strong computer and technical skills. Reg was observed to answer occasionally in class demonstrating inconsistencies in his math understanding, particularly with fractions.
Annette was described by her teacher as having a math phobia. The teacher believed that Annette needed as much one-to-one math learning as possible. It was not uncommon for the teacher to spend three days per week after school with Annette reinforcing math concepts. Annette was considered a “cool” student by her peers and used this persona to mask her lack of understanding in mathematics. Annette was frequently observed to be off task during math class, both during whole class discussion and during group work. Annette was not observed to answer questions or offer feedback during class. The teacher did not call on Annette for answers.

**Experiences with CLIPS: Adam**

From the very first session Adam demonstrated his strength with computers and technology. When this was commented on by a peer he said with great pride, “My dad taught me about computers.” When Adam was unsure about the instructions presented he was quite comfortable to experiment until he was able to figure out what was being asked of him. The other three students were quite content to let him do this, particularly Hillary. The researcher made sure that the other students had opportunities to explore, but consistently when they experienced difficulty it was Adam who showed them the steps. There were only a handful of times when the researcher had to step in to show the students what to do. In this respect Adam represented the ideal student for using CLIPS independently. This experience enabled Adam to shine in front of some of his peers. When the researcher commented on this aspect of Adam’s experience with CLIPS the teacher responded that ‘he so needed that chance’. There is evidence that Adam’s confidence within the classroom among his peers has increased because of his experience with CLIPS.

Adam embraced all the activities, enjoying the experience of learning about fractions presented through computer technology. However, areas in Adam’s conceptual understanding that were weak surfaced through the CLIPS use. Adam had great difficulty in ordering fractions on a number line and insisted that 9/10 was closer to zero than 1. The other area where Adam’s lack of conceptual understanding was apparent was in the splitting and merging task with the tackle box. It was apparent that Adam was cutting the tackle box into three equal sections instead of removing dividers to merge the sections. Adam also stated that the language used to describe the tackle box task was too difficult for some students to understand. On the other hand, Adam grimaced each time he heard the ‘Who Cares about Fractions? jingle, explaining that it was too immature for his age level. Within the group it became affectionately known as ‘Adam’s favourite song’!

**Experiences with CLIPS: Hillary**

Hillary struggled with mathematics and had low self-confidence as a math student. She was very quick to say, ‘I don’t know what to do’ or ‘I don’t know what they are asking me do’. When Hillary observed the other students struggling and laughing with the drop ball game, she was giggling at their attempts to place a ball on the line correctly. However, when asked if she would like a turn she refused. On the other hand, Hillary was able to verbalize her problem solving strategies on occasion. For example, in the tackle box task (CLIPS D), Hillary counted the sections and then divided by three to get four sections. She then proceeded to attempt to cut
or split the box instead of merging the sections. Hillary required much assistance with the CLIPS from a teacher or strong student to get through some of the tasks.

**Experiences with CLIPS: Reg**

Reg was fairly comfortable with the technical aspects of the software and, like Adam, was prepared to experiment. He also regularly self-corrected. While Reg sometimes judged the content to be too easy, there were concepts he had difficulty grasping. These included splitting the empty part of the pool into sections so that the entire pool would eventually have 12 lanes (in CLIPS D). Similarly in the tackle box exercise he was able to cut but not merge the sections. He was thrown off as soon as he clicked on the divider thinking he was splitting the box at that line and found the divider disappeared creating a double section where he wanted it to be divided.

While there were several times when Reg was observed to be somewhat disengaged with the tasks he was the most enthusiastic with the Drop Ball game (CLIPS E). He eagerly awaited his second turn and declared that the strategy he used was to place the balls randomly on the line hoping, by pure chance alone, to get some correct. The CLIPS were predominantly within Reg’s zone of proximal development, but at times he indicated that the presentation lacked sophistication or maturity.

**Experience with CLIPS: Annette**

Annette disengaged from the CLIPS from the very first session because of her perception that it was all too easy for her. Although there was evidence that Annette lacked some of the conceptual understanding of the material being presented, she took offense at the way it was presented. She felt that the ‘Who Cares about Fractions?’ video was targeted at much younger and less sophisticated students. Annette based this judgment on the presentation of the tasks. For example, she was observed to physically cringe in reaction to the request in CLIPS to count muffin pieces.

There were numerous examples of Annette being very quick to say ‘oh I don’t get it’ or ‘I didn’t understand’. However, occasionally Annette offered constructive comments such as: “I think there should be something like on a map, a legend, that tells you how things will work. Sometimes it’s a check mark and sometimes it’s not.” Further, Annette was very surprised that she had been able to place the numbers on the number line correctly. She just assumed that Adam was right and she was wrong. It is possible that Annette would have had a more positive experience if with another student at an equal or lower level.

In the tackle box task (CLIPS D) Annette’s conceptual understanding of fractions was challenged: She was unable to merge the sections of the tackle box and became confused by the task. When probed further, it became apparent that she was able to remove all the dividers and re-place them to create three equal sections - thus essentially splitting rather than merging parts. Annette was unable to describe her strategies and thinking as she worked through this task.
Cross-Case Analysis

In general, all four students benefited from using CLIPS. Three of the four students were motivated to use the learning objects on the computer. The fourth was motivated when there was a very close match between her perceived expectations of grade 7 material but was disengaged when she felt that the CLIPS were too childish. Similar to stage 3 of this study, researchers observed specific examples of all students gaining mastery experiences while working with the CLIPS. Table 12 describes five examples.

Table 12
Examples of Student Mastery Experiences with the Revised CLIPS

<table>
<thead>
<tr>
<th>CLIPS</th>
<th>Student</th>
<th>Description</th>
</tr>
</thead>
</table>
| A     | Adam    | Creating Visual Representations of Fractions ~ Activity 5
        |         | Adam’s computer literacy emerged in this first session as he jumped in to assist Reg with a task. Reg was unsure of where to enter the number of fractional parts on the screen. Adam appeared to know intuitively where the number was to be placed. “Put the number of parts in that box. Click on the part to colour them.” He went on to assist Hillary and as if sensing that he was emerging as the computer expert in the group, proudly announced, ‘ My dad taught me about computers.’ When faced with a task where the correct answer is not presented (where none of the options in the CLIPS was correct), Adam and Reg, although confused, selected an answer. Adam justified his choice knowing that it was not correct by saying, ‘ I guess because it’s the closest.’ CLIPS A provided Adam with an opportunity to be exposed to the language associated with fractions, culturally specific examples of where we use fractions (the video) and an opportunity to shine re: his computer skills among his peers as he gently and sensitively guided them through parts they were unsure of. |
| B     | Annette | Forming Equivalent Fractions ~ Rectangular Model ~ Activity 4
        |         | Annette made the fractional parts of the rectangle go up to 100
        |         | Adam: Explain what you are doing there.
        |         | Annette: I wanted the numerator to go to 100. It’s going up by two. I know it’s 40. (2/5 = 40/100)
        |         | Annette’s next turn was to create fractional parts of a circle. Annette clicked on the circle repeatedly to see what the maximum number of parts she could create. She made the number of parts 100 and responded,
        |         | Annette: Cool!
        |         | Annette was confident in her knowledge that 2/5 was equal to 40/100 and manipulated the learning object to match her understanding. |
| B     | Reg     | Equivalent Fractions ~ Circle Folding ~ Activity 2
        |         | In the folding circle activity Reg followed the instructions quite well. Although all four students were somewhat confused by the instructions Reg was the only one who did not refold his circle and make another fold line. Through making a quick observation at the screen and the others he realized that he had to make another fold and did this quickly to catch up with the action. |
Reg and the other students were able to correctly name the unshaded part of the circle in 3 different ways after the researcher reminded them of the steps they had taken in naming the shaded part of the circle. Reg was learning through the folding task, including self-corrections, not simply following instructions to demonstrate existing understanding.

D Hillary

Splitting Parts ~ The Swimming Pool ~ Activity 2
In CLIPS D the students watched a presentation about splitting parts. Hillary was able to divide the pool into two equal sections, but required assistance from Adam to describe what fraction of the whole pool would the kids get. She answered 2/2. Adam tells her, ‘No.’ She immediately realized her mistake and correctly selected 2/4 which was correct.

Hillary struggled throughout the CLIPS learning objects activities but experienced clear success with splitting the pool into lanes and finding the related fractions.

E Adam

Representing Improper Fractions ~ Drop Ball Game ~ Activity 3
Adam was very anxious to have a turn with Drop Ball. At the end of the session Adam was very keen to share the strategy he used for Drop Ball. ‘I had a strategy. It was multiplication that was my strategy. It worked.’
Researcher: Tell me about that.
Adam: Well, 6, 12, 18 with left over. It’s 3 and some.’
When the researcher suggested that Adam could use division he was adamant that multiplication was an effective strategy for him.

The drop ball task was directly in Adam’s zone of proximal development after having completed the other activities in CLIPS E.

These mastery experiences supported student development of conceptual understanding and/or increased their self-efficacy, both of which positively influence student achievement.

Of particular interest, researchers noted the positive effects of teacher lessons where the warm-up to the lesson (minds-on) matched directly to student learning using the CLIPS. These opportunities led to greater success for students who immediately thereafter used the CLIPS to further their learning. For example, the teacher used the SB to show simple circle fraction pieces to explore improper fractions. The teacher would give the students a fraction such as 5/3 and the students would illustrate 5/3 using circle pieces (3 1/3rds to make one whole plus 2 additional thirds). In the CLIPS following this lesson, the students were working with improper fractions using pizza slices (2 1/8) which was slightly more challenging than the students had done in class (CLIPS E). There was evidence that all four students were more engaged with the CLIPS activities immediately following the lesson than in other sessions where they perceived CLIPS to be too ‘easy’ for them.

Unfortunately, the students believed they had been selected to use the CLIPS because they were “stupid.” Both the teacher and researcher spoke to the students about this but their perception prevailed.

Based on all qualitative data gathered in stages 3 and 5, the researchers developed and refined a table of ideal implementation conditions and inhibiting implementation conditions. This table highlights ways that teachers and schools can most effectively make use of the CLIPS.
Table 13
*Conditions Affecting Student Learning with CLIPS*

<table>
<thead>
<tr>
<th>Ideal Enabling Conditions</th>
<th>Inhibiting Conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Student Related Conditions</strong></td>
<td></td>
</tr>
<tr>
<td>Regular attendance at school (case of Andrea, Adam)</td>
<td>Irregular attendance at school (case of Mandy)</td>
</tr>
<tr>
<td>Targeted selection of students based on need (case of Andrea)</td>
<td>Selection of students without regard to learning need</td>
</tr>
<tr>
<td>Pair of students working on the CLIPS together who work collaboratively to construct their</td>
<td>Pair of students working on the CLIPS who are incompatible (case of Mandy and Andrea esp. after Mandy’s absence)</td>
</tr>
<tr>
<td>understanding (case of Brad and Sarah)</td>
<td></td>
</tr>
<tr>
<td>Students perceive that they are selected to work with CLIPS as a reward or as a positive</td>
<td>Students perceive that they are selected to work with CLIPS as a punishment or as a negative opportunity (e.g., because “we are stupid”)</td>
</tr>
<tr>
<td>opportunity</td>
<td></td>
</tr>
<tr>
<td>Positive efficacy of student [having confidence to do math] (case of Adam)</td>
<td>Negative efficacy of student [lacking confidence to do math] (case of Hillary, case of Mandy)</td>
</tr>
<tr>
<td>Student facility with technology:</td>
<td>Lack of student facility with technology:</td>
</tr>
<tr>
<td>Student has a high level of comfort using the computer and is willing to experiment with the</td>
<td>Student has a low level of comfort or experience using the computer and is un-willing or fearful of experimenting with the learning objects (afraid to touch buttons, lack of intuitive sense of ‘what to do’, etc) (case of Hillary)</td>
</tr>
<tr>
<td>learning objects (buttons, keying in information, etc) (case of Adam, case of Andrea)</td>
<td></td>
</tr>
<tr>
<td><strong>Technical Conditions</strong></td>
<td></td>
</tr>
<tr>
<td>Technical facility:</td>
<td>Technical challenges:</td>
</tr>
<tr>
<td>Easy access to computers, required software, learning objects, audio technology such as</td>
<td>Lack of access to computers, required software, learning objects, audio technology such as headphones (lacking at all sites.)</td>
</tr>
<tr>
<td>headphones</td>
<td></td>
</tr>
<tr>
<td>Technical ease of the learning objects (e.g., capability of Flash) for the user</td>
<td>Technical problems with the learning objects (e.g., Fraction Strips CLIPS B stopped working at times so students assumed the activity was done and moved on without consolidating understanding) for the user</td>
</tr>
<tr>
<td>Appropriate pace of CLIP learning object with click forward option for student control (circle</td>
<td>Fast pace of clip materials without student control (drop ball CLIPS E)</td>
</tr>
<tr>
<td>folding CLIPS B)</td>
<td></td>
</tr>
</tbody>
</table>
Teaching Conditions

| Whole class instruction (warm-up) within zone of proximal development of the student | Warm-up outside of zone of proximal development of the student |
| Teacher warm-up matches the conceptual and procedural focus of the CLIP (i.e., related to fractions and specifically to the CLIP concept student is working on) | Teacher warm-up is unrelated to conceptual focus of CLIP (i.e., not related to fractions) |
| Teacher interventions within zone of proximal development of the individual student (case of Andrea) | Lack of teacher interventions for the individual student (case of Mandy) |
| Use of materials such as fraction circles and fractions strips, and virtual manipulatives (on SmartBoard for example), that matches CLIPS to build conceptual understanding (case of third school) | Lack of use of hands on materials to reinforce concepts related to fractions (case of Sarah and Brett) |

Summary of Key Findings

1. Did CLIPS contribute to the mathematics achievement of underachieving students in grades 7-10?

The first CLIPS implementation had no statistically significant impact. The second implementation did. There was a small positive effect (Cohen’s $d=.33$) on student achievement. However, attrition from the program was very large, far in excess of what one would expect when the teachers were all volunteers, the duration of the project was very short, and the learning needs addressed by the software were of high importance to teachers. The attrition was partly due to the extended delay between the original timeline and the actual delivery of CLIPS. This delay occurred because the development process took longer than anticipated and there was a strong push from the teachers to delay field testing until the software had been pilot tested. In addition, the Mathematics Consultant for the district was appointed to a new role and was not replaced until after the study was completed.

The most likely explanation for the difference between the experiences of the Early and Late Treatment teachers is within-school conversation. The Late Treatment teachers knew what to expect, they learned from the experiences of the previous group, and the less persistent teachers probably withdrew before assigning any CLIPS to students.

The results suggest that the CLIPS have the potential to be a useful instructional tool for teachers but only under the conditions identified in Table 13 on pages 30-31. This suggests that one of the aspirations for CLIPS—independent use by students in unsupervised conditions—is unlikely with the current version of the product.
2. Did CLIPS contribute to improved student affect about mathematics and mathematics learning?

There was no significant impact on student motivation or beliefs about mathematics learning. The duration of the treatment was too short to have an impact. However, we do not rule out the possibility that sustained use of a set of CLIPS addressed to different math topics might generate over time a positive contribution to student motivation.

3. Did the number of CLIPS used by students moderate the effects of CLIPS on student achievement and beliefs?

The number of CLIPS assigned did not make a significant difference to student outcomes, probably because the overall effect was too small. There did not seem to be an accumulative effect; however, statistical power was too low to predict whether the lack of accumulative effect would hold in the future.

4. What factors influence teacher decisions to assign particular students to CLIPS?

The logistic regression demonstrated that the only data used by teachers to assign CLIPS was student need as indicated by the placement test, a valid and reliable measure. Teachers used a variety of strategies for using the placement test scores to assign students to CLIPS. In addition, there was evidence from the case study data of teachers using other considerations such as assigning CLIPS to a student who was weak in using appropriate mathematical language or conversely assigning CLIPS to a student who was strong in computer skills.

5. How reliable are teacher interpretations of the CLIPS placement test?

Teacher marking of the CLIPS placement test was very consistent with that of external markers on most of the items. There were persistent differences regarding the interpretation of items that called for explanations. These differences suggest a need for more extensive teacher training in interpreting students’ mathematical reasoning, especially in writing.

6. What conditions contribute to or inhibit effective CLIPS use?

Table 13 summarizes the key conditions that need to be in place at the student, technology and instructional levels. The big message is that students need support to use CLIPS effectively.

**Stage 6: Further Testing of CLIPS in New Contexts**

In the final step of the research we are investigating the optimal conditions for CLIPS use and replicating the findings from Stage 5 in different contexts. For example, we are currently conducting a study to find out which is the better sequence: PRIME training followed by implementation of CLIPS or CLIPS introduced at the same time as PRIME training.
For implementation of CLIPS in stage 6 we made a number of changes to address the technology issues discovered in stage 5 of the research. The most important of these were:

- The program was put on the district’s server. This should provide high speed access to all classrooms and eliminate some of the technology problems encountered in stage 5.

- We identified the most important problems that teachers faced (such as sound cards not working) and asked teachers to try out the program before assigning students to it.

- Technology staff (i.e., developers of the CLIPS software) resolved minor glitches in the CLIPS that were impeding student use.

- We shared the conditions that facilitated and impeded CLIPS use with the teachers.

- We emphasized the importance of providing appropriate supervision and support to students while working on the CLIPS.

- We also suggested that teachers remind students that they would be completing a test measuring CLIPS content after working through the program, the goal being to increase student accountability.

**Qualitative Research Questions**

1. How do grade 7 teachers implement PRIME and CLIPS? The key sub questions follow: How do teachers assess student needs? Do teachers make accurate assessments? How do teachers use formative assessment data to differentiate instruction?

2. To what extent do teachers’ enactments of PRIME and CLIPS create mastery experiences for struggling grade 7 students?

3. To what extent does the in-service training in PRIME and CLIPS contribute to teachers’ technical skills, pedagogical content knowledge, and beliefs about their professional capacity?

**Quantitative Research Questions**

1. What are the effects of PRIME and CLIPS instruction on student achievement and motivational beliefs (i.e., functional and dysfunctional beliefs about mathematics, self-efficacy, effort, and fear of failure)?

2. To what extent are the student achievement effects of PRIME and CLIPS moderated by student motivational beliefs?

3. To what extent are the effects of PRIME and CLIPS on student outcomes moderated by teacher characteristics (teacher efficacy, pedagogical content knowledge, and self-reported instructional practices)?
4. To what extent does PRIME training of teachers facilitate effective use of the CLIPS materials?

The study is in two phases as shown in Table XX. Both phases of the study are straightforward but when combined in a single table the design appears to be complex.

The first phase of the study involves a randomized field trial organized around teacher in-service on PRIME. 24 teachers enrolled in the PRIME in-service. We used 2007 grade 6 EQAO scores and SES school profile data (13 variables from C.D.Howe database reported by Johnson, 2005) to create matching pairs of schools. Each school in the pair was randomly assigned to early (N=265 students) or late treatment (N=191 students) There were two quantitative observations: in early October (O₁) and end of December (O₂a), as shown in the left side of Table 14. The observations consisted of a PRIME test of student achievement and a student survey (described below) administered before and after the PRIME versus no-PRIME comparison. The right side of Table 14 shows that after the PRIME versus no-treatment comparison, both groups were assigned to the CLIPS treatment.

<table>
<thead>
<tr>
<th>Table 14</th>
<th>PVNC Design: CLIPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Early Treatment</td>
<td>O₁</td>
</tr>
<tr>
<td>Late Treatment</td>
<td>O₁</td>
</tr>
</tbody>
</table>

O₁ = PVNC Diagnostic Test + Student Survey + Teacher Survey
O₂a = PVNC Diagnostic Test + Student Survey + Teacher Survey
O₂b = CLIPS Fractions 1
O₃ = CLIPS Fractions 2

PRIME might magnify the effect of CLIPS in two ways: first, students who experienced PRIME teaching might start at a higher level at O₂b. Since O₂b and O₃ are likely to be correlated, PRIME trained students might have higher achievement at O₃. Second, students who experienced PRIME may learn more from the CLIPS (i.e., have greater growth from O₂b to O₃) than the group that had not experienced PRIME, after adjusting for any differences that exist at O₂b. The final test, at O₃, will assess the sequence of the treatments; i.e., whether PRIME followed by CLIPS is a better or poorer sequence that CLIPS followed by PRIME.

Although we have described the design in terms of the effects of the two treatments on all students, we will be particularly interested in the effects on lower achievers. For example, we anticipate that approximately six students will be assigned to the CLIPS in each classroom. The effects of CLIPS are likely to be felt only by those students who actually use the CLIPS. However, there may be unanticipated consequences for students not assigned to CLIPS so we will measure all students.
Student Instruments

Student achievement will be assessed with three tests. The first is the PRIME diagnostic for end of grade 6 students. This test consists of 14 items measuring core concepts in Number and 14 items measuring concepts in Operation. Student responses will be scored as incorrect (0), partially correct (1) or correct (2), following the scoring key in the manual. The test will be administered at O1 and O2a. In addition, we will administer two achievement tests used in Stage 5 of the research: Achievement Test 1 (10 items drawn from PRIME measuring fractions) and Achievement Test 2 (21 items measuring fractions). The psychometric properties are described in the Instruments and Results section of Stage 5.

Student affect will be measured with the same five scales described in Stage 5 of the research: math self-efficacy, dysfunctional beliefs about math (i.e., the belief that learning in math occurs quickly or not at all and that math ability is fixed), functional beliefs about math discussion, fear of failure, and effort. As noted above, the affect measures will be administered on two occasions, before and after the PRIME-no PRIME implementation.

Teacher Instruments

Teacher efficacy will consist of 12 items from the Teachers’ Sense of Efficacy scale (Woolfolk Hoy, n.d.), adapted for mathematics teaching. There will be four items for efficacy for engagement (e.g., “how much can you do to motivate students who show low interest in mathematics?”), four items for efficacy for teaching strategies (e.g., “how well can you implement alternative Mathematics strategies in your classroom?”), and four items for efficacy for student management (e.g., “how much can you do to calm a student who is disruptive or noisy during mathematics?”). Response options will be a five-point scale anchored by “nothing” and “a great deal”.

Standards-based mathematics teaching will be measured with 20 items (e.g., “I regularly have my students work through real-life math problems that are of interest to them”). Response options will be a six-point scale anchored by “strongly disagree” and “strongly agree”. Ross, Hogaboam-Gray, McDougall, & LeSage (2003) found this scale had high reliability (alpha=.81 in two samples totaling 2600 teachers) and validity. The validity evidence consisted of correlations of survey scores with a mandated performance assessment in grade 6 mathematics, congruence with classroom observations of a small sample of teachers, and demonstrations that teachers who were similar in their claims about using a standards-based text series differed in how they used the text, in ways predicted by the survey.

Pedagogical Content Knowledge (PCK) will consist of teacher survey items that require knowledge of math teaching. PCK will be tested in number concepts, operations, and patterns, functions & algebra (Learning Mathematics for Teaching, 2005).

We will also include other teacher background measures: previous training in mathematics will consist of four 4 items (e.g., “did you major in mathematics at university”) and professional development in teaching mathematics will consist of three items (e.g., “have you taken Additional Qualification courses that focused on mathematics education”).
Data Analysis

The quantitative analysis will begin with descriptive statistics on all quantitative measures: means, standard deviations, skewness and kurtosis. Outliers will be reduced to +/- three standard deviations beyond the mean. Missing values will be replaced using multiple imputation procedures (Peugh & Enders, 2004) of the Missing Values program of SPSS. We will use inferential statistics to answer each of the quantitative research questions.

Progress to Date

The first phase of stage 6, PRIME training was delivered to teachers in the Early Treatment group. Students and teachers in the Early and Late Treatment groups completed the assessments before and after PRIME training. These data are now being scanned and prepared for analysis.

Training and use of CLIPS for the Early Treatment group is taking place Jan 21-Feb 1 2008. The Late Treatment group will begin PRIME training on February 4. During PRIME training these teachers will also be trained in the use of CLIPS and will implement CLIPS Feb 13-27.

Recommendations from the Design Experiment

1. The Ministry of Education should consider hiring a team to produce a user manual describing: how to select students for CLIPS; suggested minds-on activities that prepare students for each CLIPS; suggestions for teacher interventions that support students while working through CLIPS; assessment tools for teachers’ use; strategies for debriefing students on their CLIPS experiences.

2. Further experimentation to identify conditions of optimal CLIPS use, such as the current stage 6 study which examines the impact of prior training in PRIME on CLIPS use. This includes close analysis with larger samples to identify which students most benefit from CLIPS use. We also need to compare the effects of CLIPS to other forms of differentiated instruction.

3. The Ministry should draw upon well researched instructional sequences as the foundation for the creation of new CLIPS. A lower priority should be assigned to CLIPS development in domains less well researched.
References


List of Appendices

Teacher Directions 1
Teacher Directions 2
Teacher Directions 3
Achievement Test 1
Achievement Test 2
Achievement Test 3
Student Survey
Teacher Implementation Survey
Fractions Test 1 – Prime – Clips
Fractions Test 2/3 – Prime – Clips
Technical Issues: Observations from the Final Case Study
Student experiences CLIPS by CLIPS

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CLIPS Data Collection 2007
Grades 7-10 Mathematics
Data Collection #1

| Data Collection Schedule  
| (October 11-12) |
|-------------------|---------------|
| Day One           | Survey        | 20 minutes |
| Day Two           | Fractions Test #1 | 30 minutes |

Student Survey Administration Instructions

1. Please note that student names have been preprinted on the surveys. We need this information in order to match the pre- and post-tests for each student. If there is no name on the survey or achievement test, we will not be able to include that student in the study.

2. Please do not cut off the name of the student or remove any part of the survey. The scanning software cannot read surveys that are damaged.

Fractions Test Administration Instructions

Fractions Test #1 consists of a two-page test of 10 Fractions questions. After completing Part A students should continue with Part B.

Please note that student names have been preprinted on the tests.

Sometimes valuable assessment information is lost when students erase answers. Encourage students to cross out incorrect answers instead of erasing them.

Tell students that they should not write in or around the columns to the right of the questions.

Students who wish to use manipulatives and/or calculators during this test are permitted to do so.

IEP Students who are provided accommodations to complete this test should be given the same level of support for all three tests.
Marking Tests

We want you to mark the Fractions tests for the purpose of identifying students who will be assigned CLIPS. The only marking required by the project is for this first test.

Score the 10 questions using the Test Answer Template
- In the Teacher Use column on each student’s test, circle the score (0-2) for each question. Record the scores on the Student Score Sheet.

Record the results in the “For Teacher Use Only” section at the top of each student’s test.
- Write in the total mark for Part A.
- Write in the total mark for Part B.

Returning Your Data

- Administer the Student Survey and Fractions Test between October 11-12.
- Mark the Fractions tests.
- Using the board courier, send the completed surveys and marked tests in the return envelope to Carolyn Brioux, OISE/UT Trent Valley Centre, Education Centre.

Next Steps

All classes have been randomly assigned to one of two groups: Early or Late Treatment.

October 15-26: The Early Treatment group will use CLIPS.

October 29-30: Student data collection for all classes + CLIPS Implementation Analysis for Early Treatment teachers.

October 31 – November 14: The Late Treatment group will use CLIPS.

November 15-16: Student data collection for all classes + CLIPS Implementation Analysis for Late Treatment teachers.
CLIPS Data Collection
Grades 7-10 Mathematics
Data Collection #2

<table>
<thead>
<tr>
<th>Data Collection Schedule</th>
<th>(October 29-30)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Day One</td>
<td>Survey</td>
</tr>
<tr>
<td>Day Two</td>
<td>Fractions Test #2</td>
</tr>
</tbody>
</table>

**Student Survey Administration Instructions**

1. Please note that student names have been preprinted on the surveys. We need this information in order to match the pre- and post-tests for each student. If there is no name on the survey or achievement test, we will not be able to include that student in the study.

2. Please do not cut off the name of the student or remove any part of the survey. The scanning software cannot read surveys that are damaged.

**Fractions Test Administration Instructions**

The Fractions Test consists of a two-page test of 21 Fractions questions.

Please note that student names have been preprinted on the tests.

Sometimes valuable assessment information is lost when students erase answers. Encourage students to cross out incorrect answers instead of erasing them.

Tell students that they should not write in or around the column to the left of the questions.

Students who wish to use manipulatives and/or calculators during this test are permitted to do so.

IEP Students who are provided accommodations to complete this test should be given the same level of support for all three tests.
Early Treatment Group Only: Identify CLIPS Used

Complete the “For Teacher Use Only” section at the top of the Fractions #2 test, for each student to whom you assigned CLIPS. Place a check mark in the box next to each of the CLIPS that were used.

Complete the short CLIPS Implementation Analysis.

Returning Your Data
On October 31

- Student Surveys and Fractions Tests
- CLIPS Implementation Analysis (Early Treatment)

Using the board courier, send the completed surveys and marked tests in the return envelope to Carolyn Brioux, OISE/UT Trent Valley Centre, Education Centre.

Next Steps

October 31-November 14: The Late Treatment group will use CLIPS.

November 15-16: Student data collection for all classes + CLIPS Implementation Analysis for Late Treatment teachers.
CLIPS Data Collection
Grades 7-10 Mathematics
Data Collection #3

Data Collection Schedule
(November 15-16)

| Day One | Fractions Test #3 | 30 minutes |

Fractions Test Administration Instructions

The Fractions Test consists of a two-page test of 21 Fractions questions.

Please note that student names have been preprinted on the tests.

Sometimes valuable assessment information is lost when students erase answers. Encourage students to cross out incorrect answers instead of erasing them.

Tell students that they should not write in or around the column to the left of the questions.

Students who wish to use manipulatives and/or calculators during this test are permitted to do so.

IEP Students who are provided accommodations to complete this test should be given the same level of support for all three tests.

Late Treatment Group Only: Identify CLIPS Used.

Complete the “For Teacher Use Only” section at the top of the Fractions #2 test, for each student to whom you assigned CLIPS. Place a check mark in the box next to each of the CLIPS that were used.

Complete the short CLIPS Implementation Analysis.
Returning Your Data
On November 19

- Student Surveys and Fractions Tests
- CLIPS Implementation Analysis (Late Treatment)

Using the board courier, send the completed surveys and marked tests in the return envelope to Carolyn Brioux, OISE/UT Trent Valley Centre, Education Centre.

Next Steps

Thank you for your participation in this project.

When we have the data analyzed we will send all participants a summary of the results.
PART A

1. \( \frac{2}{10} \) is less than \( \frac{2}{5} \).  ________________________
   How do you know?

2. a) Is 0.9 closer to 0 or is it closer to 1?  ________________________
   How do you know?

   b) Is \( \frac{1}{10} \) closer to 0 or is it closer to 1?  ________________________
   How do you know?

3. a) Write a fraction between \( \frac{2}{7} \) and \( \frac{5}{7} \).  ________________________

   b) Write a decimal between 0.45 and 0.49  ________________________

   c) Write a decimal between 0.65 and 0.70  ________________________

4. Circle all the fractions that are greater than 1.
   \( \frac{3}{8} \)  \( \frac{8}{3} \)  \( \frac{19}{17} \)  \( \frac{38}{3} \)
5. a) There is always a fraction between two fractions.
   Write a fraction that is between \( \frac{1}{2} \) and \( \frac{3}{4} \). ________________________
   
   b) There is always a decimal between two decimals.
   Write a decimal that is between 0.45 and 0.5. ________________________

PART B

6. Think of each circle as a chocolate and vanilla cookie.
   Which two circles have the same amount of chocolate? _______________________

   ![Circle A, Circle B, Circle C]

7. Draw a picture to show that \( \frac{1}{2} \) is the same as \( \frac{2}{4} \). ________________________

8. Write two fractions that are equivalent to \( \frac{3}{4} \). ________________________

9. Write two fractions that are equivalent to \( \frac{16}{18} \). ________________________

10. Fill in the boxes to write a fraction that is equivalent to 0.30. ________________________
1. Shade \( \frac{5}{6} \) of the boxes.

2. Eight children had drinks at lunch. How many children had juice? Express as a fraction.

3. Find as many equivalent fractions as you can from this picture.

4. Is two thirds of box A equal to two thirds of box B? Explain.

5. Circle the larger fraction. \( \frac{2}{1} \)  \( \frac{7}{3} \)

6. If \( \frac{1}{4} \) of a figure is shaded what percentage is shaded?

7. Write an equivalent fraction for \( \frac{2}{3} \).

8. Two friends have the exact same chocolate bar that is divided into eight equal sections. Lynn eats \( \frac{2}{8} \) of her chocolate bar. Her friend Lisa eats \( \frac{3}{8} \) of her chocolate bar. Who has the most left?

9. Change the mixed number \( 4 \frac{3}{5} \) to an improper fraction.

10. What fraction of the garden are daisies?
11. Write two fractions that are equivalent to $\frac{5}{9}$.

12. Draw a picture to show that $\frac{1}{3}$ is the same as $\frac{2}{6}$.

13. Arrange the following from least to greatest: $\frac{5}{8}, \frac{2}{8}, \frac{7}{8}$.

14. Circle all the fractions that are greater than 1: $\frac{5}{8}, \frac{9}{6}, \frac{4}{12}, \frac{19}{11}$.

15. Write a fraction between $\frac{3}{5}$ and $\frac{7}{8}$.

16. Fill in the following chart.

<table>
<thead>
<tr>
<th>FRACTION</th>
<th>DECIMAL</th>
<th>PERCENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\frac{1}{2}$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

17. Fill in the following chart.

<table>
<thead>
<tr>
<th>FRACTION</th>
<th>DECIMAL</th>
<th>PERCENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\frac{3}{4}$</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

18. Chris and his friends eat $2\frac{1}{3}$ pizzas for dinner. Rewrite the number of pizzas as an improper fraction.

19. Write a fraction for the shaded part.

20. $\frac{2}{12}$ is less than $\frac{2}{6}$ How do you know?

21. Chantal eats $\frac{3}{4}$ of a sandwich for lunch and $\frac{3}{4}$ of a sandwich after school. How many sandwiches does Chantal eat in all? Use pictures, words or symbols to explain your answer.
1. Shade \( \frac{2}{3} \) of the boxes.

2. Two fifths of the class wears glasses. Represent this as a fraction.

3. Write the equivalent fraction shown by the shaded part of the shape.

\[
\frac{6}{10} = \frac{3}{5}
\]

4. One third of lasagna will feed 2 people. How many people will one lasagna feed?

5. Circle the larger fraction. \( \frac{1}{2} \), \( \frac{7}{10} \)

6. If \( \frac{3}{5} \) of this shape is shaded gray. What percentage is shaded gray?

7. If \( \frac{3}{4} \) of the students in a class are boys, how many boys would there be in a class of 28 students?

8. Arrange in order from least to greatest: \( \frac{2}{5}, \frac{4}{5}, \frac{1}{3} \)

9. Change \( \frac{7}{9} \) to an improper fraction.

10. Write the fraction that is represented by the number line.
Section 1  This feeling scale shows how sure you are about something. It goes from 1 to 6. If you are feeling sure, pick a high number. If you are not sure, pick a low number. Fill in the bubble that best describes how sure you are about each question.

1. How sure are you that you could solve a math problem? 

2. As you work through a math problem how sure are you that you can:
   a) understand the math problem.
   b) make a plan.
   c) solve the problem.
   d) check the problem.
   e) explain the solution.

Section 2  This section asks for your opinion about discussions in math class. Using the 1 to 6 scale where 1 = strongly disagree and 6 = strongly agree, fill in the bubble that best describes your beliefs.

When there is a discussion in math class . . .

3. I listen more than talk because I don't want to say the wrong answer.
4. You've got to say what you think so you can hear what other people have to say about what you're thinking.
5. If you are there throwing out your ideas, you could find a new way of doing a math problem.
6. Don't be afraid to ask questions.
7. I just panic and can't think straight if the teacher asks me to share my ideas.
8. If I'm wrong, it doesn't really bother me.
9. You may be solving a problem OK but then another student could show you an easier way that's really fast and quick.
10. Sometimes when you answer something, it just clicks in your head and then you know what you are talking about.
11. When the teacher asks a question, you have to remember the right answer to answer correctly.
12. When the teacher asks me a question I can't answer right away, someone else will be asked.
13. When the teacher asks me a question I can't answer right away, the teacher will answer the question.
Section 3  This section asks for your opinion about learning. Using the 1 to 6 scale where 1=strongly disagree and 6=strongly agree, fill in the bubble that best describes your beliefs.
1. An expert is someone who is really born smart in something. .............................
2. If I cannot understand something quickly, it usually means I will never understand it. ..............................................................
3. Some people are just born smart, others are born dumb. ................................
4. If I am ever going to be able to understand something, it will make sense to me the first time I hear it ..............................................................
5. Students who are "average" in school will remain "average" for the rest of their lives ..............................................................
6. The really smart students don't have to work hard to do well in school...........
7. Successful students understand things quickly ...................................

Section 4  Students have a lot of different thoughts and feelings when they are working in math class. We want to know how true these statements are for you. Using the 1 to 6 scale where 1=not at all true and 6=very true, fill in the bubble that best describes how true each statement is for you.
8. If I gave the wrong answer to my teacher's math question, I would feel terrible.
9. If I were to do poorly in math, I would try not to let anyone know. ...............  
10. If I were to get a low grade in math, it would make me feel very sad. ..............  
11. I worry a lot about making errors on my math work. .................................  
12. I would get very discouraged if I made errors on a math assignment. ...........  
13. As you work through a math problem how hard are you working to check the problem? ..............................................................  

Section 5  Some students put more effort forth in math class than others. We want to know how hard you work in math class. Using the 1 to 6 scale where 1= not hard at all and 6= as hard as I can, fill in the bubble that best describes how hard you are working in math.
14. How hard are you working to learn about math? .................................  
15. How hard do you study for math tests? ..................................................  
16. How hard are you working to solve math problems? ...............................  
17. As you work through a math problem how hard are you working to understand the problem? ..............................................................  
18. As you work through a math problem how hard are you working to make a plan?  
19. As you work through a math problem how hard are you working to solve the problem? ..............................................................  
20. As you work through a math problem how hard are you working to check the problem? ..............................................................  
21. As you work through a math problem how hard are you working to explain the solution? ..............................................................  

Thank you!
CLIPS Implementation Analysis

Teacher Name: ___________________________ School: ___________________________

Part A

In the "For Teacher Use Only Section" at the top of each student's Achievement Test identify the CLIPS each student completed. For example, if Sarah completed CLIPS A, B, and C, place a check mark in the boxes beside A, B, and C.

Part B

When answering the following questions about CLIPS, think about your students as a group.

1. Did you have students work on CLIPS? (Choose as many as apply.)
   O alone  O in pairs  O in small groups larger than a pair  O other ________________________

2. How much time did you usually assign to each of the CLIPS? (Choose one only.)
   O 10 minutes or less  O 11 to 15 minutes  O 16 to 20 minutes  O more than 20 minutes

3. Was this the right amount of time for the typical student? (Choose one only.)
   O yes  O should have been more time  O should have been less time

4. Where did students usually work on CLIPS? (Choose as many as apply.)
   O in the classroom  O in the special education room  O in the library  O at home
   O other, please describe __________________________

5. How much did students like working with CLIPS? (Choose one only.)
   1  2  3  4  5  6
   O  O  O  O  O  O
   did not like at all  liked very much

6. How much did you feel students learned by working with CLIPS? (Choose one only.)
   1  2  3  4  5  6
   O  O  O  O  O  O
   very little  a great deal

7. Did you have any problems accessing the hardware or software needed for CLIPS? (Choose one only.)
   O no problems  O a few problems that I resolved  O problems were unresolved, please describe
   __________________________________________________________________________________________

59029
8. How did you interact with students when they were working on CLIPS? (Choose as many as apply.)
   - no interaction with students
   - observed for student management
   - checked student work to see they were ready to move from one CLIPS to the next
   - observed to identify student thinking about fractions
   - provided additional help when students were working on CLIPS

9. After the typical student completed his/her CLIPS did you do any of these things? (Choose as many as apply.)
   - conferenced with student about his/her CLIPS activities
   - reviewed work produced by the student in CLIPS
   - assigned follow up tasks related to CLIPS
   - other, please describe __________________________

10. Do you feel that the right students worked on CLIPS? (Choose one only.)
    - yes
    - no, more students should have worked on CLIPS
    - no, fewer students should have worked on CLIPS
    - no, different students should have worked on CLIPS
    - other, please describe __________________________

11. Would you use CLIPS again? (Choose one only.)
    - no
    - yes, for less time or fewer students
    - yes, for the same amount of time and same number of students as in 2007
    - yes, for more time or more students
    - other, please describe __________________________

12. Did you teach fractions during the research project (October 31 - November 14)?  ○ Yes  ○ No
    If yes, what topics did you teach?
    ________________________________________________
    ________________________________________________
    ________________________________________________
<table>
<thead>
<tr>
<th>TEST ITEM</th>
<th>PRIME PHASE</th>
<th>CLIPS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Part A</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. ( \frac{2}{10} ) is less than ( \frac{2}{5} ). How do you know?</td>
<td>4</td>
<td>C (Activity 3)</td>
</tr>
<tr>
<td>2. a) Is 0.9 closer to 0 or is it closer to 1? How do you know?</td>
<td>5</td>
<td>Not Addressed</td>
</tr>
<tr>
<td>b) Is ( \frac{1}{10} ) closer to 0 or is it closer to 1? How do you know?</td>
<td>5</td>
<td>C (Intro, Activity 2)</td>
</tr>
<tr>
<td>3. a) Write a fraction between ( \frac{2}{7} ) and ( \frac{5}{7} ). How do you know?</td>
<td>3</td>
<td>C (Intro, Activity 2)</td>
</tr>
<tr>
<td>b) Write a decimal between 0.45 and 0.49</td>
<td>5</td>
<td>Not Addressed</td>
</tr>
<tr>
<td>c) Write a decimal between 0.65 and 0.70</td>
<td>5</td>
<td>Not Addressed</td>
</tr>
<tr>
<td>4. Circle all the fractions that are greater than 1. ( \frac{3}{8}, \frac{8}{3}, \frac{19}{17}, \frac{38}{3} )</td>
<td>5</td>
<td>E (Activity 1)</td>
</tr>
<tr>
<td>5. a) There is always a fraction between two fractions. Write a fraction that is between ( \frac{1}{2} ) and ( \frac{3}{4} ).</td>
<td>5</td>
<td>Not Addressed</td>
</tr>
<tr>
<td>b) There is always a decimal between two decimals. Write a decimal that is between 0.45 and 0.5.</td>
<td>5</td>
<td>Not Addressed</td>
</tr>
<tr>
<td>TEST ITEM</td>
<td>PRIME PHASE</td>
<td>CLIPS</td>
</tr>
<tr>
<td>-----------</td>
<td>-------------</td>
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</tr>
<tr>
<td><strong>Part B</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. Think of each circle as a chocolate and vanilla cookie. Which two circles have the same amount of chocolate?</td>
<td>2</td>
<td>A</td>
</tr>
<tr>
<td><img src="image1" alt="Circle A" /> <img src="image2" alt="Circle B" /> <img src="image3" alt="Circle C" /></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Draw a picture to show that $\frac{1}{2}$ is the same as $\frac{2}{4}$.</td>
<td>2</td>
<td>A</td>
</tr>
<tr>
<td>8. Write two fractions that are equivalent to $\frac{3}{4}$.</td>
<td>4</td>
<td>B (Activity 1)</td>
</tr>
<tr>
<td>9. Write two fractions that are equivalent to $\frac{16}{18}$.</td>
<td>4</td>
<td>B (Activity 4)</td>
</tr>
<tr>
<td>10. Fill in the boxes to write a fraction that is equivalent to 0.30</td>
<td>5</td>
<td>Not Addressed</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>TEST ITEM</th>
<th>PRIME PHASE</th>
<th>CLIPS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Shade $\frac{5}{6}$ of the boxes</td>
<td>4</td>
<td>D</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Activity 3)</td>
</tr>
<tr>
<td>2. Eight children had drinks at lunch. How many children had juice?</td>
<td>4</td>
<td>A</td>
</tr>
<tr>
<td>Express as a fraction.</td>
<td></td>
<td>(Activity 4)</td>
</tr>
<tr>
<td>milk</td>
<td></td>
<td></td>
</tr>
<tr>
<td>juice</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Find as many equivalent fractions as you can from this picture.</td>
<td>4</td>
<td>B</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Activity 4)</td>
</tr>
<tr>
<td>4. Is two thirds of box A equal to two thirds of box B? Explain.</td>
<td>5</td>
<td>Not Addressed</td>
</tr>
<tr>
<td>A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Circle the larger fraction.</td>
<td>5</td>
<td>E</td>
</tr>
<tr>
<td>$\frac{2}{3}$</td>
<td></td>
<td>(Activities 1 to 3)</td>
</tr>
<tr>
<td>$\frac{7}{3}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6. If $\frac{1}{4}$ of a figure is shaded what percentage is shaded?</td>
<td>5</td>
<td>Not Addressed</td>
</tr>
<tr>
<td>$\frac{1}{4}$</td>
<td></td>
<td></td>
</tr>
<tr>
<td>7. Write an equivalent fraction for $\frac{2}{3}$.</td>
<td>4</td>
<td>B</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Activity 1)</td>
</tr>
<tr>
<td>8. Two friends have the exact same chocolate bar that is divided into</td>
<td>4</td>
<td>C</td>
</tr>
<tr>
<td>eight equal sections. Lynn eats $\frac{2}{8}$ of her chocolate bar. Her</td>
<td></td>
<td>(Activity 2)</td>
</tr>
<tr>
<td>friend Lisa eats $\frac{3}{8}$ of her chocolate bar. Who has the most</td>
<td></td>
<td></td>
</tr>
<tr>
<td>left?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Change the mixed number $4\frac{3}{5}$ to an improper fraction.</td>
<td>5</td>
<td>E</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Activities 1 and 3)</td>
</tr>
<tr>
<td>TEST ITEM</td>
<td>PRIME PHASE</td>
<td>CLIPS</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------</td>
<td>-------------</td>
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</tr>
<tr>
<td>10. What fraction of the garden are daisies?</td>
<td>4</td>
<td>B (Activity 4)</td>
</tr>
<tr>
<td>11. Write two fractions that are equivalent to $\frac{5}{9}.$</td>
<td>4</td>
<td>B (Activity 1)</td>
</tr>
<tr>
<td>12. Draw a picture to show that $\frac{1}{3}$ is the same as $\frac{2}{6}$.</td>
<td>2</td>
<td>A</td>
</tr>
<tr>
<td>13. Arrange the following from least to greatest. $\frac{5}{8}, \frac{2}{8}, \frac{1}{8}, \frac{7}{8}$</td>
<td>3</td>
<td>C</td>
</tr>
<tr>
<td>14. Circle all the fractions that are greater than 1. $\frac{5}{8}, \frac{9}{6}, \frac{4}{12}, \frac{19}{11}$</td>
<td>5</td>
<td>E (Activity 1)</td>
</tr>
<tr>
<td>15. Write a fraction between $\frac{3}{5}$ and $\frac{7}{8}$</td>
<td>5</td>
<td>Not Addressed</td>
</tr>
<tr>
<td>16. Fill in the following chart.</td>
<td>5</td>
<td>Not Addressed</td>
</tr>
<tr>
<td>17. Fill in the following chart.</td>
<td>5</td>
<td>Not Addressed</td>
</tr>
<tr>
<td>18. Chris and his friends eat $2\frac{1}{3}$ pizzas for dinner. Rewrite the number of pizzas as an improper fraction.</td>
<td>4</td>
<td>E (Activity 1+)</td>
</tr>
<tr>
<td>TEST ITEM</td>
<td>PRIME PHASE</td>
<td>CLIPS</td>
</tr>
<tr>
<td>-------------------------------------------------------------------------</td>
<td>-------------</td>
<td>--------</td>
</tr>
<tr>
<td>19. Write a fraction for the shaded part.</td>
<td>4</td>
<td>B (Activity 4)</td>
</tr>
<tr>
<td><img src="image1" alt="Fraction Grid" /></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20. $\frac{2}{12}$ is less than $\frac{2}{6}$ How do you know?</td>
<td>4</td>
<td>C (Activity 3)</td>
</tr>
<tr>
<td>21. Chantal eats $\frac{3}{4}$ of a sandwich for lunch and $\frac{3}{4}$ of a sandwich after school. How many sandwiches does Chantal eat in all? Use pictures, words or symbols to explain your answer.</td>
<td>5</td>
<td>E (Activity 2)</td>
</tr>
</tbody>
</table>

Created by Alison Macaulay and Sandra Connolly (Peterborough, Victoria, Northumberland and Clarington Catholic District School Board)
Technological Problems with the Fractions CLIPS Field Test – Beta Version

Specific Program Issues (from Case Study field notes)
General Notes:
Since CLIPS is primarily a technology based learning tool it would appropriate to comment on some of the technical issues encountered by the students.

First of all the teacher had requested that the researcher conduct some of the observations in the classroom using classroom computers to more closely reflect the teacher’s anticipated future use of CLIPS. The researcher discovered that the classroom computers did not have sound cards or split jacks for use of more than one headphone and there were no headphones in the classroom at all. The researcher ended up using her personal laptop computer with attached speakers.

There was evidence of a positive correlation between a student’s level of comfort with computer technology and related software and their experience with CLIPS. Students with the confidence to experiment when unsure of the instructions for the CLIPS activity had success, as in Adam’s case, and often went to support other students with the technology. Similarly, students less familiar and less comfortable with using computers gave up easily or became confused.

Students missed a potentially positive learning experience when the fraction strips activity in CLIPS C stopped just prior to the most interactive part. The students assumed the activity was done and went on to a new activity.

All four students became extremely confused by the tackle box activity because they approached the task as splitting the box into equal parts instead of merging parts. They clicked on where they wanted to split and a divider was removed thus creating a double section where they wanted to make a cut line. All four were not conceptually ready for this activity the way it was presented.

Detailed Notes about Specific Activities:

CLIPS A
Activity 5 of 7: Rudy was confused by what to do here. It wasn’t obvious where to enter the number of parts.

The students worked through the quiz. They discovered a mistake in question 2 of the quiz. There are 8 squares, 3 are blue. They are asked to selected the answer to ‘What fraction of the shape is blue?’ The options are 7/3, 4/3, 3/7 and ¼. Anthony and Rudy discussed this and selected 3/7 as the answer and the screen says ‘Correct’ They were a bit confused and Anthony said, “I guess ‘coz it’s the closest.’ Hartley correctly worked through parts of a set example with coins as the objects. Annie makes an error and was a bit frustrated that she could not correct her answer.
Annie: It won’t let me correct that’s weird.

Note: When writing up this observation I tried to go back to the quiz to discover exactly where the error was. There are several versions of the quiz and after completing several versions and not being able to find the question that had the error in it, I decided to not pursue this any longer.
The software does not indicate which version of the test the student is taking. I believe it would be confusing if a student needed to clarify an answer.

CLIPS B

Folding Circle Activity
Annie: Are we supposed to write the numbers on here?
Researcher: It doesn’t really say, but you can.
The students crossed out numbers 1 through 4 and renumbered the fractional parts 1-8 They appeared to be confused about this.

In the Fraction strips activity there have been several occasions when the activity stops - the students assume it is finished and go to the next activity. This does not happen every time the program is used, but does occur and then the students miss the most valuable experience of the activity.

The students then moved to the next activity CLIPS B Activity 5/6. They observed that there was no check mark to click on. It was also possible to change the fraction without altering the visual representation. It would be possible for students to simply multiply numbers without understanding fractional parts.
Researcher: I noticed that there was some confusion here.
Annie: I think there should be something like on a map, a legend, that tells you how things will work. Sometimes it’s a check mark and sometimes it’s not.

CLIPS C

NO technical difficulties observed.

CLIPS D

Activity 1/7

What is the number between the up and down arrow there for? Does it represent what you have to multiply by? Anthony appeared to be confused by that, thinking it was telling him how many sections he had created.

Tackle Box
In the first activity the students are asked to merge the sections to create three equal sized compartments. It appeared that Adam wanted to cut the box rather than actually merge the sections. Adam knew that there had to be three equal sections and his strategy was to visually calculate the three sections, click on the dividing line as if cutting a block of cheese. All students approach this activity as Adam did. They all clicked on the divider line where they wanted to make the division. This caused the divider to disappear creating a double section
where the students had expected a split to be created. The results of clicking on the divider confused the students so much that they were unable to even describe what they had done and how to correct it. Through further probing with the students individually it was apparent that they were attempting to split the tackle box sections and perhaps did not yet have the conceptual understanding of how to merge sections to create equal parts.

CLIPS E

Activity 1 does not tell you if you have over-estimated the number of boxes required. In a previous version of the program this feature existed. It might add to the value of the activity so that students do have to make a reasonable estimation and not select 10 boxes when they only require 2 for the leftovers.
Student experiences CLIPS by CLIPS

Anthony’s experience with CLIPS

CLIPS A

In CLIPS A Anthony agreed with the students who felt that there was no new learning for them in the video ‘Who Cares about Fractions?’ However, when probed further about where we use fractions in real life that wasn’t mentioned Anthony said, ‘Adding fractions…like pizza.’ This referred to adding fractional parts and turning into whole and mixed numbers as when calculating how many whole pizzas to order so every person gets three slices each, for example.

Anthony appeared to tire of listening to the presentation on CLIPS and became more engaged when participating in the tasks. Anthony had no difficulty in marking off a ¼ on the measuring cup (Activity 3) and talked to himself as he worked through parts of a set in Activity 4.

Anthony’s computer literacy emerged in this first session as he jumped in to assist Rudy with a task. Rudy was unsure of where to enter the number of fractional parts on the screen. Anthony appeared to know intuitively where the number was to be placed. “Put the number of parts in that box. Click on the part to colour them.” (Pobs3imp) He went on to assist Hartley and as if sensing that he was emerging as the computer expert in the group, proudly announced, ‘My dad taught me about computers.’

When faced with a task where the correct answer is not presented, Anthony and Rudy, although confused, selected an answer, knowing it was not correct. Anthony justified this, ‘I guess because it’s the closest.’

This session provided Anthony with an opportunity to be exposed to the language associated with fractions, culturally specific examples of where we use fractions (the video) and an opportunity to shine re: his computer skills among his peers as he gently and sensitively guided them through parts they were unsure of.

CLIPS B

In CLIPS B Anthony demonstrated his dislike for the ‘Who Cares about Fractions?’ as he cringed when he heard the song begin to play.

As the students began to work through the tasks Anthony asked Annie to explain what she was doing. She was dividing the rectangle into 100 fractional parts. (Activity?)

Anthony then corrected Rudy when he made an error with the number of fractional parts creating 5/15 instead of 6/15. He told Rudy, ‘You can use the up and down arrows to change the parts.’ (Pobs4imp)

Anthony answered a question about the fractional parts of a circle. The researcher asked Anthony what strategy he had used to get 3/9 as an equivalent fraction. He responded, ‘I multiplied by three.’ (Activity?)
In this CLIPS Anthony demonstrated that he was comfortable with the program and once again supported his peers when they needed assistance and also questioned their choices.

CLIPS C

Folding Circle.
Anthony was able to immediately identify that in the folding circle activity we had started with ¾ of the circle shaded in. He appeared to be unsure of which was larger, 2/5 or 2/3. (CLIPS C Activity 1)

Anthony had a great deal of difficulty in ordering the fractions on the number line in Activity C. He placed 9/10 next to 0 on the line. After the researcher stepped the students through what 1/8 meant and what 9/10 meant he was able to place the 1/8 close to the zero.

CLIPS D

In CLIPS D Anthony created too many sections in the garden. He was to make six sections and instead made twelve, possibly being confused by the number that appears between the up and down arrows. It appeared that he made the number go to 6 which in fact created twelve sections not six sections.

Anthony went on to assist Hartley with the swimming pool activity. ‘Just click on the arrow.’ He corrected Hartley when she wrote 2/2 instead of 2/4. Anthony simply said, ‘NO.’ and Hartley realized the error.

Anthony went on to work on the pool activity and was assisted by Annie who pointed out that he was not naming the sections as fractional parts of the whole pool.

Anthony along with the other three students became very confused by the tackle box activity. Anthony wanted to cut the tackle box into three equal parts instead of removing sections to merge the spaces. When he clicked on the line where he wanted to cut a divider was removed. This created a double section in the box and Anthony was not at all sure where to go from there. None of the other students were able to assist Anthony with the task.

CLIPS E

The researcher reminded the students that the task that Pizza Party example is exactly what Anthony had mentioned in the very first session when asked if there were any other areas where we use fractions in everyday life that weren’t mentioned in the video. ‘That was me.’ Replied Anthony.

Anthony pointed out that Hartley had not done anything yet. The researcher assured him that there were enough tasks for every one to have a turn. Anthony selected the popsicle example to work with and was able to place the popsicles in the boxes and name the mixed number fraction correctly. Anthony noticed that they had already done the activity that appeared on the screen.

Anthony was very anxious to have a turn with Drop Ball. At the end of the session Anthony was very keen to share the strategy he used for Drop Ball. ‘I had a strategy. It was multiplication that was my strategy. It worked.’

Researcher: Tell me about that.
Anthony: Well, 6, 12, 18 with left over. It’s 3 and some.’ (Pobs7imp)
When the researcher suggested that Anthony could use division he was adamant that multiplication was the way to go.

Hartley’s experience with CLIPS

CLIPS A

Hartley was very quiet during the session. When the other students responded to the video ‘Who Cares about Fractions’ stating that they found it too easy and immature young for them, Hartley’s response was. ‘I didn’t think about how often we use fractions.’ (Pobs3imp) Hartley remained very quiet during the session. When it was her turn to try an activity she responded, ‘I’m not sure what to do.’ (Pobs3imp) She was asked to indicate on an unmarked measuring cup where $\frac{2}{3}$ would be. When asked by the researcher how many equal parts she would first have to divide the cup into she hesitantly responded, ‘two’ (Pobs3imp). With further assistance from the researcher she determined that she would have to divide the cup into three parts and then select two.

Hartley was guided by both Anthony and Rudy for the next activity (Activity 5 of 7) She admitted, ‘It is easy once you know how.” (Pobs3imp) Anthony assisted her in the following activity where they were asked to mark fractions off on a linear number line.

In the Quiz Hartley was able to identify correctly parts of a set using coins. She did this without assistance.

CLIPS B

Hartley was once again very quiet in this session. Annie, Anthony and Rudy engaged in a chant about being dumb. The researcher spoke to them about why they were participating in CLIPS. Hartley required active assistance form the researcher to complete the task. She was asked to name an equivalent fraction. ‘I’m not sure what it says.’ (Pobs4imp)

Researcher: It’s asking you to find another way of naming the shaded part. How many parts are there?
Hartley: 10
Researcher: How many are shaded?
Hartley: 4
Hartley hesitated.
Researcher: So the number of parts goes where?
Hartley points to the denominator box.
Researcher: Right…now how many are shaded in?
Hartley: 4
Researcher: so four is the numerator and it goes where?
Hartley placed the number 4 in the box. (Pobs4imp)
CLIPS C

In the folding circle task Hartley watched what the others were doing as well as watching what was happening on the screen. Hartley did not participate in any of the discussions around the folding of the circle and the naming of the parts in different ways.

When the students moved to the task on ordering numbers on a number line Anthony had the first attempt. Annie and Rudy offered suggestions to Anthony, however, Hartley did not contribute. Nor she offer feedback when the researcher asked what they thought of Anthony’s ordering.

CLIPS D

In CLIPS D the students watched a presentation about ….The program asked them to count the muffin pieces. Hartley was the only one of the students who did not display the body language of, ‘Oh please! We are not in kindergarten!’

Hartley was able to divide the pool into two equal sections, but required assistance from Anthony to describe what fraction of the whole pool would the kids get. She answered 2/2. Anthony tells her, ‘No.’ (Pobs6imp) She immediately realized her mistake and correctly selected 2/4.

All four students struggled greatly with the tackle box example. Hartley was extremely non-vocal as she listened to her peers try to describe their thinking for this activity. Each student was later interviewed individually on this activity to further probe the sources of their confusion.

CLIPS E

In CLIPS E Anthony pointed out that Hartley had not ‘done anything yet.’ The researcher assured him that everyone was going to have a turn.

Hartley needed lots of support when it came to her turn with mixed number activity.

Annie and Rudy were talking to each other the researcher reminded them they could help Hartley with the task. Rudy and Annie were discussing which was easier to work in.

Annie: Thirds are the easiest.
Rudy: You’ve got to be kidding. It’s fourths
Harley: I’m not sure what to do

The researcher had to explain the object of the task since she was not able to get this from the program.

Researcher: Pretend you were tidying up at home and you had a bunch of containers for leftover cheese. You had 5 pieces of cheese, but only 3 pieces of cheese would fit in one box. They are asking you to estimate how many boxes you would need to put away the cheese.

Hartley: One…no two?

She drags the cheese in to the boxes and then created the fraction.

Researcher: so how many boxes are full. That makes a whole

Hartley: One

Researcher: Right and how many pieces were left over.

Hartley: 2

Researcher: and what were they cut into…how many in a box? That’s the denominator. (Pobs7imp)
Hartley thoroughly enjoyed watching the other students attempt the Drop Ball activity. She beamed from ear to ear and laughing along with them. The researcher asked her if she wanted to have a turn reminding her that she could have some one of her choice work with her. She smiled and shook her head.

Rudy’s experience with CLIPS

CLIPS A

Rudy was quiet in this first session with CLIPS. He worked through the marking of 1/4 on the measuring cup (Activity 3 of 7) but was confused by the instructions for activity 5 of 7 and admitted that he would have required assistance to work through it. In the linear representation Rudy marked off far too many sections and then admitted that he got carried away. The student worked through the quiz. They discovered a mistake in question 2 of the quiz. There are 8 squares, 3 are blue. They are asked to select the answer to ‘What fraction of the shape is blue?’ The options are 7/3, 4/3, 3/7 and 3/4. Anthony and Rudy discussed this and selected 3/7 as the answer and the screen says ‘Correct’ They were a bit confused and Anthony said, ‘I guess ‘coz it’s the closest.’

CLIPS B

Rudy, Anthony and Annie were engaged in chanting that they were dumb and the researcher reminded them why they had been selected to work with CLIPS. Rudy was more talkative possible feeling more comfortable.

Researcher: How was that? Was there any new learning there for you? Rudy: No, it was easy. We understand. (pobs4imp)

Rudy was the next student to have a turn. He played with the arrow keys and appeared a little confused.
Rudy: I thought the keys changed the numerator and denominator.
Rudy counted five parts not six so created 5/15 and therefore is told he is incorrect.
Anthony: It’s 6
Rudy: I can’t count! (pobs4imp)

The students discovered that it is possible to change the equivalent fraction in the box without creating the visual representation beside. Rudy is confused because the program was asking for another equivalent fraction while still displaying the one they had completed. There was some confusion as to what to do when asked to name another equivalent fraction.
Rudy: I just did that one and it was correct. Annie had the next turn and made the fractional parts of the circle go to 100.
In the folding circle activity Rudy followed the instructions quite well. Although all four students were somewhat confused by the instructions Rudy was the only one who did not refold his circle and make another fold line. Through making a quick observation at the screen and the others he realized that he had to make another fold and this quickly and caught up with the action. When asked by the researcher if it were possible to fold the circle one more time how many fractional parts would be created. Rudy responded, ‘24’ when in fact it would be 32.

Rudy and the other students were able to correctly name the unshaded part of the circle in 3 different ways after the researcher reminded them of the steps they had taken in naming the shaded part of the circle.

When Anthony is ordering the fractions along the number line Rudy participates with Annie in suggesting where the numbers go.

Rudy appeared to be sullen and disinterested at times in this session. During the presentation using muffins Rudy’s body language seemed to say, Please we are not in kindergarten!’

Rudy became more engaged when the students began the hands on activities. He was quick to point out to Anthony that he had created too many sections in the garden in activity one of seven. He actually corrected for Anthony who may have been confused by the number that appeared between the up and down arrow in the box.

Rudy went on to successfully divide the pool into four equal sections and then co-operated with Annie to further divided the pool into twelfths. They counted the lanes and entered the number in the box. However, when Rudy was asked to name the fraction of the pool that was Rudy really struggled with the concept of the 9/12 of the pool. He needed support from the researcher.

Researcher: What they are saying is they want to get a head start on preparing the pool. Think about how many sections the pool is going to be divided into eventually and then how many sections they can get ready in the part of the pool that is now empty.

Rudy: Oh right, I see. (Pobs6imp)

When the students worked on the tackle box activity they all became extremely confused and were unable to verbalize put in to words where they had become lost.

Rudy: that’s what Hartley did
Rudy tried…he appeared confused by the dotted lines that remained.

Anthony: You click the line to get rid of it.

By this point Hartley appeared to feel very left out as the others struggled to complete the task.

Researcher: I saw that you all were very confused by the instructions here does any one have a suggestion as to how the instructions could be improved.

Rudy: I think it should say something like; decide which piece you want to take out and then click on it. (Pobs6imp)

A few days later the researcher took each student out of the classroom individually and had them work on the tackle box activity box activity describing their strategies and understanding as they worked through the task. Through this probing it became apparent that Rudy and the others were
attempting to cut the box into three equal sections instead of removing dividers to merge sections. In CLIPS when a student click on the line A divider) where they wanted to make the cut the divider disappeared leaving a dotted line and a double section where Rudy wanted to make a cut line. This confusion demonstrated that Rudy does not yet have the conceptual understanding to shift from cutting to make fractional parts as in the swimming pool to creating fractional parts of equal size by merging sections together. It is possible that the swimming pool activity caused some confusion with the tackle box activity.

CLIPS E

The researcher had the students watch the first activity. When the researcher asked the students if there was any new learning for them Rudy responded:

Rudy: No, it was too easy. (Pobs7imp)

The students began the first activity where they are asked to work with halves, thirds, quarters or sixths.

Rudy selected to use thirds. He had 5 pieces of cheese to put away. 3 pieces of cheese fit in one box. He selected to use 2 boxes. He was able to drag and click the cheese pieces in to the boxes and name the fraction correctly. (Pobs7imp)

While Hartley was having her turn Rudy and Annie were discussing which was easier to work in. Annie: Thirds are the easiest.
Rudy: You’ve got to be kidding. It’s fourths. (Pobs7imp)

When the Drop Ball activity was presented Rudy came to life.

Rudy was instantly engaged with the activity, Hartley was laughing as Annie tried to get the numbers on the line. Anthony was clearly anxious for a turn.
Annie was not able to place any correctly.
Annie: I want the half I know where the half goes.
Annie dragged the ½ halfway along the number line not to between 1 and 2.
Rudy had a turn he did a little better.
Rudy’s strategy was to just randomly place the numbers…he got two correct.

Rudy, did you want to have another turn?
Rudy: (with enthusiasm) Yeah!
Rudy takes over he is testing his random approach again

This was Rudy’s best session with CLIPS as far as engagement and enthusiasm. Although there is evidence that he lacks some conceptual understanding of fractions He appeared to be offended at the level at which the material was presented. However, in this session there was clearly a better fit between his expectations and the actual presentation.

Annie’s experience of CLIPS
CLIPS A

Annie’s response to the ‘Who Cares about Fractions was,
Susan: Was there any new learning there for you?
Annie: It was too young… we are past that.
Susan: So are you saying that you think it is better suited for younger grades?
Annie: (nods)
She goes on to say:
Annie: They were very simple fractions…we are adding and subtracting (Pobs3imp)

When asked by the researcher if they could think of any examples where they use fractions in
real life that were not mentioned in the video. Anthony suggested when one has to calculate the
number of slices of pizza for a large group of people.
Annie: Yeah like the number of slices in more than one pizza
Susan: So you mean ordering more than one pizza and then figuring out how many slices for
each person…
Annie nods (Pobs3imp)

When it came time for Annie to participate in an activity she was able to easily mark the ½ cup
on the measuring cup.

A few moment later when Annie is having another she became a little annoyed at Anthony when
he began to tell her what to do.
Annie: I know what to do, Anthony. (Pobs3imp)

Close to the end of the session Annie entered her answer and it was incorrect. When she
attempted to change it the program would not allow her to do this. She appeared a little put off
by this and said,

Annie: It won’t let me correct that’s weird. (pobs3imp)

CLIPS B

Annie, Rudy and Anthony were engaged in a chant about being dumb. The researcher reminded
them of why they were participating in this project. They settled down, but when the researcher
asked Annie to be in charge of the program today as far as moving the screens forward. She
admitted that she had not been paying attention,

Annie: You want me to do the controls? …I kinda spaced out there.

They proceeded to watch and listened to the Fraction Strips and then moved to the next activity
which was Forming Equivalent Fractions Activity 4/6
Annie made the fractional parts of the rectangle go up to 100
Anthony: Explain what you are doing there.
Annie: I wanted the numerator to go to 100. It’s going up by two. I know it’s 40. \((2/5 = 40/100)\)  
(pobs4imp)

Annie’s next turn was to create fractional parts of a circle. Annie clicks on the circle repeatedly to see what the maximum number of parts she could create. She made the number of parts 100 and responded,  
Annie: Cool!

When the researcher asked another student what there strategy had been when completing one of the activities Annie made the comment,  
Annie: We’re cheating. I guess we are all smart together. (Pobs3imp)

The session drew to a close. The students became confused because although the program asked them to click on the check mark there was in fact no such mark on the screen. Annie offered the following feedback,  
Researcher: I noticed that there was some confusion here.  
Annie: I think there should be something like on a map, a legend, that tells you how things will work. Sometimes it’s a check mark and sometimes it’s not.

CLIPS C

The researcher began this session with the folding circle activity from CLIPS B. Annie was the first to ask if they were to write numbers on the fractional parts as appeared on the screen. Annie is the first student to respond that they have created 12/16. The researcher responded positively to this. When asked to think what fractional parts would be created if they were able to fold the circle one more time. Anthony and Rudy offered some answers, however, Annie very quickly responded, ‘Does anyone have a calculator and then sat back in her chair and applied some lip balm to her mouth.  
She participate din the naming of the unshaded part of the circle and then became distracted by activity in the room.

Anthony attempted to place fractions on a number line. He made some errors such as placing 9/10 near the 0. Annie contributed by saying,  
Annie: one …that is the whole. (pobs3imp)

The researcher asked the students what they thought of Anthony’s order. She provided them with examples of what 9/10 and 1/8 would be like in real life situations.  
Researcher: What do the rest of you think about Anthony’s ordering? He says 0 and then 9/10. What do you think about that? It might be helpful to think about it in terms of something you know…like a birthday cake. If I cut the cake into 10 equal parts and then ate 9 of them would I have eaten a little bit of cake or most of the cake.  
Annie: most of it  
Researcher: Right…now if I cut another cake into eight pieces and ate one would I have eaten a little bit of cake or a lot.
Annie: A little bit.
Researcher: So would you say 9/10 is closer to 1 or to 0.
Annie: 1
Researcher: and would 1/8 be closer to zero or to 1 whole
Anthony: Zero.
Annie: so Anthony was right then? (referring to the ordering)
Researcher: I think you were correct with the 9/10… check your answer on the next page.
Annie: We were right ?…(pobs3imp)

Annie was able to work through ordering the fractions, however, there was evidence of her low confidence in her ability to do math. She assumed that they were wrong and Anthony’s order was correct.

CLIPS D

Annie with an air of being above all this and Anthony keen as usual. The students listened to the first section. Rudy looked down at his lap for parts of the presentation. The students seemed to be offended when the program asked them to count the muffins. “Count them”
The body language of Annie and Rudy was like, “Oh Please!”

Annie completed the next section by filling in 3/6

Anthony tried the slow medium and fast lane, 3/3, and Annie corrected him. He was not naming the fractional parts of the whole pool area.

In the tackle box activity where all the students became very confused, it was Anthony and Rudy who dominated the activity. Annie observed, but allowed them to explore the program. She offered no feedback to the activity. In a session with the researcher Annie was able to describe her thinking with the tackle box….

CLIPS E

When asked by the researcher if there was any new learning for them in the video, Annie responded, Annie: We know all that.

Researcher: Now I want Annie to have the first turn. Everybody will have a turn. You can choose whether you want to work in halves, thirds, quarters or sixths.
Annie opts to uses 6ths. Annie’s task was to estimate how many boxes she would need to put away 8 slices of pizza. Six slices of pizza fit in one box. Annie selected 3 boxes. As soon as she started placing the pizza in the templates she said
Annie: I got it wrong. I didn’t understand the question I guess. I thought it was cut into 8 pieces I guess I don’t know.
She had a flippant air about her. She reads the screen and created the fraction to describe the pizza. Annie had a little difficulty clicking and dragging the pizza slices.
Hartley began working on her activity.

Rudy and Annie were discussing which was easier to work in.
Annie: Thirds are the easiest.
Rudy: You’ve got to be kidding. It’s fourths

Annie was the first to play Drop Ball. Everyone watched her and the students came alive. Rudy was instantly engaged with the activity, Hartley was laughing as Annie tried to get the numbers on the line. Anthony was clearly anxious for a turn.
Annie was not able to place any correctly.
Annie: I want the half I know where the half goes.

The researcher admitted to the students that she found this game challenging and that perhaps there should be options to alter the speed of the game. Annie immediately responded, Annie: Oh don’t make it slower… it would be boring.
Probing into the Tackle Box Activity Further with Students

CLIPS D Merging parts Tackle Box

Since all four students were very confused by the tackle box activity (CLIPS…) and were unable to explain adequately where they were not understanding it was decided to do some further probing with the students to gain further insight. The students were interviewed individually to increase the likelihood that students would be more open and honest when one on one with the researcher. It is possible that they may be afraid of appearing ‘stupid’ in front of their peers. All students had already completed the five CLIPS and appeared to feel quite comfortable with the researcher.

The researcher decided to go through the activity frame by frame and ask the students if it worked or not for them.

Anthony:
Anthony’s first concern was around the choice of language to describe the tackle box, namely ‘multi-level with flexible compartments’. Anthony is an ESL student on an IEP for language and said to the researcher, ‘people wouldn’t understand that’. It is possible that by ‘people’ he was indirectly referring to himself.
In the first activity the students are asked to merge the sections to create three equal sized compartments. It appeared that Anthony wanted to cut the box rather then actually merge the sections. Anthony knew that there had to be three equal sections and his strategy was to calculate the three sections, click on the dividing line as if cutting a block of cheese. Researcher: So I see you are looking at the tackle box like it was a big piece of cheese that you have to cut in to three parts and that’s where you want to slice it.
Anthony: yeah like cheese or pizza

Anthony: I think the dotted lines confuse people because they are still there you think they are division.
Of course when Anthony clicked on the line diving the fourth and fifth sections it disappeared leaving him with three single sections and one double section. This is where he first became confused and did not know what to do.
We go to the activity where the items require two sections to fit the objects. Anthony removes the dividers thus creating six sections and says he’s made five parts.
Researcher: Count them just to check
Anthony: Oh six
Researcher do you think it is possible to make five equal sections from the twelve sections?
Anthony: No because 1,2,3 5… it goes 2, 4, 6, 8, 10,12 to use up the sections it would be 10 sections to make 5.
Researcher do you think this task is a little easier than dividing the box into thirds and fourths like the other activities
Anthony: No not really. I think once you know what to do they are all the same. I think it would be better to remove all the sections and then put back where you think it has to go to make 3 equal parts.
We decided to go back to the pool activity of dividing the pool to see how that was approached.
Anthony demonstrated how he could cut the pool in two without using the up and down arrow. He just estimated visually where half of the pool would be.

Rudy
Rudy found the language appropriate.
He attempted the first activity to divide the tackle box into three equal sections.
Rudy counted the sections touching them as he counted
Rudy: 12
He counted across four and then clicked on the divider. It was removed.
When asked for his strategy for dividing into 4 parts 3, 6, 9, 12 he said subtracting.
Researcher: that would be dividing
Rudy: adding, subtracting, dividing... all of them!
When we approached the task with making each section 2 sections wide Rudy removed all the dividers and then replaced one in the centre to create two equal parts.
Researcher: Can you read the question again? What is it asking you to do?
Rudy reads aloud.
Rudy: Oh he replaces the dividers.
Researcher: Would you say that activity is a little easier than dividing into thirds and fourths
Rudy: No not really

Hartley
Hartley felt that the description of the tackle box was not problematic and went to describe what she thought such a box would look like. “You would open it up and there would be a lot of trays and you could take parts out.”

Hartley approached the task of creating three equal sections in the box, by first counting the existing section. She counted 12.
Hartley: Twelve divided by three... four.
She counted across four sections and then clicked on the next divider. The divider disappeared leaving a dotted line. She was left with four complete sections, followed by a double section with six untouched sections remaining. She did not know where to go from here.
She repeated the same strategy when asked to divide the box into four equal sections. She was able to explain what she was doing as she made her way through the task. However, she required support from the researcher to help her understand the expectation of removing dividers to merge sections. Hartley, like the other students, was attempting to cut or split the box, clicking on the cut line. Hartley said she did not find the task of creating double sections easier than the first two.
Hartley was more vocal in the one on one session than in the group with the other three students.

Annie
Annie also did not find the description of the tackle box problematic. Annie began by eyeballing where one third of the box would be and then clicks on the line that represented one third of the box. The divider is removed and she is unable to carry on. The researcher explains how to remove the dividers within the three sections. Annie moves on to the creating four equal parts
and there is evidence that she is gaining understanding of the task. She continues to ‘eye ball’ where a quarter of the box would be. Annie does not count the sections and divide by four. When it came to the last task of creating double sections Annie removed all the sections and then put back every other one using the dotted lines as a guide. She was able to do this task quickly and successfully. The researcher and Annie had a brief discussion as to how one might approach such a task in real life and they agreed that there might be times when it would make sense to remove all the dividers and place them back in the box as a total ‘redesign’ instead of just taking a few out at time.