The Impact of Online Professional Learning for Teaching Fractions

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Abstract

An understanding of fractions has proven to be elusive for American students for decades, yet it is critical to success in mathematics. Teachers are products of an impoverished approach to teaching fractions, but are being asked to teach fractions for deep conceptual understanding. New ways to provide effective professional development for teachers must be found. This study determined the impact of job-embedded online follow-up support for teaching fractions, following a face-to-face program. The study was informed by a review of literature surrounding effective professional development for teachers, specifically focusing on the use of online tools for professional learning and for the development and support of learning communities. The study included 9 treatment teachers and 8 control teachers who did not have face-to-face job-embedded classroom support in 2012-2013 following an intensive professional learning series about fractions. Questions that were examined include the following. What is the impact of the use of an Online Classroom Support Program (OCSP) of teachers on: teacher Pedagogical Content Knowledge (PCK); student conceptual understanding of fractions; and teachers' uses of pedagogical practices conducive to sense making about fractions? Which design features of the online-classroom-support program program were most valued by teachers as useful professional learning tools? Results indicate the following: treatment teachers' PCK was only slightly greater than control, and student achievement was not correlated to pedagogical content knowledge; students of treatment teachers showed more growth on an assessment of fractions on the number line and equivalent fractions than did students of control teachers; and the useful aspects of the included texts of lesson development and the facilitator's recordings of key points in the lessons but not the online community.

Keywords: mathematics education, online professional development, community of practice, fractions, conceptual understanding

The Impact of Online Professional Learning for Teaching Fractions

Fractions are a critical for student success in algebra and further study of mathematics. A balance of both procedural fluency and deep conceptual understanding of fractions is critical to success in algebra (The National Mathematics Panel, 2008; and Common Core State Standards, 2010). Some have argued that algebra should be demanded as a civil right, as it is the gate-keeper course for higher education and STEM fields (Cobb & Moses, 2001, pp. 13-14). American students have been woefully lacking in understanding and flexibility in application of fractions for generations, leading to dwindling numbers of students succeeding in algebra and going into STEM fields. This reveals a dire need for professional development for teachers about the teaching and learning of fractions. Today's American teachers are products of the American educational system themselves, and as such, have experienced mathematics as a set of procedures that were transmitted by the teacher for mimicry and memorization. According to Linda Darling-Hammond (2006), this teaching by transmission of knowledge is not effective most of the time. Thus we have students that are underperforming and teachers who were not provided a sufficient experience as learners themselves, and, with the implementation of the Common Core Standards, who are being asked to teach differently than they were taught. We need professional development that addresses this critical need in order to break the cycle of deficient learning.

Teachers and administrators in the Sacramento area are increasingly requesting professional development about fractions and the Common Core Standards. In response to these requests, teachers have attended more face-to-face professional development programs about fractions, however schools and districts have not been able to provide necessary job-embedded support for their teachers in classroom follow-up activities so critical to improving practice and effective implementation. Development of an OCSP could provide support to more teachers in lieu of providing face-to-face classroom follow-up support. This study sought to determine the impact on student performance of an OCSP as follow-up to previous face-to-face professional development programs.

Research Questions and Anticipated Outcomes

This study investigated the following questions.

1. What was the impact of the OCSP on (a) teacher pedagogical content knowledge, (b) teacher pedagogical practice, and c) student conceptual understanding of fractions?
2. Which features of the online-classroom-support program were most valued by teachers as useful professional learning tools?

It was anticipated that teachers utilizing the OCSP would show improvement in their pedagogical content knowledge and would report an increase in the use of the pedagogical practices modeled at the previous face-to-face professional development programs. It was also anticipated that students from these teachers' classrooms would show improved performance on pre and post student assessments of conceptual understanding of fractions. In order to measure the value added from the OCSP in relation to these hypotheses, teachers were selected to form 2 groups; one group received the OCSP (treatment group); and the other group did not receive the OCSP (control group). Pre and post surveys and assessments (both student and teacher) were administered to both groups for comparison. Finally, it was anticipated that treatment teachers using the OCSP would find value in interacting, collaborating and reflecting online.

Definitions

Online Classroom Support Program (OCSP). The intervention for teacher professional learning, OCSP, was housed on a Google Community webpage created by the facilitator for the express purpose of this study. Materials housed on the Google Community webpage included three text documents describing how instruction with students could proceed, posts by the facilitator and participants (all posts able to be accessed by all parties), and whiteboard recordings made of the facilitator talking through portions of instruction described in the text documents. The facilitator posted three sections of a text document that was first used in the face-to-face professional development program in 2012 or 2013. The facilitator provided prompts for each section of the text document that asked participants to reflect about mathematical purposes for each chunk of the lesson, about pedagogical choices for modes of response from students, and about anticipated student responses to questions.

Whiteboard Recordings. Educreations and Explain Everything are apps for a tablet that were used to create teacher support for how to teach the three topics in fractions. The apps allowed the presenter to create a visual recording of writing on a whiteboard while simultaneously making an audio recording that presented a discussion of the lesson with questions to ask students. This allowed teachers to listen to explanations of the lessons while viewing what was being written on the whiteboard. The facilitator embedded these recordings on the OCSP.

Teacher Pedagogical Content Knowledge (PCK). This is a professional understanding of instructional strategies (pedagogy) that is specialized to teach a particular content area, in this case mathematics. It also refers to the possession of specialized understanding of mathematics content pertinent to teaching. This study sought to measure changes in PCK to determine possible impact upon teacher's abilities to provide instruction resulting in greater conceptual understanding of fractions by students.

Review of Literature

Characteristics of Effective Professional Learning Programs

Decades of research have continued to bear out principles that have been difficult to institute and sustain within our educational system. An understanding of necessary and sufficient characteristics ensuring high quality professional learning is critical to designing effective programs. The following review of literature yielded four major principles that guide the *how* and the *what* of effective professional development.

1. Teachers need to be engaged in active and collaborative professional learning.
2. Focus on the *Right Work*
    a. Teachers need to develop specialized knowledge, pedagogical content knowledge, about mathematics and about instructional practice and the interplay between the two.
    b. The content of the professional development should be centered on classroom practice and student learning.
3. Goals and initiatives amongst district, schools and teachers need to be aligned.

These principles will be discussed in an examination of results and analyses offered by research. Findings from both older, seminal research and newer research will be discussed and examined in order to identify characteristics of effective professional development. Additionally, methods of connecting student-learning results to professional learning programs will be discussed.

The How: A Case for Active Engagement of Teachers. Professional Development needs to focus on active and collaborative learning just as teachers need to focus on active and collaborative student learning. In 1987, Bruce Joyce and Beverly Showers released a meta-analysis of both case studies and large-scale research about professional development, which was also updated and published in its 3rd edition in 2002. They found that one of the conditions which must be present for professional development to affect significant change on student learning is that a community of professionals exists to meet and study problems of practice, to develop and implement strategies based upon what is learned, and to share and examine the results. (Joyce & Showers, 2002) *Studying* problems of practice, *developing* strategies, *implementing* strategies and *examining* results are all active processes for professional learning.

When professional development does not actively engage the teachers in professional learning, it is ineffective. In 1995, Lieberman also posited support for active teacher learning:

> What everyone appears to want for students—a wide array of learning opportunities that engage students in experiencing, creating, and solving real problem, using their own experiences, and working with others—is for some reason denied to teachers when they are learners. (Lieberman, 1995, p. 591)

This denial of active learning for teachers in their own professional development has stifled growth in the teaching profession. "Sit-and-get" workshops where information is dispensed from a presenter to be transferred to the listening teacher have proven ineffective, yet they continue to dominate what is most used.

> The conventional view of staff development as a transferable package of knowledge to be distributed to teachers in bite-sized pieces needs radical rethinking. It implies a limited conception of teacher learning that is out of step with current research and practice." (Lieberman, 1995, p. 591)

In a large scale 3 year study of professional development programs for mathematics and science from 1996-1998, Porter, Garet, Desimone, Yoon and Birman (2000) found that if the teachers participated in active learning rather than passive learning, then they reported the professional development program had impact on their teaching. Active engagement is a necessary piece of effective professional development, but not the only piece necessary. In order to nurture teachers' professional judgment and implementation in the classroom, teachers must be actively engaged in the *right work*. What constitutes the right work?

The What: Focus on Specialized Content Knowledge and Classroom Practice and Student Learning. In order to be effective, teachers need to deeply understand the mathematics they are teaching, and the mathematics coming before and after that which they are teaching (National Mathematics Panel, 2008). However, a good understanding of mathematics content is not the only knowledge about mathematics that is necessary; effective teachers need a specialized content knowledge (SCK) (Loucks-Horsley, Hewson, Love & Stiles, 1998; Ball, Thames & Phelps, 2008). "Excellent science and mathematics teachers have a very special and unique kind of knowledge that needs to be developed though their professional learning experiences…" (Loucks-Horsley et al., 1998, p. 400). Teachers need support to develop this specialized content knowledge.

> Close examination reveals that SCK is mathematical knowledge not typically needed for purposes other than teaching. In looking for patterns in student errors or in sizing up whether a nonstandard approach would work in general, as in our subtraction example, teachers have to do a kind of mathematical work that others do not. This work involves an uncanny kind of unpacking of mathematics…(Ball et al., 2008, p. 400)

In 2008, Ball, Thames and Phelps offered a theoretical basis for defining specialized content knowledge (SCK) stemming from their research. They identified four types of specialized knowledge for teaching stemming from their data: common content knowledge (CCK), specialized content knowledge (SCK), knowledge of content and students (KCS) and knowledge of content and teaching (KCT). Ball et al. (2008) provided the example below of teacher tasks that elucidate differences in those components of specialized content knowledge.

> The shifts that occur across the four domains, for example, ordering a list of decimals (CCK), generating a list to be ordered that would reveal key mathematical issues (SCK), recognizing which decimals would cause students the most difficulty (KCS), and deciding what to do about their difficulties (KCT), are important yet subtle. (Ball et al., 2008)

These types of tasks are also examples of classroom practice around which Joyce and Showers research suggests professional learning should be centered. Thus a connection can be made between Joyce & Showers' meta-analyses that showed the necessity of focusing on classroom teaching and student learning, and Ball, Thames and Phelps' theoretical framework for the definition of specialized content knowledge. The same sorts of tasks that distinguish teacher's specialized content knowledge from common content knowledge were identified as a necessary focus for effective professional development in Joyce and Showers research. Those professional development programs that were specifically focused on actively and collaboratively engaging teachers in classroom-centered tasks about student learning were shown to be more effective. (Garet et al., 2001; Joyce & Showers, 2002;)

Research has shown that effective programs focus on the *right work* where specialized content knowledge is developed by active and collaborative engagement of teachers in learning mathematics. This method of professional learning is congruent to desired methods of student learning. Effective professional learning activities focus on classroom practice and student learning.

Alignment of Goals. Not surprisingly, research shows effective professional development is part of a system for working with teachers in which there is alignment of the professional development goals, the teachers' goals, the school and the district goals (Garet et al., 2001). Some professional learning activities are implemented in a manner that conflicts with the very learning theories and instructional strategies being presented for teachers to implement with students. The degree to which the design and implementation of professional learning for teachers parallels the intended learning experiences teachers are being asked to create for students, dictates how effective the professional experience will be for teachers (Loucks-Horsley et al., 1998; Joyce and Showers, 2002). In others words, teachers learn more when their learning experiences are similar to those they are expected to provide for students.

Loucks-Horsley et al. (1998) state that teachers content knowledge is best improved by "immersing teachers in content as learners themselves…" and that

> Principles that guide the reform of student learning should also guide professional learning for educators…People teach as they are taught, so engaging in active learning, focusing on fewer ideas more deeply, and learning collaboratively… (Loucks-Horsley et al., 1998, p. 400)

They offered precepts for the design of professional development in their book in 1998.

1. Professional development experiences need to have students and their learning at their core…
2. Excellent science and mathematics teachers have a very special and unique kind of knowledge that needs to be developed though their professional learning experiences…
3. Principles that guide the reform of student learning should also guide professional learning for educators…People teach as they are taught, so engaging in active learning, focusing on fewer ideas more deeply, and learning collaboratively…
4. Teachers as leaders exert a powerful force for school improvement…
5. Professional development must both align with and support system-based changes that promote student learning. (p.15-16)

The longevity of this conversation about effective professional development is in itself, an indictment of our educational development system for teachers. It signifies that our American educational system of districts and schools has not determined a sustainable method of providing structured ongoing professional learning even though the knowledge for how to do so exists. Why has this proven so difficult? Barab, MaKinster, Moore and Cunningham (2001) point to what we should *not* continue to do:

> It is how to function in the context of complex classrooms, not some orderly delivery of "best practices", that teachers need to observe, discuss, and evolve if professional development is going to stimulate the use of teaching methods that promote student engagement and inquiry. (p. 74)

One barrier to teachers having this type of meaningful discourse is the structure of the school day. There is no time within the school day for deep collaboration. Several studies seek to determine the use of online community of peers as a solution to this problem.

Creating a Place for Job-Embedded Support—Online Communities of Support

Creating Online Structure for the Development of Community. Barab et al. (2001) studied the impact of a community of practice as they looked at the systematic adjustment of design features of the Inquiry Learning Forum (ILF), an online structure to create a learning community for teachers. Although whole group findings about the impact on preservice or inservice teachers were not discussed, the authors specified types of information collected during implementation that informed adjustments to the structure Inquiry Learning Forum. This information included: (1) identification of research based practices and theory underlying the design features of ILF; (2) needs assessment of pre-service, novice and veteran teachers; and (3) case studies of those categories of users. The case study participants did not find the intended sense of community on the ILF site, and were not using ILF as a place of professional learning to investigate problems of practice. Both the preservice teacher and the inservice teacher noted that ILF did provide support for their problems of practice. The preservice teacher used ILF as it was required for coursework, and the inservice teacher used only the section of ILF that supported work on a Lesson Study project that started in a face-to-face setting. A question about online communities remains—is the existence of a tool designed to support online learning communities sufficient to ensure a community of practice will develop?

Barab et al. (2001) also discussed a change in the design features of ILF to support smaller communities of practice. The original design feature did not allow smaller groups to be created within the ILF community, as the original intent of the study was to determine ILF's impact upon the development of a larger community of practice among all users. But the needs assessment and case studies showed that teachers could engage and reflect meaningfully around artifacts of practice (Barab et al., 2001, p. 84). This lead the authors to change the ILF structure to allow for smaller communities of practice looking at particular artifacts.

The most telling case study was from a veteran user of ILF, who wanted to use ILF in order to grapple with "the complexities inherent to inquiry-based classrooms aris[ing] precisely because students are engaged in learning the subject matter by doing as opposed to simply being told about it" (Barab et al., 2001, p. 74). Although the ILF structure was developed to allow for precisely this sort of examination of practice by a community of teaching professionals, the case-study teacher was not able to find that community via ILF.

Perhaps building a tool to support the development of a large learning community must come *after* the identification of a common purpose binding a learning community together. This notion is supported by the work of Parr and Ward in a study of FarNet, an online networking tool to support teachers from 10 isolated schools in sharing resources and ideas for improving instruction.

> If a simple definition of a functioning online community is employed, namely, that members of the community participate by posting resources, accessing resources, and communicating around those resources and related curriculum issues, and that they find the experience relevant and useful, then the attempts to form a FarNet community could be viewed as unsuccessful. (Parr & Ward, 2006, p. 781)

Through structured interviews with teacher participants and leaders, Parr and Ward determined that teachers were often reluctant to share resources as they doubted others' need for them or ability to reciprocate, or that teachers felt their resources were not of sufficient quality to post. Parr and Ward noted that "[f]or teachers to be willing to share and to reveal elements of their practice, requires a climate conducive to the operation of a professional community." (Parr & Ward, 2006, p. 784) All of this interfered with teachers' perceptions about the utility of FarNet and impeded the growth of an online community. The study did reveal that two smaller online communities did develop and function effectively. In one case, there was an existing cultural community of practice within a school and a community, and FarNet fulfilled a need for a method of communication and collaboration amongst its teachers. For the other case, a principal spearheaded efforts to support collaboration amongst his staff, and supported their use of FarNet in order to nurture their collaboration. The findings support the notion that a shared need or purpose for community precedes the development of that community in an online setting. Parr and Ward (2006) conclude:

> Building a professional learning community is difficult to achieve within a school, let alone across schools, let alone virtually. As this research demonstrates, building on or strengthening an existing community is one way to approach this while supporting and guiding the building of communities within schools is another. (p. 790)

Online Support for Developing Teachers' Pedagogical Content Knowledge. Dash, Kramer, O'Dwyer, Masters and Russell (2012) sought to measure the impact of online learning on the teachers' abilities to apply this learning to their teaching, and conducted an experimental study on 79 fifth grade teachers from 12 states participating in an online professional development program (no face-to-face component) consisting of three 7-week online courses. The teachers self-selected into the study but were then randomly assigned to the experimental group (enrolled in the courses) or the control group (not enrolled in the courses). Researchers hypothesized that improved teacher pedagogical content knowledge (PCK) would lead to improved instruction which would lead to improved student achievement. Measurement tools include: pre teacher background survey, pre and post teacher PCK instruments (open and closed response), pre and post teacher pedagogical practices surveys, student background surveys, pre and post student assessments (closed response). Student assessments used closed items released from state and national tests and some designed for this study. Data were analyzed statistically to expose differences in control and experimental group assignment over the different measures. Both PCK scores and scores for changes in pedagogical practices of teachers in the experimental group were significantly higher than those of the control group; however there was no significant difference in student scores. Dash et al. (2012) suggest teachers may not have had an opportunity to apply course precepts to their teaching as the topics may have already been taught to their students. They also call for more research studying the effects of classroom follow-up support after online courses and studying the impact of a combination of face-to-face and online professional development.

The study of online courses by Dash et al. (2012) has other alternate explanations. Perhaps closed response items on the student assessment did not capture differences in learning between the two groups of students, which would suggest that closed response items from state achievement tests that are not in alignment with course precepts are not be the best measurement tool. Also, though the facilitators for the online courses were trained in online facilitation, perhaps they were not experienced in mathematics professional development. Thus problems of practice presented by participating teachers may not have been addressed, as the online facilitation may not have provided support for classroom application. Finally, there was no discussion of online peer-to-peer interaction having been utilized, only interactions between the participating teachers and the facilitator. Perhaps a focus of the online community must be to support classroom application and problems of practice is a necessary component to have a positive impact in teachers' classrooms.

Online Community of Peers. In a study of the impact of the use of an online community of peers following a face-to-face professional development program, Green and Cifuentes found that librarians participating in follow-up activities using an online peer community were more likely to complete the development of an intervention plan to use at their schools than those librarians who did not have access to the online peer community. The online community provided support as they negotiated applying principles learned at the professional development in order to develop an intervention plan for students. The online community allowed them to "build upon the shared expertise of the group in resolving difficulties in creating the plan" (Green and Cifuentes, 2008, p. 301). It allowed the participants to negotiate problems of practice they encountered when trying to apply course precepts in developing their school intervention plans. The difficulty in determining the ultimate effect of this online support system on student learning was that there was no student achievement data gathered, only self-reported data from participating librarians about their perceptions of the potential implementations of the intervention plans they designed.

Measuring the Effects of Online Professional Learning

Much educational research is challenged to connect the teacher professional learning experience to changes in student achievement. Brunner and Rivas studied the effects of Harvard University's WIDE World Online courses on teachers' abilities to apply their Teaching for Understanding Framework (TfU). The large number of participating teachers from all over the world prohibited the use of student and classroom data. Instead they chose to measure change in teachers' abilities to apply course precepts as measured by rubric scored responses to midcourse and end of course reflection prompts. They argued that this would indicate teachers were ready for successful classroom application.

> A second premise of this evaluation, then, is that a significant growth in the number of learners who are able to explain their choice of assessment in theoretical terms, is a valid indicator that they are successfully learning to apply the TfU framework intellectually, which is a precondition for applying it in practice. (Brunner & Rivas, 2006, pp. 4-5)

The tool used to gather information about the depth of teacher understanding of the principles underlying the TfU framework, and about teacher integration of the principles into their practice, was a Critical Incident Technique report. This report was administered at the midpoint and the endpoints of each course. Each participant described a moment to which a principle from the course was applied, how that interaction would have gone differently before participation in the course, and explained the course precept that was applied. A qualitative analysis of responses was done utilizing rubric scoring of each response and comparison of matched sets of early and late Critical Incident Reports for each participant. This was done in order to determine differences in application of targeted practices and depth of understanding of targeted principles. Findings showed positive impact upon teachers' abilities to correctly define and apply course precepts to their classroom contexts. This study contends that proof of successful application of course precepts to participants' contexts is a precursor to correct implementation of TfU with students. This method of measuring impact of online learning holds promise for future research. Supporting student data confirming the connection between teachers' understanding of contextual application and teachers' abilities to successfully implement TfU would strengthen the argument.

Implications of Research

Research has shown evidence that effective professional development possesses several characteristics. It must nurture specialized content knowledge, while engaging teachers in a manner congruent to the manner in which teachers are to engage students. It must be part of a system in which goals for teacher and student learning are aligned. Connecting professional learning activities directly to positive impact on student learning has proven elusive, and yet research states that a focus on classroom learning and problems of practice is necessary. A barrier to being able to focus on classroom activity is that most teachers' time is fully expended in providing face-to-face instruction for students. As a solution, in order to provide an on-demand collaboration space for job-embedded support, the use of online communities has been studied. However, a connection between the use of the online community and any change in student learning was not detected. More research into the use of online communities as a forum for teachers to collaborate about problems of practice could be conducted.

Methods

A mixed methods study was used in order to measure the impact of the OCSP. In an effort to determine the potential connections between teacher and student data, quantitative analyses were conducted on teacher CPK assessments about fractions, on teacher Likert-scale responses to survey questions about attitude and classroom-practices, and on student assessments about fractions. Also, in an effort to better understand the teacher and student data, qualitative analyses were performed on all responses and interactions posted on the OCSP by teachers and the facilitator, and on open-response items on the teacher survey about the use of the computer for professional learning.

Setting

The teachers and students participating in the study were drawn from a population of 34 teachers who voluntarily attended face-to-face professional development about teaching fractions using a conceptual foundation in the summer of 2012 or during the 2012-2013 school year. None of those 34 teachers had face-to-face classroom support following their initial professional learning experience about the teaching of fractions. Of those 34 teachers invited to participate in the study, 17 agreed and submitted data for the study. Those 17 teachers and their students comprised the treatment and control populations for the study. The treatment was the OCSP created as a Google Community, "Making Sense of Fractions – Online Support" comprised of: (1) three text documents outlining conceptual ways to develop the fraction lessons; (2) four whiteboard recordings supporting those lessons; (3) six prompts for reflection about mathematics content, anticipated student thinking and potential teacher moves; and (4) online discussion to prompts and questions and comments by facilitator and participating teachers.

Population

Participants for the study had participated in face-to-face professional learning provided by CMPSS in 2012 or-2013, but who had not had face-to-face in classroom support. The 17 participating teachers secured a total of 461 students who also agreed to participate. Consent forms were collected from participating teachers (Appendix A) and from parents of their students (Appendix B), and assent forms were collected from their students as well (Appendix C). The 17 teachers came from 11 schools belonging to 7 school districts from second through eighth grade in the greater Sacramento area.

Participating teachers were divided into a treatment group of eight teachers with access to the OCSP, and a control group of five teachers without access to the OCSP. Grade level, school district, and number of participating teachers per school were considered in creating pairings before random assignment to the treatment or control groups. In order to control for potential impact of face-to-face collaboration between teachers within the study, teachers from the same schools were considered one school-group, and those school-groups were randomly assigned as treatment or control. Two of those school-groups were randomly selected to be in the control group, and three were randomly selected to be in the treatment group. For the remaining teachers, the grade level taught was considered as the primary factor in assignment to treatment or control. The resulting treatment group and control groups are displayed in Table 1 below.

Control and Treatment Group Assignment of Teachers School-Group Pairs are Indicated Using the Same Colors							
Control Teacher Code	**Grade Level**	**Number of Students**	**District**	**Treatment Teacher Code**	**Grade Level**	**Number Students**	**District**
CR26	7 - 8	64	Elk Grove USD	DO10	8	31	San Juan USD
FA26	7	18	Roseville City USD	HO04	5	25	Davis Joint USD
ST20	6	34	Roseville City USD	BA20	5	23	Rocklin USD
NI32	6	15	San Juan USD	PO09	5	29	Sacramento City USD
TA14	6	35	San Juan USD	BO04	4	28	Sacramento City USD
ME12	5	31	Davis Joint USD	EE02	4	26	San Juan USD
DI19	4	23	San Juan USD	LO18	4	24	San Juan USD
LE11	2-3	20	Horizons CS	CA25	4-6 Title I	20	Rancho Cordova USD
				LI28	4	15	Rancho Cordova USD

Table 1: Control and Treatment Group Assignment of Teachers

Measures

Measures for teachers included a survey comprised of Likert-scale closed and open response items (Appendix D), a teacher PCK assessment about fractions comprised of closed response items (Appendix E), written posts from the OCSP, and a final survey about the usefulness of the OCSP comprised of closed response items (Appendix F). The pre-participation and post-participation teacher survey identified the following information: number of years of teaching, amount of professional development in mathematics in last two years, attitudes about teaching, frequency of classroom practices used in general, frequency of classroom practices used when teaching fractions, and attitudes about professional learning using the computer. The teacher PCK assessment about fractions contained 12 closed response items requiring analysis of student thinking about fractions and understanding of the conceptual foundation of operations with fractions. Five of the items for the teacher assessment were taken from the Learning for Mathematics Teaching project (Hill, Schilling and Ball, 2004). The facilitator and mathematics professor faculty advisors from the California Mathematics Project at Sacramento State created the remaining items for use in professional development about fractions. Two measurement tools captured information about the use of the OCSP: the teacher and facilitator written posts to the OCSP and the post-participation survey of treatment teachers about the usefulness of OCSP.

To capture any change in student conceptual understanding, two measurement tools (Quiz 1 and Quiz 2) were used before and after instruction (Appendix G). Quiz 1 had six multiple-choice items and two open response items covering the definition of fractions on the number line, identifying locations on the number line with improper fractions, and equivalent fractions. Quiz 2 had seven multiple-choice items and two open response items covering equivalent fractions and adding fractions.

Assumptions

Teachers had online access in order to use the Google Community, the platform on which the OCSP resided. Since one of the participating districts used Google Documents and accounts for student learning, it was assumed that district firewalls would not prevent the Google Community from being accessed by teachers at their schools. It was also assumed that teachers had online access to the Google Community webpage at home as well. Because Google was a tool that teachers could use more broadly with their own students, it was assumed that they would have been willing to invest the time into learning how to use it for this study.

Procedures

Teachers from both the treatment and control groups received the same materials for the study including consent forms for the teacher and parents, assent forms for students, teacher pre study survey, teacher pre assessment, student pre and post assessments, teacher post-study survey, and teacher post assessment. Teachers began the project by completing the pre study survey, the teacher pre assessment, and then the student pre assessment. Then teachers from both the control and treatment groups provided instruction about fractions to their students.

While planning instruction about fractions, the teachers in the treatment group had access to the OCSP, to the Google Community, “Making Sense of Fractions Online Support”. After instruction, both groups administered the student post assessments, and also completed the teacher post survey and teacher post assessment. Together, both treatment and control group teachers submitted 490 student assessments for quiz 1, and 375 assessments for quiz 2. From those, matched pairs comprised of a pre assessment and a post assessment taken by the same student, were identified. For quiz 1, there were 194 matched pairs of pre and posts from treatment teachers’ classes, and 189 matched pairs from control teachers’ classes. For quiz 2, there were 159 matched pairs of pre and posts from the treatment teachers’ classes, and 134 matched pairs from control teachers’ classes. For the final phase of the data collection, the treatment teachers submitted their responses to a survey with five items capturing their attitudes about the value of the OCSP.

The Treatment. The OCSP provided support for the teachers in three areas of fractions: (1) understanding fractions on the number line and changing whole numbers to improper fractions and back; (2) understanding equivalent fractions on the number line; and (3) understanding how to add fractions using the number line. Each topic had a text document outlining a conceptual approach to deliver instruction to guide the students to figure out the procedure for themselves, without the teacher lecturing and telling. There were also whiteboard recordings for each topic talking through targeted parts of the instruction so teachers could hear and see what the whiteboard would look like during instruction. Finally, there were reflective prompts asking teachers to post thoughts to the community about the mathematical purpose behind particular parts of each topic, or about particular modes of response to use at key junctures, or about anticipating student thinking at key junctures. The online community also allowed treatment teachers to begin threads, and post their own thoughts and questions if they chose to do so. All posts to the Google Community were captured for qualitative analysis.

Flexibility in Application and Student Assessments. In an effort to reach as large a population of teachers as possible, flexibility in application of the 3 fractions topics was allowed. Because teachers came from different grade levels, and because they determined varying needs for their students, they selected which of the 3 fractions topics, (definition of fractions on a number line, equivalent fractions, adding fractions) to access in support of their teaching. Some teachers used only the first topic and second topics covering the definition of fractions on the number line and changing whole numbers to improper fractions and back and equivalent fractions. Student Quiz 1 measured change in student achievement for this application of the first and second topics on the OCSP. Other teachers used both the first two topics, and the third topic that covered adding fractions on the number line. Student Quiz 2 measured changes in student achievement for this application of the second and third topics on the OCSP.

Data Analysis

Statistics. Descriptive statistics were used to compare results of data from both the teachers and the students. For the teachers, comparisons were made between the treatment and control groups using three of the measures: 1) the pre study and post study surveys; 2) the teacher pre and post PCK assessments; and 3) the post study survey of treatment teachers about the value of the OCSP. Descriptive statistics were also used to compare student achievement of classes taught by treatment teachers to classes taught by control teachers. A regression analysis was performed to determine if teachers PCK was related to student achievement on Quiz 1 and Quiz 2. Also, in order to identify the possible impact of control and treatment teachers on student learning, inferential statistics (t-tests) were performed on the change in score from pre to post taken from the entire population of students for Quiz 1, and on the entire population of students for Quiz 2.

Student Assessment Scoring Process. For the two open response items on the student assessments, a 4-point rubric scale was used by a three person scoring team comprised of the facilitator/researcher, a mathematics professor, and a teacher leader who was not part of the project, but who had previous experience with using these lessons with her students. On the rubric a score of 4 indicated the student demonstrated conceptual understanding well; a score of 3 indicated the student demonstrated most of the conceptual understanding but had a minor computational error; a score of 2 indicated that no conceptual understanding was demonstrated, that a rule was cited; and a score of 1 indicated that no correct understanding was demonstrated. The mathematics professor and the facilitator/researcher developed and agreed upon the rubrics for the items (Appendix H). After standardizing their scoring process by scoring the same student responses for several students, the team scored every student response. Two members of the team scored each student response. If the two scores were the same, then the student response was given that score. If the scores were different, then the paper was given to the third member to break the tie. In order to maintain objectivity, scoring was blind so that the next member to read the response could not see the previous member's score.

Qualitative Analysis about the use of the OCSP. All written posts to the online community by the teachers and the facilitator were extracted from the website housing the OCSP, and categorized in order to identify emerging themes about the manner in which the online community was used.

Limitations

There are some factors that could have placed limitations upon the results of this study. First, students or teachers may have showed improvement from pre to post assessments due to two administrations of the same assessment. On the student assessments, some of the items required open response explanations that may have assisted in mitigating this circumstance. A second limitation is that only self–reported data was gathered from teachers about their changes in practice while teaching fractions or while teaching other subjects. Thus the survey responses collected from teachers may have been skewed toward their perceptions of how they *wanted* to be teaching as opposed to how they were actually teaching. Classroom observation of teaching practice would have assisted with this issue, but was beyond the scope of this study. Other data that was entirely self-reported by teachers included the perceived effectiveness of online learning features. Here again classroom observations of teacher implementation would have assisted in determining effects of particular design features of the OCSP. A third limitation is that teachers may have had other school or district enacted professional support programs or initiatives that could have positively or negatively impacted the instruction with students. Data was not collected about other professional development initiatives happening at the time of the study. The fourth limitation of this study was the potential impact of teacher's professional interactions with other colleagues not involved in the study. In the general population of teachers, some have a teaching partner with whom they regularly plan lessons and collaborate. Such collaboration may have influenced a participating teacher's use of the OCSP or the methods of teaching. No data was collected regarding this eventuality, so the impact of such interactions in comparison to the impact of the teachers' use of the online community was not taken into account.

Delimitations

One of the factors that influenced the results of this study is population size which impacted the equivalence of the two teacher groups created. The researcher chose to select teachers from within the pool of teachers who had participated in a particular face-to-face professional development program about fractions, but who had not participated in face-to-face classroom-embedded support of that program during the school year. No teachers from other face-to-face professional development programs were invited to participate. Part of the reason for this choice was to control for potential differences in philosophical approaches built into the different professional development programs. Having all participants come from the same professional development program meant an equal philosophical approach and face-to-face experience for them. However, choosing from one professional development program limited the pool of teachers from which to draw participants for the study. This in turn impacted the differences between the treatment and control group teachers, and also on the differences between their respective classrooms of students. Truly equivalent populations of control and treatment teachers and corresponding equivalent populations of control and treatment students were not formed. A second factor that may have influenced the results of the study is teacher affinity for the use of online community as a professional learning tool. Although the there was an item about the use of computers as a professional learning tool on the teacher surveys, this information was not used as a factor in creating pairs of teachers before random assignment to the control and treatment groups.

Timeline

The following outlines the timeline for events in the study.

Step	**Benchmark**	**Dates**
1	Submitted and obtained research proposal for departmental review	May 2013
2	Recruited teacher participants	August – October 2013
3	Began Data Collection • Collected teacher consent forms, parent consent forms, student assent forms and pre surveys and pre assessment from teachers • Assigned teachers to control or treatment group	January 1 – 15, 2014
4	Administered treatment of OCSP to participating treatment teachers in time for them to teach fractions	Jan 16, 2014 – February 2014
5	Concluded Data Collection • Teachers administered pre and post student assessments before and after providing instruction • Collected all student data and teacher post surveys and teacher post assessments • Collected survey of treatment teachers about the	January 2014 – February 2014

	value of OCSP	
6	Analyzed Data • Organized and Extracted Data • Scored Open Ended Student Assessment Items • Performed Statistical Analyses of all assessments and surveys • Compared results	March 2014 – April 2014
7	Composed Draft of Research	April 2014
8	Refined and Finalized Findings and Paper; Completed and Submitted Paper	May 2014 – November 2014

Validity and Reliability

The quasi-experimental portion of the study included a comparison of pre and post assessment measures for students and teachers, and an analysis of Likert-scale items on teacher surveys. Teacher assessments included five multiple-choice items (#'s 3, 5, 8, 10 and 12) taken from the Learning for Mathematics Teaching (LMT) Project (Hill, Schilling and Ball, 2004) that have yielded valid results. Other teacher assessment items were developed by CMP at Sacramento State using similar design principals from LMT, and have been used for several programs in the last five years.

A three person scoring process used to score open-ended student assessment items supported the reliability of the student assessment results. Student assessments were composed of both multiple choice and open response items. Three of the CMP at Sacramento State staff comprised the scoring team that used a 4-point rubric to assign a score to each open-ended student assessment item. In order to ensure reliability and to reduce bias, the team participated in standardization protocol by scoring the same responses and comparing scores. Thereafter, each response was scored twice and when the scores did not match, the response was given to a third scorer to break the tie. This system of scoring mitigated any possible bias the facilitator/researcher may have had.

Results

Evidence of Impact of the Online Classroom Support Program

Data was gathered to measure the impact of the OCSP on teacher's pedagogical content knowledge, on teachers' classroom practices, and on student conceptual understanding of fractions. The results of those measures in each of those areas are discussed below.

Teachers' Pedagogical Content Knowledge. All participating teachers were asked to complete the assessment of their pedagogical content knowledge prior to beginning the study before preparing for student instruction about fractions, and at the close of the study after student instruction had been completed. The window of time between those administrations was between 6 and 8 weeks. Unfortunately, both pre and post assessments were gathered from only 10 of the 17 participating teachers, while at least one of the assessments was gathered from 15 of the participating teachers. Because the brief time between administrations of the assessment, and in attempt to capture an accurate portrayal of the level of content knowledge possessed by each teacher at the time, an average of the two administrations was used as the measure of PCK for each teacher. There were 12 question stems on the assessment. Two of the question stems, number 8 and number 10, had multiple parts. So as not to have those two question stems have a disproportionate effect on the overall score, each of those multiple parts counted as a fraction of the score for that stem. Thus some scores are not whole number quantities. Table 2 below displays the assessment scores for teachers from both the control and treatment groups.

Control Teacher	Pre Assessment Scores (12 possible)	Post Assessment Scores (12 possible)	Average % of Pre and Post	Treatment Teacher	Pre Assessment Scores (12 possible)	Post Assessment Scores (12 Possible)	Average % of Pre and Post
C1	9.75	10.55	84.58%	T1	9	9.75	78.13%
C2	N/A	10.3	85.83%	T2	N/A	10.25	85.42%
C3	8.4	8.1	68.75%	T3	6.85	7.55	60.00%
C4	N/A	N/A		T4	9.95	7.35	72.08%
C5	N/A	N/A		T5	8.3	9.3	73.33%
C6	8	9.2	71.67%	T6	4.5	N/A	37.50%
C7	4.9	3.3	34.17%	T7	N/A	8.35	69.58%
C8	4.35	4.35	36.25%	T8	8.4	8.6	70.83%
				T9	4.75	N/A	39.58%

Table 2: Teacher Pre and Post Assessment Scores for Control and Treatment Groups

The box plots depicted below on Figure 1 show the treatment teachers' average PCK percentages were slightly less variant than the control teachers' average PCK percentages.

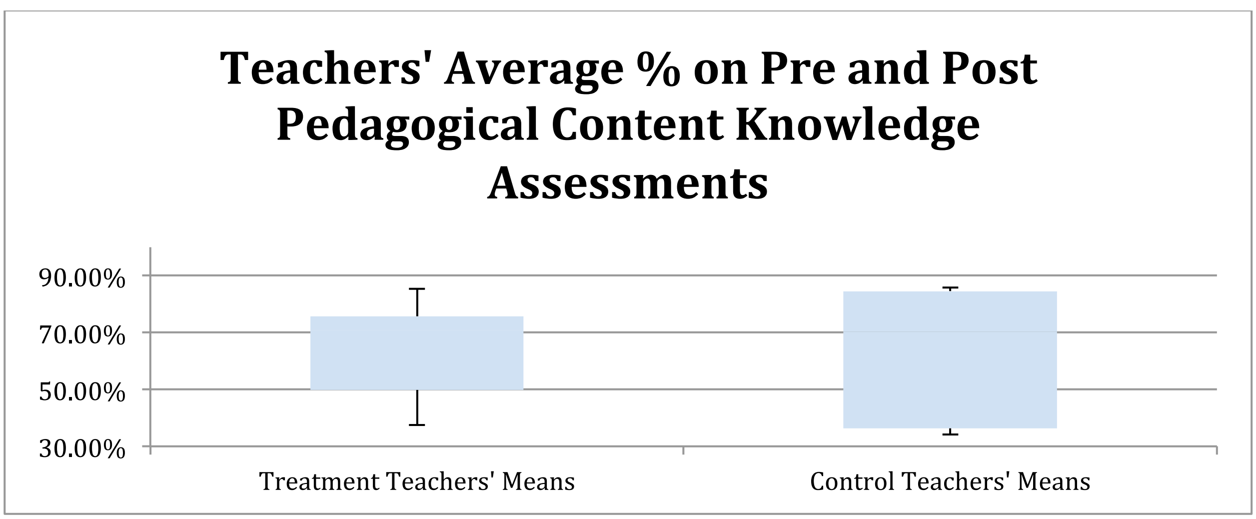

Figure 1: Comparing the set of teacher PCK scores for the Treatment Population and the Control Population

The mean of the control teachers' average percentages of PCK was 63.54%, while the mean of the treatment teachers was slightly higher at 65.16%.

The slightly less variant distribution of PCK percentages for the treatment group points to the possibility that the use of the OCSP may have had an impact on treatment teachers' mathematics pedagogical content knowledge. In order to determine this, a t-test was conducted using averaged pre and post assessments for each control and treatment teacher as a measure of teacher PCK. For the t-test, the null hypothesis was that the control and treatment populations were not different, that there was no difference in the means of the average percentages of the teacher PCK assessments for the two groups. The t-test yielded a p-value of .87574 indicating that the probability that the two groups were the same was approximately 87.6%, and a difference between the two groups was not detected. Thus the null hypothesis cannot be rejected, and the data did *not* reveal that the use of the OCSP impacted the treatment group's mathematical pedagogical content knowledge.

Impact on Classroom Practice. Figure 2 below shows teachers' self reported frequencies of their use of practices that contribute to developing a classroom atmosphere in which students of supported to make sense of the mathematics and to develop conceptual understanding of the mathematics. Each of the four categories listed below (practices conducive to sense making, mental math, explaining why, and checking for understanding) contained two to six question stems about classroom practice. Teachers were asked to report the frequency with which they used each of the practices. Each teacher's responses within a category were averaged, and the means for the treatment and control groups are depicted in Figure 2. These data do not show a significant difference in the treatment group's use of those practices when compared to the control group's use of them, suggesting that the use of the OCSP did not make a difference in the treatment group's reported classroom practices.

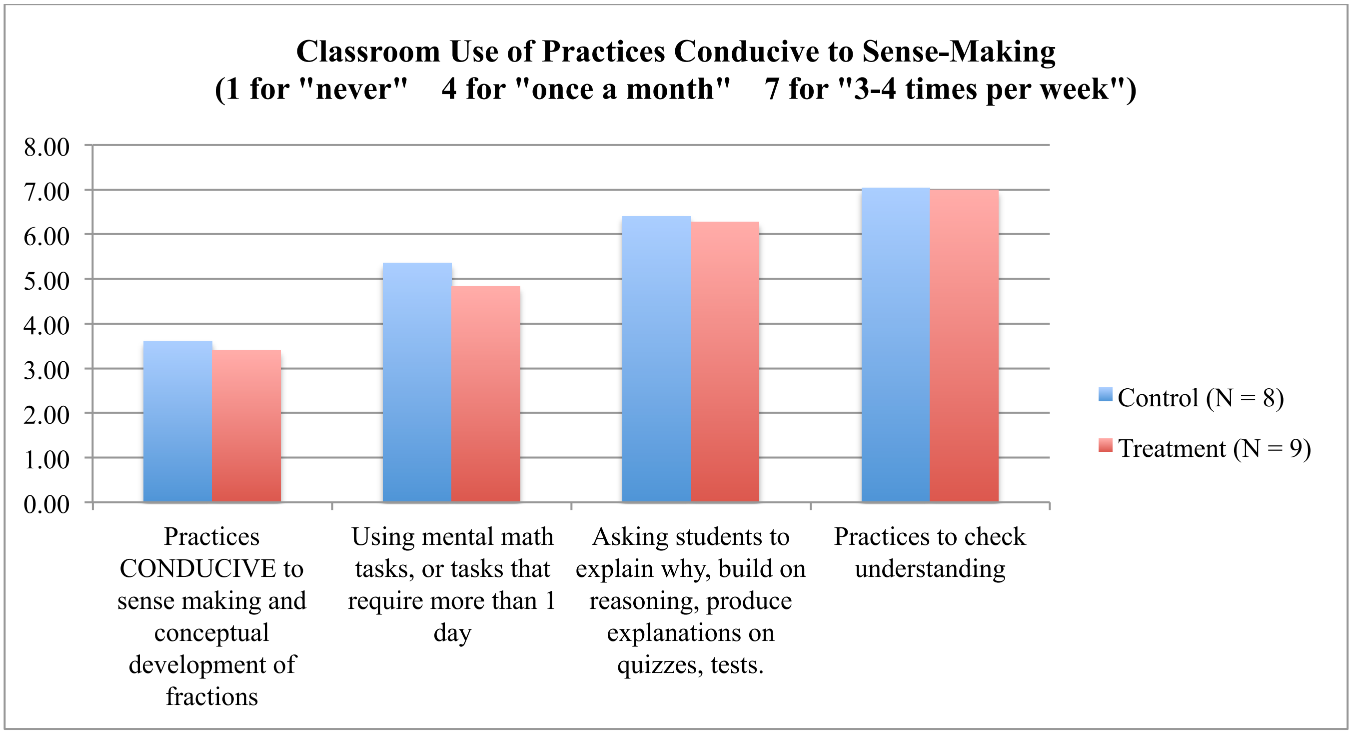

Figure 2: Teachers Use of Classroom Practices Conducive to Student Sense-Making. Frequencies were self-reported by teachers.

Even though the closed response items on pre and post study survey did not show the impact on the treatment teachers, some impact was captured on the open response items. Treatment teachers were asked to describe something learned from the OCSP that they would apply to teaching fractions in future. One teacher's comment described changes she intended to continue when teaching fractions in the future, "The continual use of # lines & organized patterns that helps & invites students to discover & 'figure-it-out'. The discovery or a-ha moments are so exciting to see when a student gets the new concept." Another wrote, "I learned how powerful number line is, especially in teaching equivalent fractions." Treatment teachers were also asked to describe the most significant change in their teaching resulting from the online support program. One teacher commented that, "I slowed down the amount of "new learning" I expected each day". Another identified the most useful ideas she learned, "Giving students tools to figure out how to get the answers rather than the other way around. Conceptual before procedural." These comments indicate that teachers did take away deeper understandings from their experiences with the OCSP.

Student Conceptual Understanding of Fractions. Descriptive statistics were used to determine the mean student change from pre assessment to post assessment on Quiz 1 and Quiz 2 for each teacher's class. Figure 3 below compares the treatment and control means of teacher PCK, as well as the treatment and control means of student growth on Quiz 1 and Quiz 2.

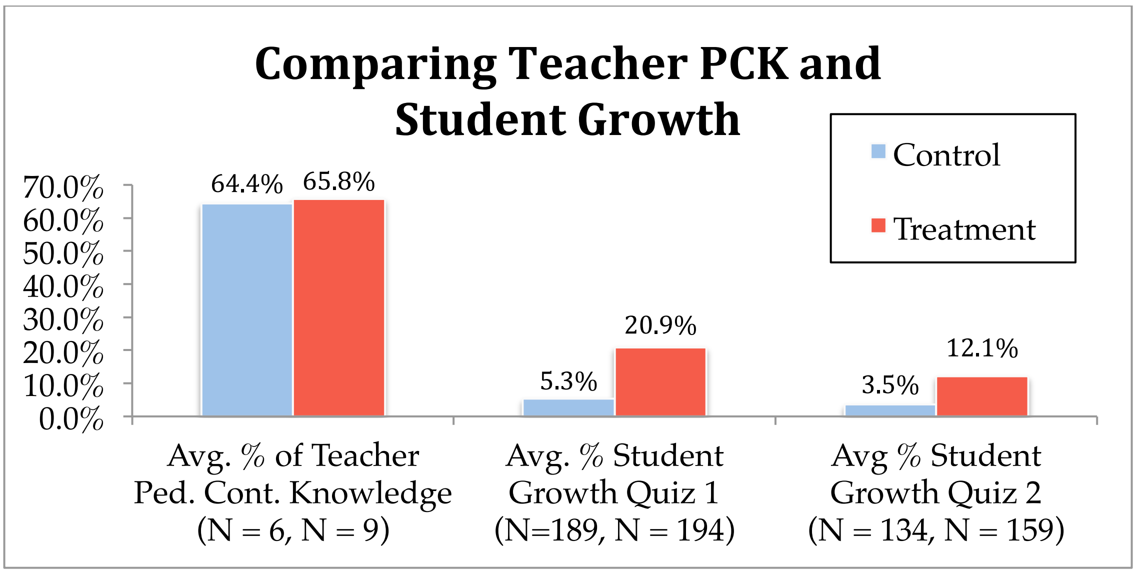

Figure 3: Comparison of the Teachers' PCK to Change in Student Growth on Quiz 1 and Quiz 2. This graph depicts the average of teacher PCK for the control and treatment groups, and the average % of growth each teacher's class made from Quiz 1 to Quiz 2 for the control and treatment groups.

The comparison depicted above implies the teacher pedagogical content knowledge was not correlated to the amount of student understanding as the control and treatment teachers had almost equivalent means for teacher PCK, yet the mean student growth per class was greater for treatment students. In order to see if there was correlation or not, the mean of the two averages of student growth was calculated for each teacher, resulting in 15 measures of student understanding. Then a regression analysis were performed using teacher average PCK percentage as the independent variable and this mean of the class averages of student growth on Quiz 1 and Quiz 2 for the dependent variable. The correlation coefficient was 0.084 indicating that the mean student growth per class was not correlated to teacher PCK level.

The means shown in Figure 3 above, also suggested a possible relationship between the teacher PCK assessments and student growth on Quiz 1 and Quiz 2. Further analysis using linear regression was conducted using each teacher's average percentage on the PCK assessment as the independent variable (teacher measure), and each teacher's average of the class means on Quiz 1 and Quiz 2 as the dependent variable (student measure). A regression coefficient of .08441 was calculated indicating that teacher PCK was not correlated to student achievement on Quiz 1 and Quiz 2.

Figure 4 below shows that in general, students from the treatment group's teachers had greater average change from pre to post than did students from the control group for Quiz 1 and Quiz 2.

Each Teacher's Mean Change per Student (Pre to Post)									
Treatment Group					**Control Group**				
Teacher Code Grade	No. Students	Quiz 1 Change	No. Students	Quiz 2 Change	Teacher Code Grade	No. Students	Quiz 1 Change	No. Students	Quiz 2 Change
T1/8th	27	27.7%	27.00	28.0%	C1/8th	50	10.3%	66	14.0%
T2/5th			23.00	0.0%	C2/7th	16	2.7%	18	7.3%
T3/5th	24	7.4%	23.00	23.3%	C3/6th	28	-5.7%	33	3.9%
T4/5th	29	18.1%			C4/6th	15	-1.5%		
T5/4th	28	20.8%			C5/6th	17	15.1%	13	-5.8%
T6/4th	26	30.2%	26.00	10.9%	C6/5th	23	13.9%	30	
T7/4th	24	44.9%	25.00	19.3%	C74th	20	8.4%	23	5.8%
T8/4th	20	17.8%	20.00	8.3%	C8/2-3	20	-0.7%		
T9/4th	16	21.5%	15.00	7.0%					
Mean of Treatment teachers' means	8 teachers	23.5%	7 teachers	13.8%	Mean of Control teachers' means	8 teachers	5.3%	6 teachers	5.0%
Mean Change: Students from Treatment Group	194 students	23.7%	159 students	14.7%	Mean Change: Students from Control Group	189 students	5.8%	183 students	7.8%

Figure 4: Table of each teacher's class of students mean growth in score from pre to post for Quiz 1 and Quiz 2.

A broader look at the student data reveals a clearer picture of all students for whom pre and post quizzes were submitted. Figure 5 for Quiz 1 and Figure 6 for Quiz 2 below depict a box plot for each teacher showing the amounts of growth for each teacher's population of students with half of each teacher's student growth measures residing within the box. This shows that more students from the treatment teachers' classes made greater gains in growth (above 0 growth) than in the control teachers' classes.

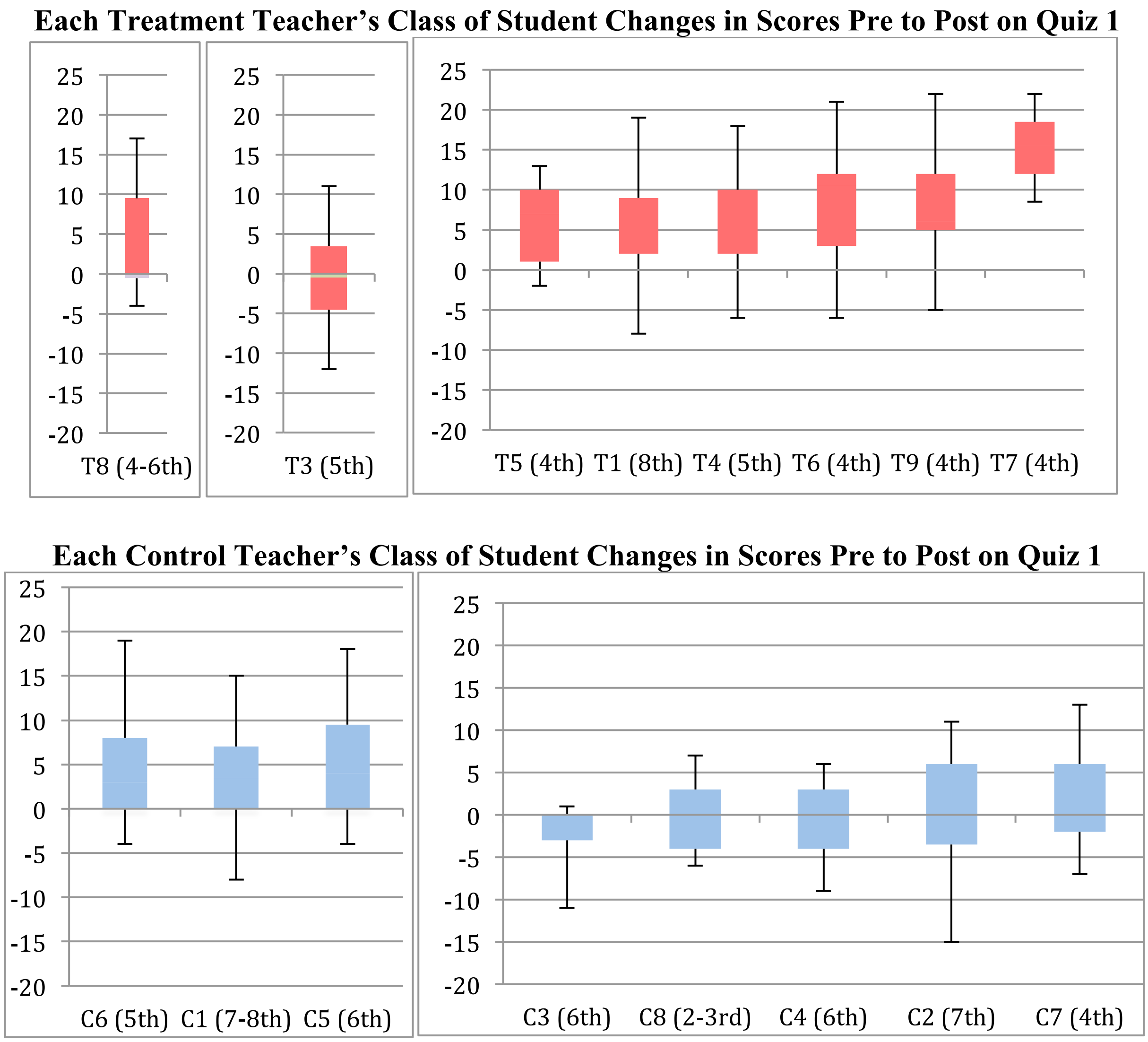

Figure 5: Each box plot above depicts a teacher's class of student change in scores on pre and post assessments for Quiz 1

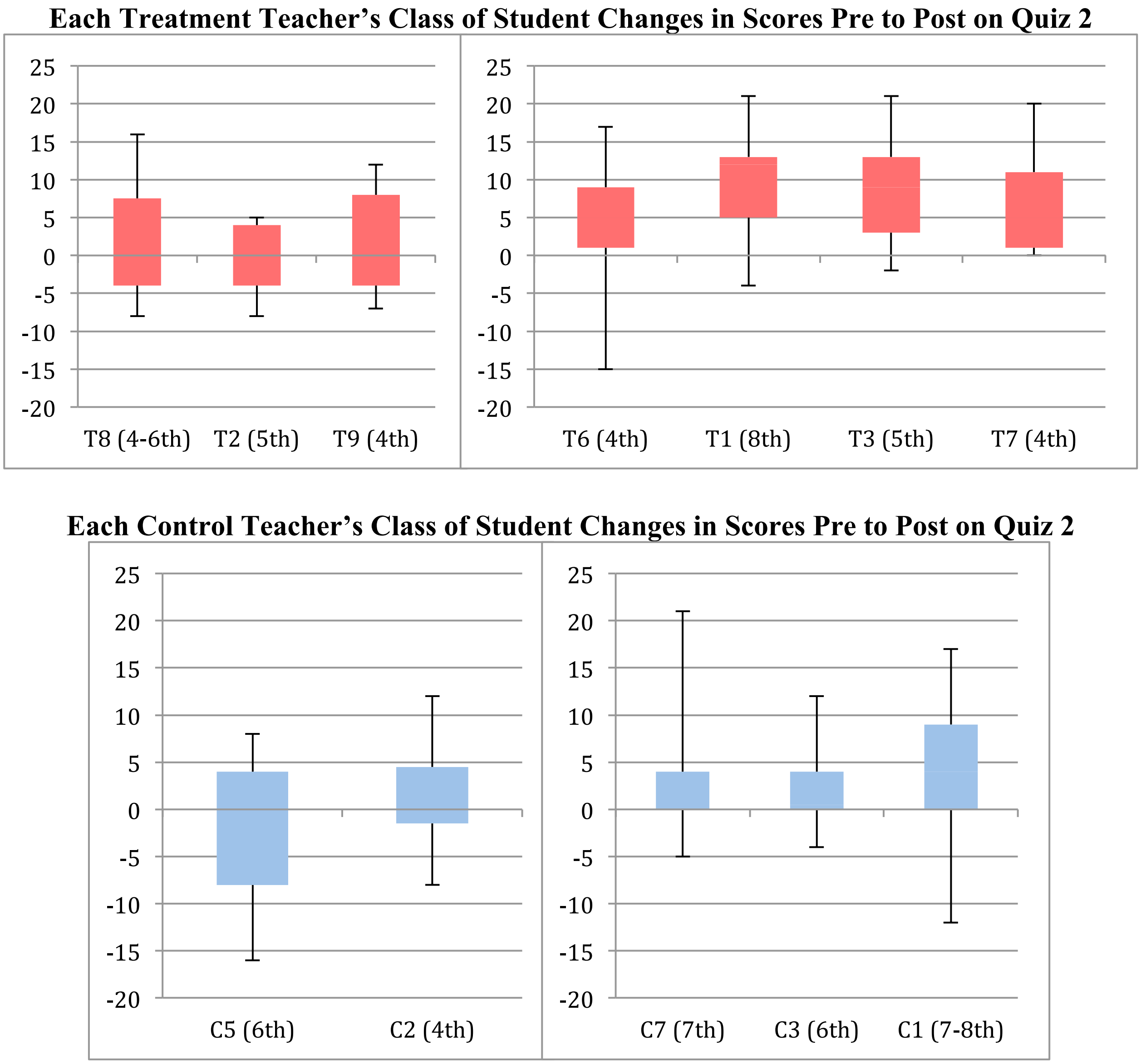

Figure 6: Each box plot above depicts a teacher's class of student change in scores on pre and post assessments for Quiz 2

A still broader view of the data can be achieved when the each population of students from each group of teachers (control and treatment) are collapsed into one representation. This results in the four box plots displayed in Figures 7 and 8 below, one box plot for each student population (treatment and control) displaying student growth on each student assessment (Quiz 1 and Quiz 2).

Collapsing Quiz 1 Results for Students of Treatment and Control Teachers

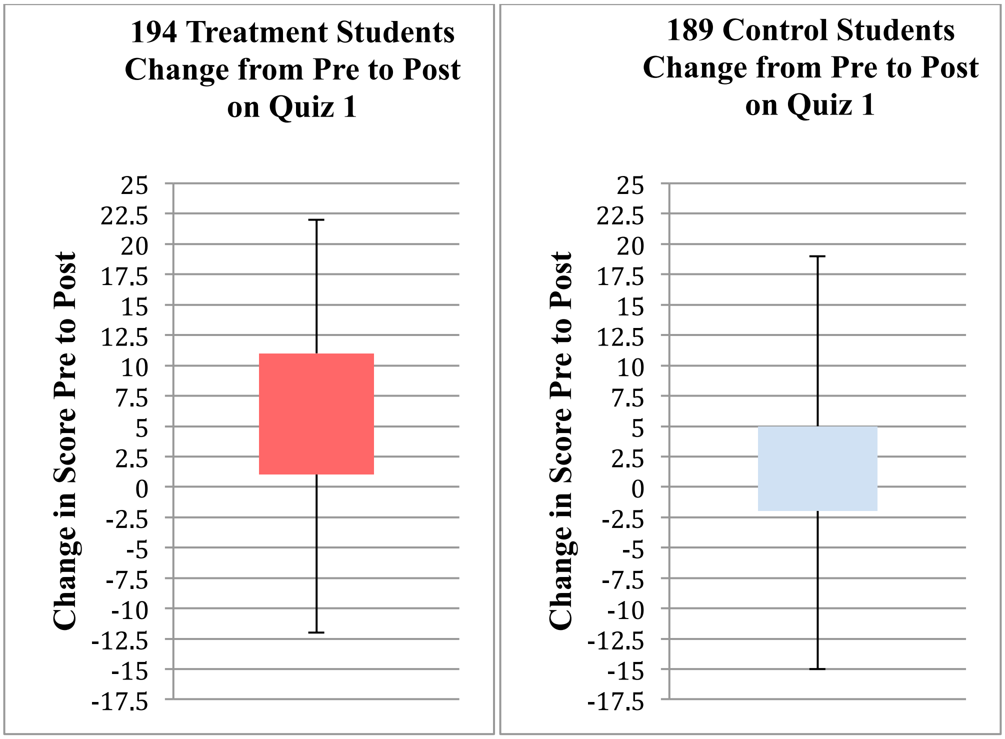

Figure 7: Change in scores on Quiz 1 for all students in the treatment group and all students in the control group.

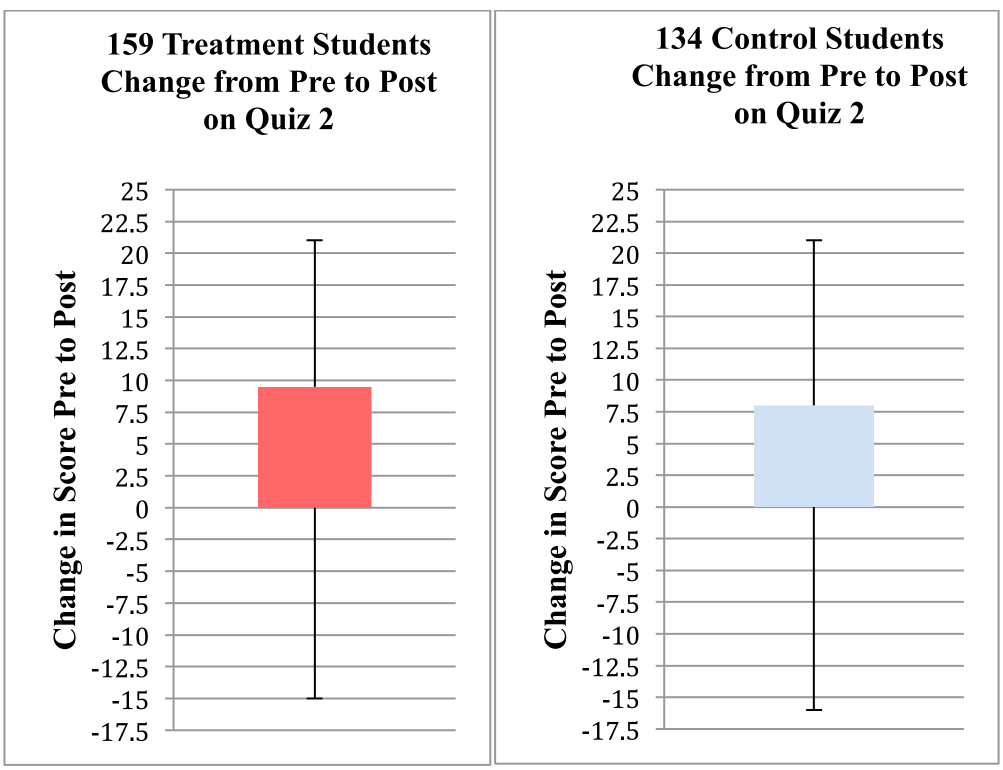

Figure 8: Change in scores on Quiz 2 for all students in the treatment group and all students in the control group

For Quiz 1, the treatment population of students showed greater growth than the control population. However there is not a significant difference between the two populations for Quiz 2, which is contrasting to the graphical display in Figure 6 above. Upon closer examination of the individual control group teachers' classes from Figure 6, it is apparent that teacher C1's students showed more gain than the students from other control group teachers. Teacher C1 had approximately twice the number of students as any other teacher in the control group, and so C1's effect on the overall student sample from control teachers was greater. This resulted a larger control population mean than would have resulted if teacher C1 had the same number of students as the other control teachers.

Inferential Statistics were used to determine if there was really was a difference in mean growth scores for the control and treatment populations. A t-test was calculated using the growth scores on Quiz 1; a p-level of .00182 resulted providing evidence to reject the null hypothesis that there was no difference in the control and treatment populations of mean growth per student on Quiz 1. This would provide evidence that the alternative hypothesis was correct, that there was a difference in the means of the treatment and control populations. Thus there was evidence that the treatment, using the OCSP, positively impacted the treatment population. Additionally, a t-test using the growth scores on Quiz 2 was calculated and resulted in a p-level of 0.1238. This does not indicate that there was a difference in the two populations meaning that the use of the OCSP for the treatment group did not have a measurable impact on Quiz 2.

The similarity of the populations of control and treatment populations, and the similarity of their student populations, affect whether the results can be extrapolated to the general populations of teachers and students. If the treatment and control teachers and their students were equivalent at the outset of this study, a p-level of .00182 for Quiz 1 would have allowed an inference that there would be similar results in the general population. However, because teachers from the same school were considered as a group during the random assignment to control or treatment, the grade levels of the two populations of teachers were not equivalent (Figure 9).

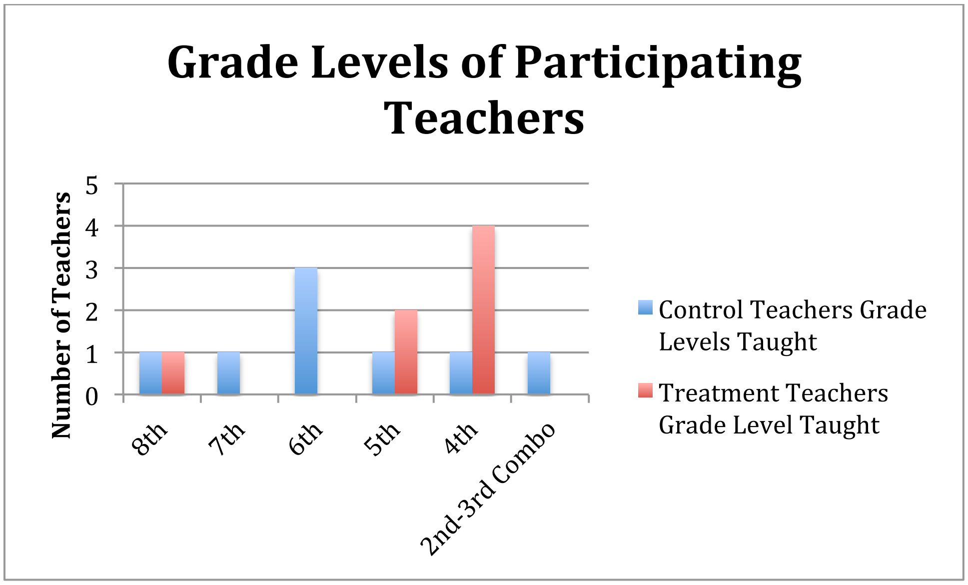

Figure 9 displays the grade level distribution of the Control and Treatment Groups

Another factor influencing the grade level distribution of the final control and treatment populations was attrition. A 6th grade treatment teacher who would have been part of a school group, and a 7th and 8th grade treatment teacher both began the study but didn't finish it. This created a less equitable distribution of grade levels. For students, there were no statistics gathered to compare the two populations. There was an effort to assign schools with similar socio-economic populations and AYP performance to opposite groups, however other factors such as school group and grade level were given more weight in constructing the pairings before random assignment occurred.

Usefulness of the Online Classroom Support Program

Posted Reponses and Comments to the Online Community. The number of comments, the purposes of comments, and the type of interactions between users were analyzed in order to identify useful features of the OCSP. The total number of comments posted was 82; the facilitator posted 43 of those, and the participating teaches posted 39 of them. All 39 of the participant-posted responses and comments were qualitatively analyzed and six common themes emerged.

The first common theme included comments about interface issues such as difficulties in reading or downloading text documents from the Google Community, and difficulties in following the threads and order of the posts. The second theme included comments showing evidence of community being developed such as participants offering suggestions to others for how to see all posts. The third common theme included responses to solicited prompts by the facilitator, such as participant thoughts about what specific numbers should be used in numerators and denominators in order to move students to generalization. The fourth theme included all the occurrences of participants using the "+1" feature of Google + to indicate they had read those posts. One of the richer themes included questions posted about the scope of the project. For example a few participants requested support in developing homework problems aligned to OCSP lessons, as they weren't aligned well to their texts. This was originally not intended as part of the scope of the project, but the facilitator adapted and provided some thoughts about tasks that could be used as independent practice. The final theme included unsolicited comments and questions about classroom practice and teaching by one participant. She was trying to reconcile her previous experiences when teaching reading to primary students, wondering if student understanding of common denominators for fractions worked in development stages like reading does for primary students. She was working to integrate her previous experiences in watching students learn reading at different rates, with her more recent ones in watching students understand how to add fractions at different rates.

Figure 10 below shows the percentage breakdown of the six different themes of how the OCSP was used by the teachers.

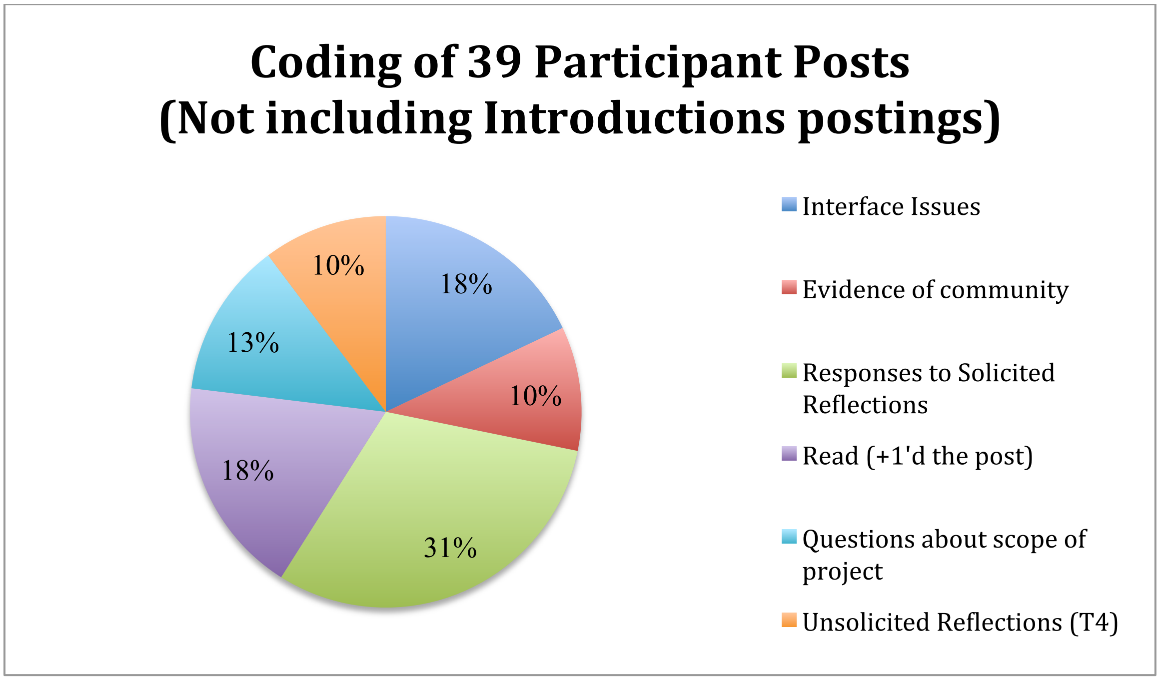

Figure 10 displaying the percentage of responses falling within the 6 themes of purpose.

This shows that participants used the OCSP as a tool for teaching for 54% of the time (including 23% responding to facilitator's prompts, 10% posting unsolicited reflections about teaching fraction lessons and 13% questions about the scope of the project.) Evidence of community was indicated by the 10% of the responses from participants showing assistance or support for each other, but also in a small way by the 10% of unsolicited reflections offered by one participant. It was hoped a greater percentage of participants would have found it useful to interact with each other, that they would value each other as a community.

Another method used to investigate the nature of the community built on the OCSP was to categorize the interactions of the posts on the OCSP. Posts were separated into six categories which included facilitator to all, facilitator to participant, participant to all, participant to facilitator, and participant to facilitator indicated by the use of the "+1" feature of Google + (Figure 11).

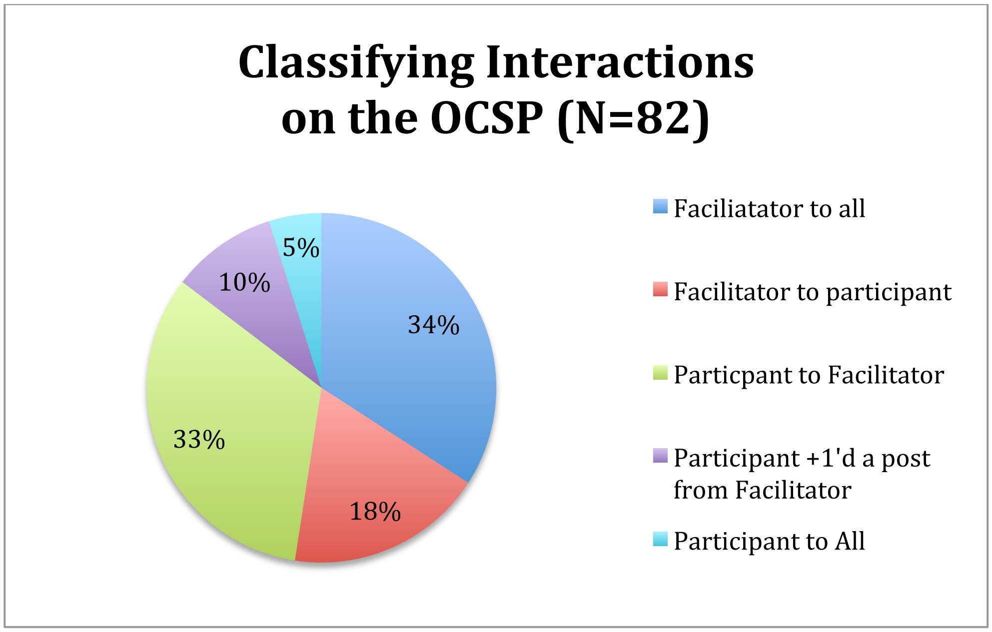

Figure 11 depicts the directionality posts of participant interactions.

This shows that the OCSP supported professional relationships between the facilitator and each participant, but there is little evidence of relationships between participants. Connections between the facilitator and each participant were evident, but a rich community of practice between participants was not. An analysis of the themes emerging from the facilitator's posts pointed to a possible factor that may have influenced this result.

The facilitator's posts fell into six categories of purpose: building community; supporting the development of a conceptual mathematical trajectory for each lesson; supporting pedagogy allowing low risk ways to engage all students, multiple access points for all students, and methods of providing feedback for formative use when teaching; responses to participants about their thinking while planning a lesson or while reflecting about their students; responses to participants about their interface issues in dealing with the OCSP; and responses to participants' problems of practice posted online. Figure 12 displays the percentage of use of each of these six purposes.

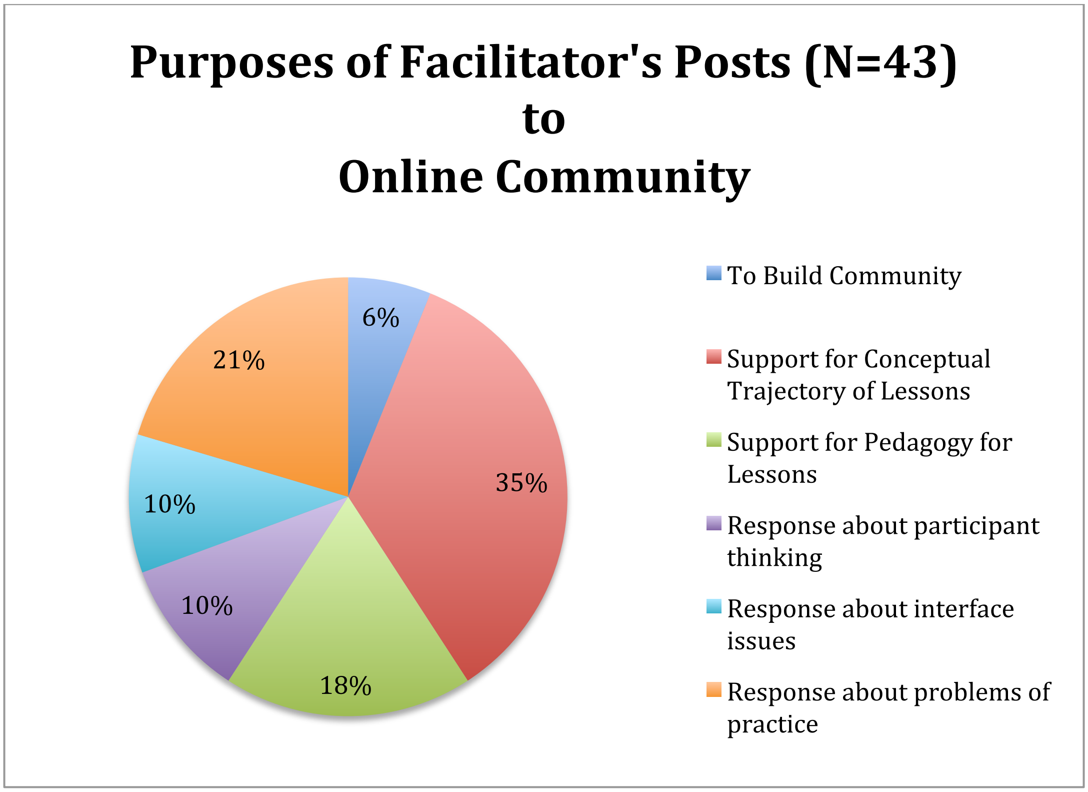

Figure 12 displaying the percentages for each of the 6 purposes for the facilitator's posts.

Most of the facilitator's online energy (53%) was devoted to supporting participants in their use of the lessons to teach prompting them in reflecting about the mathematics content and pedagogy to use. The facilitator devoted only 6% of the posts to build community between the participants, which may be one cause of the low level of interaction between participants regarding substantive topics. A total of 41% of the posts were from the facilitator in direct response to some sort of participant questions. This supported the continuing relationship between each participant and the facilitator, but there was not evidence in the online community that others benefitted from those interactions. It is possible that a participant was impacted by the online discussion between the facilitator and other participants, but that she/he didn't post comments about those discussions. Unfortunately, this study did not utilize a method like post-study interviews to gather such information.

Analysis of Teacher's Thoughts about Features of the OCSP. A second measure of what the participating teachers found valuable about the OCSP is the 5-question post study survey specifically inquiring about OCSP features. The five questions and percentages for teacher responses are displayed in Table 3 below.

Results of 5-Question Survey about Features of OCSP			
Always	Sometimes	Never	
63%	38%	0%	1. I was glad Deb emailed those documents as getting them from the Google site was difficult.
63%	38%	0%	2. After reading the documents, I found each of the 3 word documents Deb uploaded or emailed about each the 3 parts (fractions on the number line, equivalent fractions, adding fractions) useful.
75%	13%	13%	3. I found the Educreations or Explain Everything recordings of Deb talking through the sections of the lesson using a whiteboard, useful.
0%	50%	50%	4. Even if I didn’t post, I found reading the discussion and posts by others useful.
25%	75%	25%	5. I had trouble following the arrangement of the posts on the Google Community site that prevented me from reading the discussions.

Table 3: Questions and Responses to the Treatment Teacher 5-Question Post Study Survey about the features of the OCSP.

Results of that survey indicated that more of the treatment teachers always valued the Educreations or Explain Everything whiteboard recordings of the facilitator (Deb) talking though the lessons. The next most valuable feature was the text documents for each of the three lesson topics. The text documents and the whiteboard recordings could have been shared via email, and did not utilize the power of the Google community. Comments from posts and emails from teachers as they navigated setting up Google + accounts showed they did not appreciate the Google + features. This was supported by the results of the five items on the teacher pre and post survey that showed no significant changes in their thinking about the use of the computer for professional learning (Table 4).

Survey Responses Regarding the Use of the Computer as a Professional Learning Tool		
Treatment Teachers		5: Strongly Agree 4: Agree 3: Neither 2: Disagree 1: Strongly Disagree
Pre Average	Post Average	
4.1	4.0	I find the computer is a useful tool for me to learn new ideas for my life in general.
3.9	4.0	I find the computer is a useful tool for me to learn new ideas for teaching.
2.9	3.5	I can learn facts on the computer, but not deep learning that helps me be a more effective teacher.
3.2	2.6	I find online discussions with colleagues present me with different ideas and help me form a more robust notion of the topic of discussion.
2.8	3.1	I find that online discussions are generally redundant statements of ideas from different people.
3.6	3.6	I find it difficult to discuss ideas deeply in an online forum.
2.7	1.9	I find that I can see more people's thoughts in an online forum than I can hear in a face-to-face discussion.

Table 4 displaying treatment teachers' responses to survey items about professional learning using the computer.

The survey allowed for comments after each set of questions. The two treatment teachers who did not post anything to the OCSP provided comments to understand their reasons for not posting. One person commented that, "I'd like to talk out my ideas vs. just write them down for the whole world to see. Especially if [the] idea is just fresh and not well thought [out] yet. I do not trust online forums in general." Wishing to talk ideas over and have fully formed thoughts prevented this person from participating in the online discussions. Another person commented on her pre study survey, "I am new at this. Oh my, can I admit that I don't do Facebook and am excited to push my learning to use the computer in a forum? I recently got an iPad so did a few webinars on that. Just got great input from colleagues in using the iPad for math instruction. Cool. I may become a BIG fan." Her only posts to the Google+ community were at the beginning when folks were asked to introduce themselves. On her post survey she wrote, "The tech business is still new to me & I like the face to face discussions, but given everyone's busy schedules, the interactive discussions online will be a wave of the future." Perhaps the learning curve for the use of her iPad and Google+ was too steep and required too much time for her to continue participating in the online discussion. However she does remain optimistic about technology's use for the future.

Discussion

The purpose of this study was to determine the impact of the use of an online community to provide job-embedded classroom support for teachers while they taught fractions using the number line. The OCSP was intended to provide classroom support after an intensive face-to-face professional learning program. Research has shown that classroom follow-up is a necessary component in order to have classroom impact. Other studies have had difficulty in showing connection between professional development and classroom impact, and this study was not different.

Research has also shown that classroom impact on student achievement is related to teacher pedagogical content knowledge, however the results of this study did not show a correlation between the teachers' PCK level and average student achievement on Quiz 1 and Quiz 2. The small sample size of the teachers may have had a bearing on this. Also, difficulties in collecting both pre and post measures for teachers and for students may also have had an impact. Another possible explanation is that the amount of work required to participate in the study may have been too time consuming, so that teachers chose to devote more time to planning and teaching, and less time to taking the teacher assessment. This is supported by post survey comments from two treatment teachers from the same school who stated that using the OCSP required more than an hour a day to plan math lessons. Thus a pre post 12-item assessment may not be the best method to capture teacher PCK when it must be administered as teachers are working during the school year. A suggestion for a future study would be to measure teacher PCK by scoring their responses to desired student explanations for some key student tasks. This is work related to lesson preparation that could be part of the professional learning and also be useful for data collection.

Results for this small sample of teachers showed a classroom impact on student understanding for the treatment teachers' students on Quiz 1, but not on Quiz 2. Dissimilarity between the treatment and control groups threatens internal validity of this study. During treatment and control group assignment, so as not to risk cross group contamination from teachers discussing fractions and lessons, a decision was made to form school groups to be assigned as a whole group, to treatment or control. This, coupled with attrition of teachers from the study, resulted in treatment and control groups with unequal grade level representation. A larger pool of teachers from which to draw may have assisted in creating an equal distribution of grade levels for the two groups. These factors impede both internal validity and external reliability to extrapolate results to the general population of teachers and students.

The lack of positive t-test results for Quiz 2 (as were found for Quiz 1) was puzzling. One possible explanation of this is related to the development of ideas in fractions. In an effort to assist upper grade teachers with difficult topics, the decision was made to use addition of fractions as the third topic, skipping the topic of comparing fractions. The understanding developed over time while students compare fractions, is the conceptual foundation upon which addition of fractions is built. It is possible that moving from equivalent fractions to addition of fractions without doing enough comparison was not enough support for students. Additionally, reasoning about equivalent fractions and addition of fractions are more traditionally more difficult for both students and teachers. It is possible that for these topics, teachers tend to fall back to emphasizing procedures, or that the OCSP did not provide enough support for how to use questions to guide students to explain the reasoning underlying the addition of fractions. Another possibility is that the teachers' frustration levels and abilities to devote time to interacting with the OCSP was better during the first two topics, and worse by the time they got to the third topic of adding fractions. Data was not gathered that could shed light on this. If a similar study was undertaken in the future, useful data could be collected about the teachers' thoughts while interacting with each of the three topics which might assist in better understanding differences in results between topics.

Another factor that may have influenced results, for which the researcher did not control, was whether or not instruction provided was first-time instruction about those topics in fractions, or whether it was a re-teaching situation. Attitudes, by both teachers and students, can be different in re-teaching situations because, once students have learned the steps of a procedure, it is more challenging to engage them in the reasons why those steps yielded a correct answer, which is the conceptual basis being measured on the assessments. This may have presented more of a challenge to grade 6, 7 and 8 teachers than for lower grades. Perhaps the data from this study could be further investigated to reveal any impact that grade level, or the factor of first-instruction versus re-teaching may have had on student results.

There was not evidence that the OCSP had any impact upon teacher practice, as there were not significant differences in data reported by the treatment and control teachers regarding their classroom practices. It is possible the previous relationship between the all participants and the facilitator developed during the initial face-to-face professional learning program influenced the teachers' responses. They may have unconsciously said what they *thought* the facilitator wanted to hear, or said they used practices they *wish* they were using. Also, teachers may have held different understandings of the practices on the survey, which would have impacted the reporting of the frequencies with which they used them. All of this would confound the data. In future research, if classroom observations by a researcher were not possible, perhaps the use of daily logs by each teacher to capture frequencies of each practice would be more likely to yield accurate data.

Qualitative analysis of the posts on OCSP revealed a sense of community was supported between the facilitator and each participant, but that relationships between participants did not develop into an online community of support. One of the major impediments to this was the Google Community itself—its lack of design control for windows on the page did not allow the facilitator to organize posts to support lesson flow of the three topics. This was a source of frustration that may have caused participants to cease reading and responding to posts. The online nature of the support program was intended to assist teachers with just-in-time support for lesson planning and collaboration when each person needed it. However analysis showed the features of the OCSP most valued did not include reading and responding to others' thoughts. Instead, the most valued features were the three text documents outlining the lesson ideas for each topic, and the accompanying whiteboard recordings modeling key parts of each lesson. The conversation between the facilitator and the teachers, and amongst them all, could have been done via email, which would have been preferred by this population of teachers. Selecting a platform that satisfied the needs of the project while remaining within the technological capacities of the teachers impacted the development of community. A suggestion for future research is to select platform with more design control, and to determine what platforms teachers are already being used by teachers. For this population of teachers, a website with a closed system for blogging (so that thoughts were not visible to the general public) would have been a more suitable selection. Also perhaps future research could investigate whether or not online synchronous discussion for collaboration (with or without video) could provide an alternative method of interaction. Just as in teaching in the classroom, there is a constant tension between the time to learn the tool, and the resulting potential richness of the learning experience it provides.

A final suggestion for further research that can be drawn from this study is to change the focus of support for the OCSP to profession learning communities or grade-level teams at school sites. The OCSP's prompts could be adjusted to intentionally provide discussion stems for face-to-face team interactions. The research could then focus on studying differences in impact in the use of the OCSP on grade-alike control and treatment teams. Controlling for differences in student populations would still present a challenge. But this would allow teachers to have face-to-face support of colleagues, while using the online platform for support by a facilitator and interaction with other teams.

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Appendix A – Teacher Consent Form

Teacher Consent for Video and Student Work RELEASE FORM

Dear Teacher:

I, Debra K. Stetson, am a participant this school year in a master's program and a research project for California State University Mathematics Project about how to improve instruction and learning about fractions. The primary purposes of this research are to encourage excellence in teaching for understanding and to enhance student engagement and learning.

If you participate you will be asked to complete some mathematics problems on a pre and post assessment in order to measure pedagogical content knowledge fractions. If you have participated in past CSUSMP professional learning activities, I may use past teacher assessments we conducted in order to compare new learning. You may also be captured in video of lessons conducted in classrooms or in professional development activities. Neither student names nor teacher names will be used in analysis or reporting of results. All teacher and student names will be removed and codes will be used instead. Clips of classroom video will be used only to assist others in learning how to teach fractions for understanding. A student's first name may be heard on the video as a teacher calls on her/him for a response, but no last names will be used. The name of the school will not be used. The video clip will be part of a collection of video clips from several classrooms and several schools used as a way for teachers to receive professional development about how to teach fractions for understanding. You may choose not to participate in videos and we will not record your image.
Because this research is about teaching techniques there is no potential risk to teachers nor students.

Participation in this project is voluntary.

For questions, please contact: CSUS Mathematics Project Director, Debra K. Stetson at stetson@csus.edu or (916) 278-5951.
By signing this form, I am stating that I have read and understand that information above. I freely give my consent for (please check those that apply)

- ☐ my image and
- ☐ my work

to be used as outlined above.

Printed Name of Teacher:	Date:
Signature:	

Appendix B – Parent Consent Form

Parental Consent for Classroom Video and Student Work RELEASE FORM

(to be completed either by a parent or legal guardian of minor students)

Dear Parent/Guardian:

I, Debra K. Stetson, am a participant this school year in a master's program and a research project for California State University Mathematics Project about how to improve instruction and learning about fractions. I am working with your child's teacher. The primary purposes of this research are to encourage excellence in teaching for understanding and to enhance student engagement and learning.

If your child participates she/he will be asked to complete some mathematics problems in order to measure understanding about fractions. She/he may also be captured in video of lessons conducted in class about fractions. Students who do not participate in the study will still complete the same activities, but their student work data will not be included, and they will be seated outside of range of the camera. No student names or teacher names will be used in the student work analysis as all documents will be coded. Clips of classroom video will be used only to assist others in learning how to teach fractions for understanding. A student's first name may be heard on the video as a teacher calls on her/him for a response, but no last names will be used. The name of the school will not be used. The video clip will be part of a collection of video clips from several classrooms and several schools used as a way for teachers to receive professional development about how to teach fractions for understanding.
No student will be required to participate in the program outside of class time.
Because this research is about teaching techniques there is no potential risk to teachers nor students.
Participation in this project is voluntary. It will not mean more work for students, only that instruction will delivered in a different manner. *Students who choose not to participate will still complete the activities, but will be left out of the data collection and the camera shots.* If you decide not to have your student participate, there won't be any negative consequences.
If you consent to your child's participation in the research project please sign below. If you do not consent to your child's participation, your child will be out of view of video recordings, and your child's work will not be included in the research.

For questions, please contact: CSUS Mathematics Project Director, Debra K. Stetson at stetson@csus.edu or (916) 278-5951.

By signing this form, I am stating that I have read and understand that information above. I freely give my consent for my child's participation.

Printed Name of Student:	Printed Name of Teacher:
Printed Name of Parent or Guardian:	Date:
Parent or Guardian Signature:	

Appendix C – Student Assent Form

Will You Participate in Research about Teaching and Learning about Fractions?

(to be completed by the students who are involved in this project)

Dear Student:

This school year I am participating in a research project with the CSU Sacramento Mathematics Project to learn how to improve teaching and learning about fractions. This letter is asking if you would be willing to share some work that you do on some fraction problems, and to be in some video of your class learning about fractions.

Even though the video recordings might show you working in class, they will be used to work with teachers for how to teach. I may also ask you to turn-in samples of your work, so I can learn how you think best. I will not use your name on any work that I use for my research.

Your parents have already been asked whether it is OK with them for you to be in this research. But if you decide not to participate, no one will be upset with you, and you will be out of view in making the video. Please write your name and today's date on the line below if you are willing to be in the videos and the research.

Thank you,

Ms. Stetson, CSU Sacramento Mathematics Project

____________________________ __________________

Please Sign Your Name Here Date

Appendix D – Teacher Surveys

Making Sense of Fractions

Pre-Study Survey

Code: ______________

Directions: Make a 4 character code using the first 2 letters of your mother's maiden name, and then one more than the number of the day of the month on which you were born.

36 questions

1. In which of the following CSUSMP professional learning activities about fractions did you participate this last year? [Please circle all that apply.]
   a. Making Sense of Fractions Summer Institute summer 2012
   b. After school workshop series at my school
   c. Making Sense of Fractions Summer Institute Tier I (3 days), summer 2013
   d. Making Sense of Fractions Summer Institute Tier II (2 days), summer 2013

2. I have been teaching for:
   a. 0-2 years
   b. 3-5 years
   c. 6-8 years
   d. 9-12 years
   e. 12-15 years
   f. 16 or more years

3. Please estimate the number of hours of professional development in mathematics in which you have participated since August 1, 2011 (last 2 years). Please include any professional development provided by CSUSMP staff members (Deb, Rick, Scott, Kim) in that estimate.

How often did you utilize each instructional strategy, method or practice?

	Never	1 time every 3rd or 4th month	1 time every other month	1 time per mo.	2-3 times per mo.	1-2 times per week	3-4 times per week	Every day
4. Begin a lesson by presenting the definition of new vocabulary	1	2	3	4	5	6	7	8
5. Begin a lesson by reminding students of previously learned skills necessary for this lesson.	1	2	3	4	5	6	7	8

Appendix D – Teacher Surveys (continued)

	Never	1 time every 3rd or 4th month	1 time every other month	1 time per mo.	2-3 times per mo.	1-2 times per week	3-4 times per week	Every day
6. Ask students to do a sequence of *mental math tasks* in order to review and apply old skills and concepts.	1	2	3	4	5	6	7	8
7. Organize a presentation of steps in a procedure and model by doing examples showing the students how I do the steps, and then have them do examples with me helping them do the steps.	1	2	3	4	5	6	7	8
8. Give students a problem or a question and ask them to predict what will happen before solving or answering.	1	2	3	4	5	6	7	8
9. Ask students to solve a problem that requires more than one day to think about and do.	1	2	3	4	5	6	7	8
10. Ask students to verbally explain an answer or a solution method for a particular problem to a partner or small group.	1	2	3	4	5	6	7	8
11. Ask students to build on another student's idea adding to that student's explanation or thoughts.	1	2	3	4	5	6	7	8
12. After a student responds, ask how many students agree with that response.	1	2	3	4	5	6	7	8
13. Call on students using popsicle sticks or just randomly in order to ensure that they attend to the lesson.	1	2	3	4	5	6	7	8
14. Ask students to solve a problem on whiteboard slates or paper in order to check student progress when they show their work.	1	2	3	4	5	6	7	8
15. On quizzes or tests, ask students to explain using words (and perhaps pictures) why a procedure or a solution works the way it does.	1	2	3	4	5	6	7	8

If you would like to add comments about items 4-15, please do so here…

Appendix D – Teacher Surveys (continued)

How often did you utilize each instructional strategy, method or practice when teaching fractions?

	Never	Once every 2 weeks in each fraction unit	Once a week in each fraction unit	Twice a week in each fraction unit	3 or 4 times a week in each fraction unit	Every day in each fraction unit
16. Begin a lesson by asking students to solve a problem with whole numbers that will help them see how to apply that to fractions.	1	2	3	4	5	6
17. Ask students to do a sequence of mental math tasks involving fractions.	1	2	3	4	5	6
18. Ask students about problems about fractions they have not seen before to allow them to invent methods of solving them.	1	2	3	4	5	6
19. Ask students to explain an answer or a solution method about a fractions problem in writing and/or by drawing a picture.	1	2	3	4	5	6
20. Ask students to analyze similarities and differences among diagrams, representations, solutions, or methods about fractions problems.	1	2	3	4	5	6
21. Ask students to explain *why* a method of solving a problem about fractions works for *all* similar problems.	1	2	3	4	5	6

If you would like to add comments about items 16-21, please do so here…

Appendix D – Teacher Surveys (continued)

Please use the numbers to indicate the level with which you agree or disagree with each statement.

1	2	3	4	5
Strongly Disagree	Disagree	Cannot determine	Agree	Strongly Agree

22. To assess student learning and understanding on quizzes and tests, only problems like those done in class or on homework should be used. 1 2 3 4 5

23. The primary job when teaching mathematics is to assist students in knowing the definitions, in knowing what the instructions mean so they know which steps to do. 1 2 3 4 5

24. The most useful learning tool for a student is for her/him to create her own mnemonic or method of remembering the steps. 1 2 3 4 5

25. The most useful learning tool for students is to understand the underlying concepts in order to be able to adjust and apply skills and concepts to unforeseen situations in the future. 1 2 3 4 5

26. I find it difficult to find the time to teach the students conceptually, and so I fall back to making sure they know how to do the right steps in order to get the right solutions. 1 2 3 4 5

27. During instruction, instead of me teaching the students how to solve the problem, if there is one student who understands how to do the problem, it is useful for the other students' learning if that student tells the class how to do the problem. 1 2 3 4 5

28. Being told how to do a problem is more likely to be forgotten than figuring out how to solve the problem on one's own. 1 2 3 4 5

29. A few children can figure out how to solve problems on their own without me telling them the steps, but the majority would find that frustrating and shut down and not learn if I did not help them with the steps. 1 2 3 4 5

If you would like to add comments about items 22-29, please do so here…

Appendix D – Teacher Surveys (continued)

The following questions are about using the computer for *YOUR OWN LEARNING*— not students. Please use the same numbers to indicate the level with which you agree or disagree with each statement.

1	2	3	4	5
Strongly Disagree	Disagree	Cannot determine	Agree	Strongly Agree

30. I find the computer is a useful tool for me to learn new ideas for my life in general.
1 2 3 4 5

31. I find the computer is a useful tool for me to learn new ideas for teaching.
1 2 3 4 5

32. I can learn facts on the computer, but not deep learning that helps me be a more effective teacher.
1 2 3 4 5

33. I find online discussions with colleagues present me with different ideas and help me form a more robust notion of the topic of discussion.
1 2 3 4 5

34. I find that online discussions are generally redundant statements of ideas from different people.
1 2 3 4 5

35. I find it difficult to discuss ideas deeply in an online forum.
1 2 3 4 5

36. I find that I can see more people's thoughts in an online forum than I can hear in a face-to-face discussion.
1 2 3 4 5

If you would like to add comments about items 30-36, please do so here…

→I sincerely thank you for your time in taking this survey as I work to learn more about teacher and student learning.

Appendix D – Teacher Surveys (continued)

Making Sense of Fractions

Post-Study Survey

Code: _____________

Directions: Make a 4 character code using the first 2 letters of your mother's maiden name, and then one more than the number of the day of the month on which you were born.

36 questions

1. Please describe something you learned from using the Online Classroom Support program (Google Community, Making Sense of Fractions—Online Support) that you will apply to ***teaching fractions*** in the future.

2. Please describe what something you learned from using the Online Classroom Support program (Google Community, Making Sense of Fractions—Online Support) that you will apply to ***teaching mathematics each day***.

3. Please describe the most significant change in your teaching that has resulted from using the Online Classroom Support program (Google Community, Making Sense of Fractions—Online Support)

How often did you utilize each instructional strategy, method or practice?

	Never	1 time every 3rd or 4th month	1 time every other month	1 time per mo.	2-3 times per mo.	1-2 times per week	3-4 times per week	Every day
4. Begin a lesson by presenting the definition of new vocabulary	1	2	3	4	5	6	7	8
5. Begin a lesson by reminding students of previously learned skills necessary for this lesson.	1	2	3	4	5	6	7	8

Appendix D – Teacher Surveys (continued)

	Never	1 time every 3rd or 4th month	1 time every other month	1 time per mo.	2-3 times per mo.	1-2 times per week	3-4 times per week	Every day
6. Ask students to do a sequence of *mental math tasks* in order to review and apply old skills and concepts.	1	2	3	4	5	6	7	8
7. Organize a presentation of steps in a procedure and model by doing examples showing the students how I do the steps, and then have them do examples with me helping them do the steps.	1	2	3	4	5	6	7	8
8. Give students a problem or a question and ask them to predict what will happen before solving or answering.	1	2	3	4	5	6	7	8
9. Ask students to solve a problem that requires more than one day to think about and do.	1	2	3	4	5	6	7	8
10. Ask students to verbally explain an answer or a solution method for a particular problem to a partner or small group.	1	2	3	4	5	6	7	8
11. Ask students to build on another student's idea adding to that student's explanation or thoughts.	1	2	3	4	5	6	7	8
12. After a student responds, ask how many students agree with that response.	1	2	3	4	5	6	7	8
13. Call on students using popsicle sticks or just randomly in order to ensure that they attend to the lesson.	1	2	3	4	5	6	7	8
14. Ask students to solve a problem on whiteboard slates or paper in order to check student progress when they show their work.	1	2	3	4	5	6	7	8
15. On quizzes or tests, ask students to explain using words (and perhaps pictures) why a procedure or a solution works the way it does.	1	2	3	4	5	6	7	8

If you would like to add comments about items 4-15, please do so here…

Appendix D – Teacher Surveys (continued)

How often did you utilize each instructional strategy, method or practice when teaching fractions?

	Never	Once every 2 weeks in each fraction unit	Once a week in each fraction unit	Twice a week in each fraction unit	3 or 4 times a week in each fraction unit	Every day in each fraction unit
16. Begin a lesson by asking students to solve a problem with whole numbers that will help them see how to apply that to fractions.	1	2	3	4	5	6
17. Ask students to do a sequence of mental math tasks involving fractions.	1	2	3	4	5	6
18. Ask students about problems about fractions they have not seen before to allow them to invent methods of solving them.	1	2	3	4	5	6
19. Ask students to explain an answer or a solution method about a fractions problem in writing and/or by drawing a picture.	1	2	3	4	5	6
20. Ask students to analyze similarities and differences among diagrams, representations, solutions, or methods about fractions problems.	1	2	3	4	5	6
21. Ask students to explain *why* a method of solving a problem about fractions works for *all* similar problems.	1	2	3	4	5	6

If you would like to add comments about items 16-21, please do so here…

Appendix D – Teacher Survey (continued)

Please use the numbers to indicate the level with which you agree or disagree with each statement.

1	2	3	4	5
Strongly Disagree	Disagree	Cannot determine	Agree	Strongly Agree

22. To assess student learning and understanding on quizzes and tests, only problems like those done in class or on homework should be used. 1 2 3 4 5

23. The primary job when teaching mathematics is to assist students in knowing the definitions, in knowing what the instructions mean so they know which steps to do. 1 2 3 4 5

24. The most useful learning tool for a student is for her/him to create her own mnemonic or method of remembering the steps. 1 2 3 4 5

25. The most useful learning tool for students is to understand the underlying concepts in order to be able to adjust and apply skills and concepts to unforeseen situations in the future. 1 2 3 4 5

26. I find it difficult to find the time to teach the students conceptually, and so I fall back to making sure they know how to do the right steps in order to get the right solutions. 1 2 3 4 5

27. During instruction, instead of me teaching the students how to solve the problem, if there is one student who understands how to do the problem, it is useful for the other students' learning if that student tells the class how to do the problem. 1 2 3 4 5

28. Being told how to do a problem is more likely to be forgotten than figuring out how to solve the problem on one's own. 1 2 3 4 5

29. A few children can figure out how to solve problems on their own without me telling them the steps, but the majority would find that frustrating and shut down and not learn if I did not help them with the steps. 1 2 3 4 5

If you would like to add comments about items 22-29, please do so here…

Appendix D – Teacher Surveys (continued)

The following questions are about using the computer for *YOUR OWN LEARNING*— not students. Please use the same numbers to indicate the level with which you agree or disagree with each statement.

1	2	3	4	5
Strongly Disagree	Disagree	Cannot determine	Agree	Strongly Agree

30. I find the computer is a useful tool for me to learn new ideas for my life in general. 1 2 3 4 5

31. I find the computer is a useful tool for me to learn new ideas for teaching. 1 2 3 4 5

32. I can learn facts on the computer, but not deep learning that helps me be a more effective teacher. 1 2 3 4 5

33. I find online discussions with colleagues present me with different ideas and help me form a more robust notion of the topic of discussion. 1 2 3 4 5

34. I find that online discussions are generally redundant statements of ideas from different people. 1 2 3 4 5

35. I find it difficult to discuss ideas deeply in an online forum. 1 2 3 4 5

36. I find that I can see more people's thoughts in an online forum than I can hear in a face-to-face discussion. 1 2 3 4 5

If you would like to add comments about items 30-36, please do so here…

→I sincerely thank you for your time in taking this survey as I work to learn more about teacher and student learning.

Appendix E – Teacher Assessment

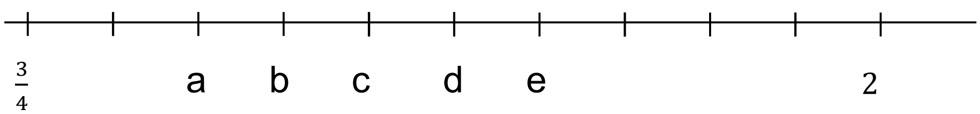
Making Sense of Fractions - Study

Code: ______________ (SAME CODE All the Time)

Directions: Make a 4 character code using the first 2 letters of your mother's maiden name, and then one more than the number of the day of the month on which you were born.

Example: Mother's maiden name = Smith and born on August 3, then my code would be SM and (3+1) to make 04. Code: SM04

1. Locate $\frac{5}{4}$ on the number line:



2. Which of the following is the best explanation, using $\frac{1}{4}$ on the number line, for why $\frac{1}{4} = \frac{3}{12}$?

a. Start with the point $\frac{1}{4}$ on the number line and divide the interval from 0 to $\frac{1}{4}$ into three equal pieces. Then we have 3 pieces, but each of them is $\frac{1}{12}$ long because 12 of them would just make 1.

b. We have $\frac{1}{4}$ and $\frac{1}{12}$ on the number line. They are $\frac{1}{3}$ apart from each other.

c. If we divide the line segment from 0 to 12 into 3 equal pieces, each is $\frac{1}{4}$ of the length of the original line segment.

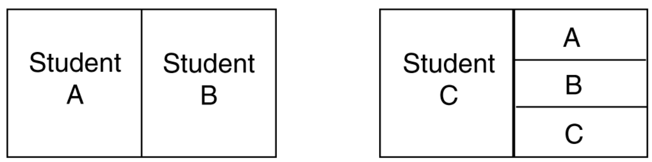
d. 3 and 12 both have a common divisor of 3. Dividing both by 3 has no effect on the location of the fraction on the number line, and so $\frac{3}{12}$ is in the same position as $\frac{1}{4}$.

Appendix E – Teacher Assessment (continued)

3. Mrs. Ng’s class was discussing the following problem:

Divide two identical rectangular cakes equally among three students. How much cake does each student get?

One group of students arrived at the following solution:



The students argued that each person should get $\frac{1}{2}+\frac{1}{3}$ of a cake, even though the answer should have been $\frac{1}{2}+\frac{1}{6}$. What is the most likely reason for their mistake? (Mark ONE answer.)

a) Students prefer to work with fractions they know, such as 1/2 and 1/3. This group probably had not yet been introduced to 1/6.

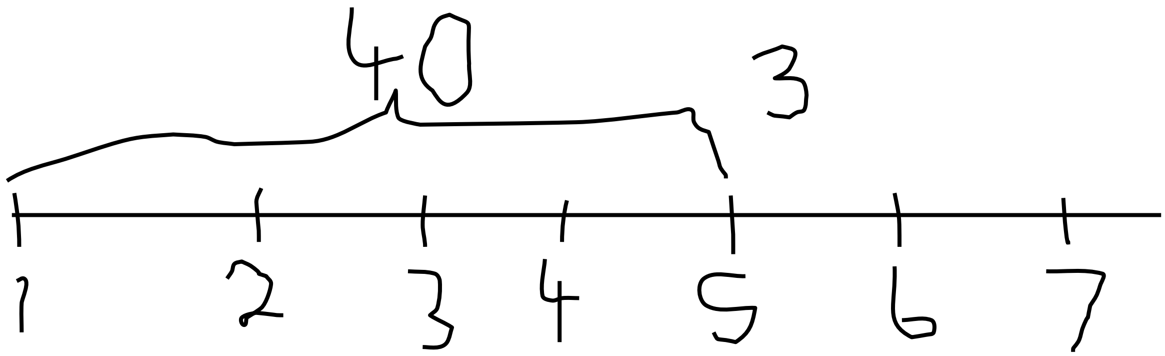
b) When talking about the second cake, students were confused about what the whole was.

c) Students forgot to divide up part of the second cake.

d) This is not the correct method for sharing cakes; instead, students should have divided each cake into thirds.

Appendix E – Teacher Assessment (continued)

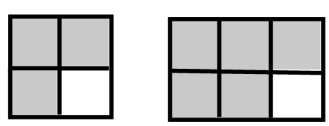
4. Marcus was given a mixed number and asked to write it as an "improper fraction" and to solve this he drew the following on a number line and got the correct answer:



What was the denominator in the mixed number?

a. 3 b. 5 c. 8 d. 40

5. Tatiana's teacher asks her to make drawings to compare $\frac{3}{4}$ and $\frac{5}{6}$. She draws the following:



and claims that $\frac{3}{4}$ is less than $\frac{5}{6}$ because there are more shaded squares in $\frac{5}{6}$ than in $\frac{3}{4}$. Which of the following is correct? (Mark ONE answer.)

a. Her criterion is correct and provides a visual method of comparing any two fractions.

b. Her criterion is correct for comparing fractions in which the numerator is one less than the denominator.

c. Her criterion is correct for comparing any fractions in which the numerator is less than the denominator.

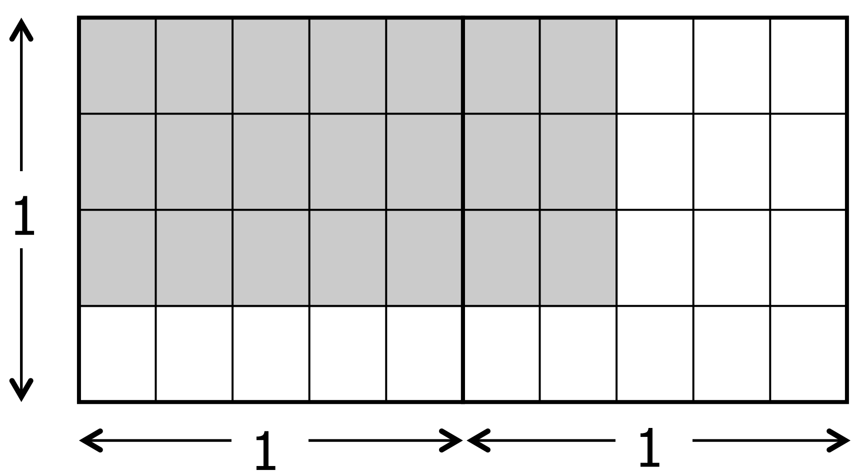
d. Her criterion is incorrect and always leads to the wrong conclusion.

Appendix E – Teacher Assessment (continued)

6. Arrange the following fraction addition problems in the order in which you would introduce them to a student (first to last), to have a reasoned progression through the topic.

(A) $\frac{2}{3}+\frac{1}{5}$ (B) $\frac{3}{5}+\frac{1}{5}$ (C) $\frac{1}{6}+\frac{3}{4}$ (D) $\frac{2}{3}+\frac{1}{6}$

7. The area of the shaded region below is:



(A) $\frac{21}{20}$ (B) $\frac{21}{28}$ (C) $\frac{21}{30}$ (D) $\frac{21}{40}$

Appendix E – Teacher Assessment (continued)

8. Ms. Peterson's class was working on understanding the meaning of division using fractions. She asked her students to interpret $\frac{1}{6} \div \frac{2}{3}$.

For each of the questions below, decide whether it can be a mathematically valid interpretation of $\frac{1}{6} \div \frac{2}{3}$. (For each item below, circle VALID INTERPRETATION, NOT A VALID INTERPRETATION, or I'M NOT SURE.)

	Valid interpretation	NOT a valid interpretation	I'm not sure
a) How many $\frac{2}{3}s$ are in $\frac{1}{6}$?	1	2	3
b) How much is $\frac{1}{6}$ of $\frac{2}{3}$?	1	2	3
c) $\frac{1}{6}$ is two-thirds of what number?	1	2	3
d) How much is $\frac{2}{3}$ sixths?	1	2	3
e) How many $\frac{2}{3}s$ can you subtract from $\frac{1}{6}$?	1	2	3

Appendix E – Teacher Assessment (continued)

9. Finding the value of the blank space in the equation:

$$6 \div \frac{3}{2} = \square$$

is equivalent to finding the value of the blank space in which if the following?

a. $6 \times \square = \frac{2}{3}$ b. $\frac{1}{6} \times \square = \frac{3}{2}$ c. $\frac{3}{2} \times \square = 6$ d. $\frac{2}{3} \times \square = 6$

10. Ms. Lawrence is making up word problems for her students. She wants to write a word problem for $3 \div \frac{1}{2}$. Which word problem(s) can she include? (Mark YES, NO, or I'M NOT SURE for each problem.)

	Yes	No	I'm not sure
a) Melissa has 3 pizzas and she wants to give half of them to her friend. How much pizza will her friend get?	1	2	3
b) Dan has 3 cups of chocolate chips. He wants to bake cookies, and each batch requires 1/2 cup of chocolate chips. How many batches of cookies can Dan make if he uses all of the chocolate chips?	1	2	3
c) Three friends each have half of a cookie. How many cookies would they have if they put them all together?	1	2	3
d) Jacquie has 3 dollars. If she has half the amount needed to purchase a discount phone card, how much does a phone card cost?	1	2	3

Appendix E – Teacher Assessment (continued)

11. Which is the greatest of the following fractions? Determine your answer without using common denominators, decimals, or cross multiplication.

a. $\frac{7}{15}$

b. $\frac{9}{17}$

c. $\frac{10}{19}$

d. $\frac{11}{23}$

e. I'm not sure how to do this without using common denominators, decimals, or cross multiplication

12. One of Ms. Hines' students was comparing $\frac{2}{5}$ and $\frac{3}{7}$ and made the following argument:

> $\frac{2}{5}$ is one-half of a fifth less than $\frac{1}{2}$ and $\frac{3}{7}$ is one-half of a seventh less than $\frac{1}{2}$, and half a fifth is bigger than half a seventh, so I conclude that $\frac{2}{5}$ is bigger than $\frac{3}{7}$.

What is the best assessment of the student's argument? (Circle ONE answer.)

a) The student has a clever idea, but it does not work for these particular fractions.

b) The student has a clever idea, but drew the wrong conclusion.

c) The student does not understand how to compare fractions, because to compare fractions you need to find a common denominator.

d) The student does not understand $\frac{1}{2}$ because the student tries to think about one-half of one-seventh and one-half of one-fifth, which do not make sense.

Appendix F: 5-Question Post Study Survey about Use of OCSP

Hey All,
I realized I need some input from you to improve for next time I try an online deal. I am hopeful you might take a couple minutes to answer either "Always", "sometimes", or "never" after each of the 5 statements below about what you used from the Google online community about Fraction Sense Making.

Always, sometimes or never true. You fill in "always" or "sometimes" or "never" for each statement.

1. I was glad Deb emailed those documents as getting them from the Google site was difficult. (Always, sometimes or never) _________

2. After reading the documents, I found each of the 3 word documents Deb uploaded or emailed about each the 3 parts (fractions on the number line, equivalent fractions, adding fractions) useful. (Always, sometimes or never)_______

3. I found the Educreations recordings of Deb talking through the sections of the lesson using a whiteboard, useful. (Always, sometimes or never) _____

4. Even if I didn't post, I found reading the discussion and posts by others useful. (Always, sometimes or never)________

5. I had trouble following the arrangement of the posts on the Google Community site that prevented me from reading the discussions. (Always, sometimes or never)______

Thank you. If you have any other thoughts, I am happy to have them.

Deb

Appendix G– Student Assessment

Student Code:

___ ___ ___ ___ ___ ___

Directions to make a code: You will make a 6 character code. First, think of your initials of your first and last name. Use the letter after each of those. Then think of your birthday as 4 numbers (m m d d). Then add 1 to that number.

Example: My Name is Deb Stetson so my initials are DS, so I use the letter after D, and the letter after S which would be E T. Then I was born on August 31 which is 0831, and adding 1 to that makes 0832. So my code would be E T 0 8 3 2

Please do you best to show what you know and understand about the following.

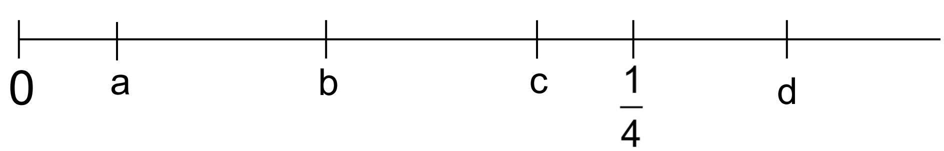
1. Express as a fraction: $5\frac{2}{3}$

a. $\frac{7}{3}$ b. $\frac{10}{3}$ c. $\frac{13}{3}$ d. $\frac{17}{3}$

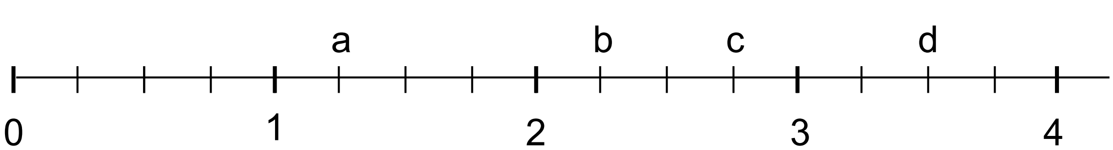
2. Express as a mixed number: $\frac{25}{7}$

a. $2\frac{5}{7}$ b. $3\frac{4}{7}$ c. $3\frac{6}{7}$ d. $5\frac{2}{7}$

3. Where on the number line below should $\frac{1}{5}$ be located? Circle the correct letter.



4. Where is $\frac{11}{4}$ on this number line? Circle the correct letter.



Appendix G– Student Assessment (continued)

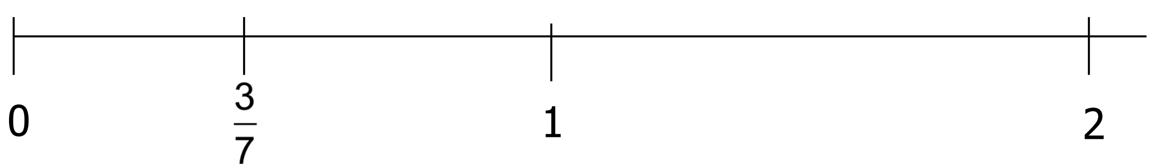
5. Express as a fraction: $3 + \frac{10}{5} + \frac{1}{6}$

a. $\frac{29}{6}$ b. $\frac{26}{5}$ c. $\frac{31}{6}$ d. $\frac{29}{5}$

6. On the number line, how far is $\frac{23}{5}$ from the nearest whole number (such as 1 or 2 or 3 or 4 or …)?

a. 0 b. $\frac{1}{5}$ c. $\frac{2}{5}$ d. $\frac{3}{5}$ e. $\frac{4}{5}$

7. The number $\frac{3}{7}$ is shown on the number line below. Mark where $\frac{1}{7}$ should be on the number line, and **explain how you decided**.



Appendix G– Student Assessment (continued)

Student Code:

__ __ __ __ __ __

Directions to make a code: You will make a 6 character code. First, think of your initials of your first and last name. Use the letter after each of those. Then think of your birthday as 4 numbers (m m d d). Then add 1 to that number.

Example: My Name is Deb Stetson so my initials are DS, so I use the letter after D, and the letter after S which would be E T. Then I was born on August 31 which is 0831, and adding 1 to

Please do you best to show what you know and understand about the following.

1. If you want to break both of the fractions $\frac{1}{3}$ and $\frac{1}{4}$ into pieces that are the same size, what size pieces would you use?

   a. $\frac{1}{5}$ b. $\frac{1}{6}$ c. $\frac{1}{7}$ d. $\frac{1}{12}$

2. Analya needs to decide which fraction is larger, $\frac{2}{3}$ or $\frac{3}{5}$. Which of the following is most likely to be helpful to her?

   a. Write both fractions in 3rds ($\frac{?}{3}$)

   b. Write both fractions in 5ths ($\frac{?}{5}$)

   c. Write both fractions in 6ths ($\frac{?}{6}$)

   d. Write both fractions in 15ths ($\frac{?}{15}$)

3. Find the sum: $\frac{3}{5}+\frac{1}{4}$

   a. $\frac{17}{20}$ b. $\frac{4}{20}$ c. $\frac{4}{9}$ d. $\frac{17}{9}$

Appendix G– Student Assessment (continued)

5. To add two fractions, Alex did the following addition:

$$\frac{4}{12} + \frac{1}{12} = \frac{5}{12}$$

Which fraction addition problem was Alex doing?

a. $\frac{1}{3} + \frac{1}{12}$ b. $\frac{2}{3} + \frac{1}{6}$ c. $\frac{1}{4} + \frac{1}{12}$ d. $\frac{4}{6} + \frac{1}{3}$

6. To add the fractions $\frac{1}{2} + \frac{3}{8}$, which is the most helpful fraction equivalence?

a. $\frac{1}{2} = \frac{3}{6}$

b. $\frac{1}{2} = \frac{4}{8}$

c. $\frac{3}{8} = \frac{9}{24}$

d. $\frac{3}{8} = \frac{12}{32}$

7. How much larger is $\frac{1}{7}$ than $\frac{1}{10}$?

a. $\frac{1}{3}$ b. $\frac{1}{17}$ c. $\frac{1}{70}$ d. $\frac{3}{70}$

Appendix G – Student Assessment (continued)

8. Circle the largest of these four:

a. $\frac{1}{3}+\frac{1}{5}$ b. $\frac{1}{5}+\frac{1}{7}$ c. $\frac{1}{3}-\frac{1}{5}$ d. $\frac{1}{5}-\frac{1}{7}$

Explain how you know.

9. To add the fractions $\frac{1}{x}+\frac{3}{8}$, which is the most helpful fraction equivalence?

a. $\frac{1}{x}=\frac{3}{3x}$

b. $\frac{1}{x}=\frac{4}{4x}$

c. $\frac{1}{x}=\frac{8}{8x}$

d. $\frac{3}{8}=\frac{6}{16}$

Appendix J – 4 point rubric for scoring open response items on student assessment

Rubric for Balance: Grounding a Correct Procedural Method with a Conceptual Explanation

1	2	3	4
No correct thinking or present that will assist with the task	**Imbalance**: Only rule or procedure driven to produce right answer (no conceptual) OR Nails the conceptual but cannot compute or perform any procedure with accuracy	**Attends to both** procedural and conceptual explanations, but something is incomplete or has a minor error	**Complete and Balanced Approach:** Attends to both procedural and conceptual fully.
Nothing Correct Or No Work Done	Correct answer with procedural method shown (for example, a written explanation that states the steps used) or cites a rule BUT no conceptual explanation given Or Incomplete work shown or incorrect answer AND some conceptual explanation given	Correct answer with procedural method shown (for example, a written explanation that states the steps used) AND some conceptual explanation given Or Incorrect answer due to a minor computational error with complete conceptual explanation	Correct answer and procedural method with a complete and logical conceptual explanation, written in a clear and well-organized way.