Closing Learning Gaps with Differentiated Math Lessons

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Abstract: In a multiethnic mathematics classroom, there are many different students with unique learning backgrounds and academic needs. Often in a public school, it is difficult to address individual needs with personalized attention and instruction in a classroom setting. At San Francisco International High School, a public school that serves immigrant students, teachers are often faced with the challenge of assessing all their students' learning levels, teaching required content, and motivating each student. This daunting and seemingly impossible task might be possible with the aid of technology. This action research project studied the effects of using an online learning platform to differentiate mathematics instruction. Lessons were intended to strengthen mathematics skills of those with learning gaps and further the knowledge of those who needed to be challenged with new content. With different levels of lessons, students focused only on lessons that they needed and were able to test out of lessons in which they were already competent. The action research method was used to make observations and necessary modifications to improve the subsequent week's lessons. Quantitative data from the teacher observation tools and module quizzes and qualitative data from the teacher journal and student reflections were collected to assess the effectiveness of these lesson based on the areas of learning mathematics, engagement, and confidence level. The research results found that differentiated learning had positive results for students' mathematics learning, engagement, and confidence level. For future lessons, differentiation can be enhanced through incorporation of other structures and teaching strategies.

Introduction

Many immigrants come to America for a better education. Some immigrate for an educational opportunity that would not have been possible in their home countries due to their low socioeconomic status. Others who are more affluent have come for a more desirable education philosophy that does not only focus on rote memorization. San Francisco International High School (SFIHS) serves this diverse immigrant population. Having had different educational upbringings, some students come with very little formal education while others have been exposed to the equivalent of U.S. college level mathematics content in the seventh grade. Creating project-based lessons in a collaborative environment, teachers at SFIHS seek to simultaneously educate students in

different content areas and English. Through this collaborative learning environment where students travel in cohorts, students are able to develop strong friendships and a supportive learning culture. Students who had lower mathematics content knowledge are often able to succeed in their classes with the support of their peers, despite having severe learning gaps. Students who supported their peers through projects and collaboration, were able to strengthen their language skills, develop cooperative skills, and deepen their knowledge on mathematics concepts. However, the breadth of knowledge in which they could have learned was limited in this cooperative learning structure. The purpose of this action research project was to evaluate the effectiveness of online differentiated mathematics skills lessons for 12th grade Pre-Calculus students at SFIHS. This project focused on helping students fill in learning gaps from previously missed content, deepen their current understanding of mathematics content, and further their mathematics knowledge beyond the Pre-Calculus curriculum. Weekly lessons were designed in three different levels to target students' different skill levels and the online platform was used to allow students to work individually at their own pace.

Literature Review

This literature review covers different topics related to planning online mathematics lessons for high school students. The two main sections of this review explores ways to strengthen students' mathematics skills and theories for online course design.

Strengthening mathematics skills.

Missing content in students' mathematics knowledge. Learning gaps in math are often the cause of why high school students are not ready for college. Race and poverty readiness gaps could possibly be closed by having students take higher level math courses (Long, Iatarola, & Conger, 2008). The high school courses that students take significantly contributes to their college readiness and the results from taking Advanced Algebra had the greatest positive impact on students (Long et al., 2008). Besides Advanced Algebra, a consistent relationship between students' fractional knowledge and their general mathematical knowledge was observed regardless of whether students were from US, China, or Belgium (Torbeyns, Schneider, Xin, & Siegler, 2015). Further research still needs to be done to observe whether understanding fractions can transfer to mathematical achievement (Torbeyns et al., 2015) but the fractional knowledge and Advanced Algebra content seem to be crucial for students' success in mathematics and college.

Importance of conceptual and procedural understanding. For students to be proficient in math, they need to have a good grasp of both conceptual understanding and procedural skills (Yu & Singh, 2016). Another epistemological framework furthers this idea and suggests that mathematical understanding equates to the ability to problem solve (Cottrill, 2003). It is a cyclic process where building a solid conceptual understanding helps students learn procedural skills and practicing procedural skills strengthens conceptual understanding (Yu & Singh, 2016).

Theories and strategy for mathematics learning using technology.

***Connectivism and constructivism*.** The connectivist theory focuses on accessing students' prior knowledge while having students make sense of what they learn through different interactions. When amalgamating mathematics content creation with the use of technology, technology can provide different forms of interactions and aid in customizing learning for students (Bari & Stafford, 2016). The use of technology also allows teachers to more effectively differentiate instruction (Bari & Stafford, 2016). With the use of technology to differentiate instruction, there is a greater capability to meet students' individual needs compared to traditional classrooms (Davies, Dean, & Ball, 2013). Adding to connectivism, constructivism helps students learn mathematics by constructing new personalized knowledge through connections with their prior knowledge (Mercer, Jordan, & Miller, 1994). This works when students are proactive in their learning process and have ample opportunities to learn, practice, and reflect (Mercer et al., 1994).

***Online differentiated instruction*.** Differentiated instruction is a teaching strategy where teachers recognize their students' differences and teach in a way that personalizes instruction. Features of differentiation include starting students at the right level, allowing students to work at their own pace, and providing instruction that stimulates students (Morgan, 2014; Tomlinson, 2014). The proper amount of stimulation to the brain needs to happen for students to learn successfully and physiological brain research has shown that when instruction is too difficult or too simple, the brain will release too much or too little noradrenalin which will cause students to become withdrawn or cause their brains to have a lack of stimulation (McAllister and Plourde 2008; Morgan, 2014). Teachers must remember that students are different in many way and there will not be a specific learning approach that will work for every student all the time (Ares, 2010; Tomlinson, 2014). As the United States is becoming more diverse, differentiation through the use of technology is becoming more crucial to personalize learning for students and work at bridging the achievement gap (Morgan, 2014; Rosen & Beck-Hill, 2012). Brain research supports the notion that technology enhances learning and that brain activity increases when navigating a web page as opposed to reading from print (Herther, 2009; Morgan, 2014). Since many students are more interested in using technology than traditional approaches, using technology for teaching can help teachers to motivate students and differentiate learning (Morgan, 2014). The online differentiated learning approach is becoming an important trend to help the education field improve (Morgan, 2014).

***Challenges in online learning environments*.** Often with online math courses, issues with a lack of motivation, low self-efficacy, and frustration lead to low completion rates (Cho & Heron, 2015). A strategy to counteract low completion rates is to teach students to become better self-regulated learners through completing reflections on their learning process (Cho & Heron, 2015). Reflections are especially important in multicultural classrooms because it helps integrate language and mathematical learning (van Eerde & Hajer, 2014). Providing a flowchart is a tool to help students take more ownership of their learning by helping students better visualize their progress (Foshee, Elliott, & Atkinson, 2016). Besides low completion rates, another obstacle that must be

avoided when designing and delivering multimedia is cognitive overload because learners are only able to process a certain amount of information at a given time (Bari & Stafford, 2016). Micro learning, is a method that can prevent cognitive overload because it closely aligns with the way learners naturally acquire information through bursts of learning (Jomah, Masoud, Kishore, & Aurelia, 2016).

Action research to improve teaching. In designing instruction, there needs to be a certain amount of flexibility for students to test out of and modify lessons to fit their needs (Cara-Chellman, 2015). Action research is a spiral iterative research method that teachers can use to implement changes in their classroom to improve their practice (Hien, 2009). This is a highly reflective research process that leads to implementing modifications. It is a fitting method to study online differentiation because like differentiation, it seeks to make changes to better meet students' needs. Not only does action research benefit students, action research can transform teachers' attitudes and their approach to mathematics instruction (Bonner, 2006). An important tool that can be used in action research is a teacher research journal (Rust & Clark, n.d.). The teacher journal can be used to record observations, keep track of the research, and write down thoughts. This tool supports the action research process as it provides a forum for the teacher researcher to reflect on the lesson as well as the research.

Project Design and Development

Purpose statement. The purpose of this action research project was to evaluate the effectiveness of online differentiated math skills lessons for 12th grade Pre-Calculus students at SFIHS. When developing this project, it was important to have enough lessons so that learning can be personalized to match students' skill levels. Choosing the right content for each lesson and structuring a logical lesson progression of the topics was essential to ensure that learners can have the right starting point in their learning and be able to create their own learning paths.

Development of the lessons. The online mathematics lessons were built based on different concepts from the literature review. Since the online lessons were developed to fit English learners' mathematics needs, each math lesson contained a balance of conceptual teaching with procedural practice and concluded with student self-reflections (Figure A1 in Appendix). Written reflections (Figure A2 in Appendix) and vocabulary reviews (Figure A3 in Appendix) were integrated with the mathematical content to help students simultaneously learn mathematics and English. Each lesson included the following components: a pre-quiz, an introduction with the objectives and basic vocabulary, some content material, different examples, at least ten practice problems, additional activities, a post-quiz, and a self-reflection. In terms of the lesson topics, concepts around numeracy, fractions, and Advanced Algebra content were emphasized since studies have shown that these areas have high effects on students' general math knowledge and college readiness (Torbeyns et al., 2015; Long et al., 2008). To avoid cognitive overload, content in each lesson was designed to be minimal but specific and descriptive. (See Appendix A to see screenshots of sample lesson components.) Another design to prevent cognitive overload, was to present a limited number of lessons each

week. During each week, only three to four lessons were published for students to access and these lessons were leveled to be of increasing difficulty. An interactive flowchart was created for students to view the lesson progressions they could choose (Figure A8 in Appendix). Lessons were structured to be built on the knowledge developed from the previous week and were progressively more difficult each week.

Development of the online module. When choosing a Learning Management System to create these lessons and quizzes, it was important to have a quiz creation feature with formulas. Canvas has a multifaceted quiz creation tool that allows typing mathematics formulas and creating different types of test questions such as fill-in the blank and multiple-choice questions. Canvas also has a test bank feature that allows multiple questions to be stored in the test bank. Each quiz will randomly select different questions from the test bank. This allowed students to take the quiz multiple times without having the exact same questions. Having Canvas randomly generate different questions for the quiz from the quiz bank prevented students from passing quizzes by memorizing the answers from the previous time they took the quiz. To build an online differentiated math skills course, there needed to be different levels of lessons to meet students' needs. There were three different levels of lessons and one lesson from each level was presented in each of the four weeks for a total of twelve lesson. Also, the lessons needed to progress by level and by the week. An interactive flowchart was presented on the homepage to help students better manage and self-regulate their learning. They used this chart to visualize which lessons they have completed and which lessons they could take next. There were originally 12 lessons created but an additional three lessons were added to the course so that Week 2, Week 3, and Week 4 each had a total of four lessons instead of three. This was a modification made during the action research process and the course now has a total of 15 lessons.

Development of the research tools. For the research portion of this project, quantitative and qualitative data from students were collected from the quiz scores on Canvas. Additional data from the teacher was collected from an observation tool (Figure B1 in Appendix) and research journal (Figure B2 in Appendix). These tools as well as the student reflections focused on observing student learning, engagement, and math confidence (Figure B3 in Appendix).

Methodology

Research questions.

1. What changes has the use of online differentiated lessons had on the 12th grade Pre-Calculus students' engagement at SFIHS?
2. How has the implementation of online differentiated lessons influenced the 12th grade Pre-Calculus students' math confidence level at SFIHS?
3. What changes has the use of online differentiated lessons had on 12th grade Pre-Calculus students in learning mathematics at SFIHS?

Participants. The learners of this action research project were 12th grade Pre-Calculus students at SFIHS. All of the students at this school are immigrants and English

Language Learners. The teacher taught four different sections of Pre-Calculus classes with a total of 66 students. The teacher explained this research project to the student and allowed them to choose whether they would like to participate or not. (See Appendix C for recruitment statement.) Only the 24 students who returned both the assent and consent forms participated in the study (See Appendix D for assent and consent forms.) Since this was an action research project, the study participants did not do anything different from those who did not participate in the study. The only difference is that the study participants' data were analyzed while the data of those who did not participate in the study were not.

Instruments. The action research method was used to conduct this project. This action research process evaluated the effectiveness of the online differentiated mathematics lessons. During the class time, an observation tool was used by the teacher to observe and tally the students' engagement and confidence to provide quantitative data. A research journal was used for the teacher to reflect on how the lessons went, how students did, and what changes could be made for the following week's lessons. This was used for the teacher to process what happened in class as well as record qualitative data that was later reviewed and analyzed. Quiz scores from Canvas were analyzed and provided quantitative data on student learning. At the end of each lesson, students completed a self-reflection on Google Forms. This allowed students to process their learning, their engagement, and their confidence. This provided both quantitative data from the scaled responses and qualitative data from the comments sections.

Procedures. This action research project was conducted once a week for four consecutive weeks during the students' normal Pre-Calculus class time. During these times, students had individual computers and logged into Canvas to access the online differentiated math lessons. The teacher explained to the students that the purpose of these lessons were to strengthen their mathematics skills and better prepare them for their college placement tests, college, and their futures. The goal was for them to focus on specific lessons, practice, and learn the lessons at their own level and pace. There was also a homepage on Canvas explaining the goal, modules, and lessons progression. Each week, three lessons at three different levels were provided for students. Each lesson had a pre-quiz, an introduction with the objectives and basic vocabulary, some content material, different examples, at least ten practice problems, additional activities, a post-quiz, and a self-reflection. Students needed to successfully complete the pre-quiz or the post-quiz to unlock other lessons. If students passed the pre-quiz, they could unlock the next lessons without having to go through the whole lesson, but if they did not pass the pre-quiz, they needed to go through the lesson and pass the post-quiz to continue onto other lessons. The pre-quiz could only be taken once while the post-quiz could be taken as many times as needed for students to pass. There was a certain progression for the lessons but also some autonomy for students to decide which progression they wished to follow. For lessons that students completed, there was a self-reflection for students to process their learning as well as give feedback to the teacher about the lessons.

While students worked on these lessons individually, the teacher took on the roles of being a researcher and an instructional facilitator. As a researcher, the teacher used an

observation tool to observe student engagement and confidence. As an instructional facilitator, the teacher circulated the classroom to help students who had math questions or needed support with using the different technology tools. After each lesson, a research journal was used to reflect and process on how each lesson went. The different data collected were reviewed and used to modify the following week's lessons to better meet students' needs. At the end of the four weeks, all the data was revisited to determine the effectiveness of the online differentiated math skills lessons regarding student learning, engagement, and math confidence.

Results

Since the purpose of this research is to evaluate the effectiveness of the online differentiated math skills lessons at meeting students' needs, the results of this paper are separated into three sections. Each section will seek to answer one of the three research questions and provide insight on what areas were successful and which areas are in need of improvement.

Impact student's engagement. Engagement and disengagement data was collected from the teacher observation tool, the teacher journal, and the student reflections. For overall engagement and disengagement levels, the data collected from the observation tool (Table E1 in Appendix) suggests that 74.61% of the time, students displayed signs of engagement and 8.98% of the time, students displayed signs of disengagement. Students were categorized as both when they displayed both engaged and disengaged behaviors. For example, if a student was taking notes and talking to their friends, the teacher would mark E2 and D3 on the observation tool and categorize that as both. Using this method of categorization, students displayed both behaviors 16.41% of the time observed. The level of engagement observed was lower than student self-reported data from the student reflections (Table 1). From all the student reflections, 90.74% of the time was charted as engaged, 7.41% neutral, and 1.85% disengaged. Overall, the differentiated online mathematics lessons were succeeded in engaging most students but there was a small percentage of students who were disengaged. Since the purpose of differentiated instruction is to personalize instruction for every student, more needs to be done to tailor lessons to the needs of the disengaged students.

Table 1. Tally of Teacher and Student View on Engagement.

	Teacher Observation			**Student Reflection**		
	Engaged	**Both**	**Disengaged**	**Engaged (4 or 5)**	**Neutral (3)**	**Disengaged (1 or 2)**
Total Student Data	256	256	256	54	54	54
Tally	191	42	23	49	4	1
Percentage	74.61	16.41	8.98	90.74	7.41	1.85

Note. Total refers to the total amount of data collected not the total number of students. Tally is the number of times teacher or student rated a certain category. Student data was measured on a Likert scale of 1 to 5, where 1 was not engaged or not confident and 5 was very engaged or very confident. Student responses were tallied and grouped into the categories above.

Impact on students' confidence. Similar to the engagement data, data on students' confidence was collected from the teacher observation tool and the student reflections. When using the observation tool, confidence data was much more difficult to collect than engagement. It was difficult to decipher what certain facial expressions and body languages meant. For example signs of stress can often be misinterpreted as focus and vice versa. Thus, when collecting data on confidence level, nothing was logged unless it was obvious that a student was displaying signs of confidence or a lack thereof. Examples of these obvious signs were when students verbalized their triumphs or their frustrations. Although percentages of this data might not be fully accurate, certain trends can be observed. According to the data from the teacher observation tool, students displayed many more signs of confidence during the middle of the class period rather than the beginning or the end of a class period (Appendix Table E2). Also, throughout the four weeks, confidence level stayed about the same but students' lack of confidence more than doubled during the fourth week than the first week. This could be due to the fact that students were to take their college placement test at the end of the fourth week. A lack of confidence could also have stemmed from the increased amount of lessons that were available in later weeks. Each week, three new locked lessons would be available for students to work on. For students who only worked on one or two lessons, the increased amount of locked lessons became a sign that there was a lot that they did not learn and complete. The intent of this course was for students to learn lessons at their skill level. This would mean that students should complete approximately one lesson at their level each week but from the students' view of the online module, lower skilled students might have felt that they needed to complete three to four lessons each week. This lower confidence could have resulted from students feeling rushed or having a lack of time. This speculation was mentioned in student's final reflection. Students commented that they wanted more time or that they wished that the Canvas practice days started earlier in the year (Figure F1 in Appendix). Some students even worked on the lessons after the four weeks of the action research project. Running out of time during the end of a class period and feeling the pressure of the placement test approaching probably resulted in students feeling less confident. Rather than being able to focus on the success of completing a lesson students saw the many lessons that they were unable to finish.

In comparison to the teacher observation data, students' self-reported data from the student reflections reported a much higher level of confidence. The percentage of students who felt confident was even higher than the percentage of students who were engaged (Table 2). On a scale of 1-5 where 1 was very unconfident and 5 was very confident, 94.44% of the students felt confident or very confident, while 5.56% were neutral, and no students reported that they felt unconfident or very unconfident. This was pretty consistent throughout the four weeks of data collection. The difference in having a lack of confidence could not be observed from this data because only one student completed a self-reflection on the fourth week. Although the link to the self-reflection was on the home page, it was also the last page of each module. That could means that students who completed a module were the students that filled out the self-reflection and not as much data was collected from students who were struggling to pass a module.

Table 2. Tally of Teacher and Student View on Confidence Level.

	Teacher Observation			Student Reflection		
	Confident	**Both**	**Unconfident**	**Confident (4 or 5)**	**Neutral (3)**	**Unconfident (1 or 2)**
Total Student Data	86	86	86	54	54	54
Tally	51	7	28	51	3	0
Percentage	59.3	8.14	32.56	94.44	5.56	0

Note. Total refers to the total amount of data collected not the total number of students. Tally is the number of times teacher or student rated a certain category. The both category in the Teacher Observation is when a teacher notices a student displaying both an engaged and disengaged behavior within the 5 minute data collection time.

Impact on student's mathematics knowledge. The changes that the differentiated lessons had on students' learning gaps were mainly measured through their quiz scores on Canvas. Averaged pre-quiz and post-quiz scores were compared to observe whether learning occurred and the number of lessons students were able to complete was used to measure how much math students were able to learn.

Pre-quiz vs post-quiz scores. In general it can be assumed that students' mathematical knowledge improved. The final averaged post-quiz score of 4.7 is higher than the average pre-quiz score of 3.25 (Table G1 in Appendix). A more holistic perspective of students' learning for each lesson can be observed through the analysis of specific post-quiz scores. For each lesson, the results are similar to the total quiz average since average post-quiz scores for each lesson was higher than the pre-quiz score for the corresponding lesson (Figure 2). All the pre-quiz and post-quiz attempts were included in Figure 2 but scores of students who tested out of a lesson through a pre-quiz were removed. This was done to specifically observe only the students who went through the whole lesson and took the post-test and not the students who tested out of the lesson. When observing all the 237 post-quiz attempts, there were 222 times where post-quiz scores were higher than pre-quiz scores and 15 times when post-quiz scores were lower than pre-quiz scores (Table G2 in Appendix). That means that around 93.7% of all the individual quiz scores were higher than pre-quiz scores. Having the total final average post-quiz scores be higher than pre-quiz scores means that in general, most students were able to master the mathematical concepts. The higher post-quiz scores for each lesson shows that all the lessons were successful in helping the average student improve their mathematics knowledge. Having over 90% of all the post-quiz attempts be higher than the pre-quiz attempt shows that over 90% of the time that students took a post-quiz, students improved their learning. Students might not have been able to master the concepts and pass the post-quiz in one attempt but students were able to progressively improve.

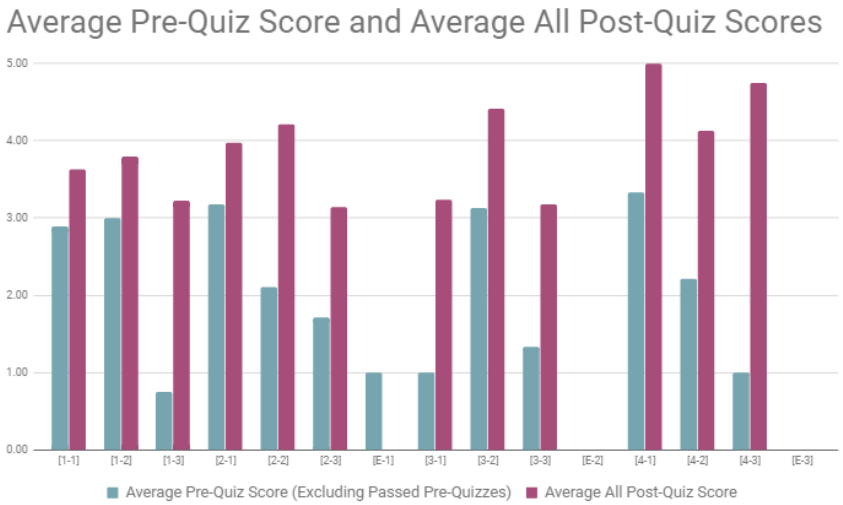

Figure 2. Comparison of Averaged Pre-Quiz and Post-Quiz Scores for each Lesson.

Lessons available and lessons completed. Looking at the number of lessons that students were able to complete can shed light on whether these lessons worked better for higher or lower skilled students. It can also show whether further differentiation was needed.

Traditional classroom instruction versus differentiated instruction. Without differentiation, only one lesson would be taught per class period. So in the four weeks of this action research project, there could have been around four traditional lessons taught. However, even if four lessons are taught there is no guarantee that students would have learned or mastered the concepts in these four lessons. From the online differentiated lessons, the average number of new lessons students mastered through post-quizzes was 3.1, the average number of lessons completed through pre-quizzes or post-quizzes was 5.5, and the average total number of lessons that students worked on but might not have completed was 6.7 lessons (Table G3 in Appendix). Although the number of new lessons mastered is about one lesson less than what could be offered in a traditional setting, this number does not represent what was offered to students but what they were able to successfully learn and complete. Using the online lessons provided a better guarantee that students master what they learned. In addition, without differentiation, four lessons would be taught but those four lessons might not be the lessons that all the students were ready for or needed. With these differentiated online lessons, students were able to work on lessons for their specific skill level and be able to work at mastering those concepts. There was a total of 391 quizzes taken and graded by the online module and students were able to receive instant feedback. This would have been extremely difficult for a teacher to do by hand. These differentiated online lessons were much more adept at providing a personalized learning experience for students.

Successful and struggling students. Besides being able to complete more lessons that fit their needs, the amount of content that students were able to learn, significantly varied. A student only completed one lesson while another student completed twelve. Student skill levels were extremely different and differentiation was necessary for

students' diverse needs to be met. If only four lessons were taught to all the students, the lessons would have been too easy or too hard for most students. From the higher post-quiz scores for each lesson, it can be assumed that many students were able to learn mathematical content through these differentiated lessons. From the lessons that students were able to complete and master, it can be seen that the differentiation process was effective in having students work on lessons that matched their skill level. However, looking at the range of number of lessons students completed, the lowest starting point of these modules might have been too high for some students. Six of twenty four students only completed one to two modules. This equates to having one fourth of the students being exposed to less than half of what they would have in a traditional learning setting (Table G4 in Appendix). Thus for certain students who started with fewer mathematics skills, they probably struggled more than the other students. This could also mean that the online differentiated lessons worked better for average and higher skilled students. The high number of post-quiz attempts needed for lesson [1-1] confirms that some students struggled to complete the starting level lesson. Although, no student mentioned lessons being too hard, there were two students who used seven attempts to pass lesson [1-1] (Figure G1 in Appendix). For these students to be more successful, there are several possible modifications that might be needed. First, lessons might need to be further differentiated to have an easier starting level for certain students. Second, there might be a need to modify the content presentation method and lesson styles to better match students' different learning styles. Third, there might need to be an intervention from the teacher to help these struggling students. Since students are working individually on these online differentiated lessons, the teacher is freed up to give individual help to higher need students.

Discussion and Conclusions

Being in the same grade level and taking the same mathematics course does not mean that students' mathematics skills are the same. Observing that a student completed one out of fifteen lessons while another student completed twelve out of fifteen lessons, confirms the need for differentiation. The intent of this research project was to explore the impact that the online differentiated mathematics lessons had on students' engagement, confidence, and mathematics learning.

Positive effects for higher skilled students. Most students rated favorable results in engagement and confidence. However, for learning math content, the differentiated lessons were most successful for higher skilled students. These students were able to learn content, master the quizzes, and expand their mathematical knowledge. They mentioned that the simple and straightforward content presentation style used within these lessons were helpful and they had very positive comments about the online differentiate math lessons. Many students also appreciated the quiz feature that gave immediate feedback on what skills they needed to work on. Some other students also commented on how these lessons were practical in helping them prepare for the college placement test. Providing an abundance of lessons, allowed higher skill students to be challenged to do more. Rather than having to work at the pace of the rest of the class, these students were free to work as quickly as they could. This increased the amount that

they could learn within a class period. Without the usage of the online module, there would be no way for a classroom teacher to provide that amount of differentiated lessons and give instant quiz feedback to students. The online differentiated mathematics lessons accomplished the goal of meeting students' needs to learn more than what can be offered in a traditional classroom. By providing personalized lessons for students' varying skill levels, students were able to work on lessons at their skill level and at their own pace.

Improvements to better support struggling students. For most students, the differentiated content and the teaching style used within the module lessons were successful. However, some students' lack of confidence increased during the end of each lesson and over the four weeks, a small group of students were disengaged, and about one fourth of the class was not able to successfully progress through lesson modules as quickly as intended. Students' struggle in these areas does not mean that differentiation was not needed or that it was ineffective. Rather, modifications need to be made to how lessons are differentiated so that struggling students can be supported and successful during this learning process.

Ways to prevent students' decrease in confidence. To improve students' confidence, tactful time management skills are needed. Rushing to ending each period possibly caused students to have a lack of confidence. To implement the micro learning strategy successfully, the teacher must ensure that lessons would not take longer than the 45 minute class period for students to complete with multiple quiz attempts. If lessons are more difficult, they should be further differentiated and separated into additional lessons. Further differentiation will also be helpful for students who struggled with passing the first lesson. If students struggle with a lesson, there should be lessons that differentiate down for students. In the current iteration of these online differentiated math lessons, all lessons are differentiated upwards, thus if students' struggle, there is no other option besides continuing to struggle until they pass. The students' view of the module with many uncompleted locked lessons is another confidence wrecker. Although Canvas does not have this structure, if lessons were not published for students to view until they unlock it, students would not feel the pressure and discouragement from seeing numerous uncompleted lessons.

Using different teaching strategies for students' different learning styles. When students struggle, it could also mean that a different style of teaching is needed. These lessons only differentiated content for students' different skill levels but the lessons were not differentiate for students' different learning styles. If students tried to learn a lesson but could not pass the quiz, it might mean that they needed another approach to learning the same lesson. Although varying methods such as games and discussions were used to help students practice solving problems, these practices were not highlighted for students. A reminder of the games and discussions could have helped students better prepare to pass the quizzes. Also, content was taught through images and color coded text. This worked for many of the higher skilled students but might not have been as learner-friendly for the lower skilled students. In other lessons that the teacher has taught, the use of videos, games, and demonstrations were more engaging for these students. During a video lesson, a student purposely mentioned to the teacher that the video lessons could

have aided the effectiveness of the text-based content in Canvas. Differentiating the way that content is presented is key to differentiating for students' different learning styles.

Balancing collaboration with differentiation to improve engagement and learning. Another way to differentiate for different learning styles is to incorporate and balance individual work with peer collaboration. Since the school structure is based on collaboration and group work, completely taking that away for students during these lessons was difficult. It is important to help students develop the ability to work individually but removing group work from these lessons probably caused lower levels of engagement and success in learning. It can be difficult to balance differentiation with collaboration and individual work with peer interactions but this balance could improve student engagement and their ability to learn content. A simple way of implementing peer interaction could be having student discussions before or after lessons. Simple one minute discussions could involve goal setting, questions they have, or other lesson related topics. A more involved change could be to restructure these lessons by incorporating them into a larger lesson structure. For example, these lessons could be part of a jigsaw activity where students learn the differentiated content individually and then bring what they learned to heterogeneous groups to complete a project together.

Using classroom structures to effectively implement differentiation. Besides collaboration and group work, other classrooms structures such as openings, goal setting, and turning in work were removed during these lessons. Having students be good self-regulated learners is an important feature needed to properly implement online differentiated learning. Although there were aspects of self-regulated learning that was included in the design of the modules such as the lesson progression flowchart and student self-reflections, self-regulated learning does not happen automatically. Rather than letting students immediately regulate their own learning, student could have been more successful if they taught how to and supported to become self-regulate learners. Students who struggled on the same couple of lessons could have benefitted from skills on how to self-regulate their learning. If structures such as goal setting or having to complete a certain amount of modules was implemented, students might have been more effective at completing lessons. Also, if there were questions asking structures or getting help protocols implemented, struggling students would have a venue to get help and support. Although this online module was designed for students to work on personalized lessons and this structure was to develop students' ability to work individually, students do not need to struggle alone. Having a certain amount of accountability and finding ways to get help and wrestle through their struggles are also important aspects of self-regulated learning.

Teacher as a supporter rather than a presenter. Restructuring the role of the teacher is also an improvement that can be made to better support students. Since students can access the differentiated lessons on their own, the teacher's role as a lecturer is no longer needed. The teacher can take on more of a supporting role. When students encounter struggles and difficulties the teacher can step in to support them and guide them through that struggle until they can work on their own again. Besides helping students who ask for help the teacher can also incorporate structured check-ins with

individual students or small groups of students so that all students are supported and not only those who are better as self-advocating.

Impact on improving teaching practice. A side benefit of action research is its impact on the teacher. Having a conscious effort to observe and reflect is beneficial to teaching and allowed the teacher to improve her teaching practice. The observation tools confirmed a lot of general observations the teacher had and the weekly informal analysis of all the data helped the teacher make modifications to subsequent lessons. This process allowed the teacher to look at classroom trends more accurately and be more aware of students' needs. Using the teacher journal provided a forum to process through different challenges that occurred each week, the teacher was able to more thoughtfully make modifications to support students. Each week, the written reflection from the teacher journal was sorted into different categories to determine what modifications were necessary for the following week. For example, in Week 1, it was observed that some students were able to complete all the lessons within the class period. Since the first week included an introduction to the course and time to create a Canvas account, more lessons will be needed in the subsequent weeks. So for the modification, the teacher designed a fourth level of lessons so that there was an additional lesson for the second, third, and fourth week. (See Appendix Figure H1 for categorized teacher journal notes and detailed weekly modifications.) Besides being able to make more appropriate modifications, the teacher also became more empathetic of students' situations and struggles. Rather than focusing on how students need to change and improve, the teacher was able to focus on how the lessons can be improved for the students. The teacher's mindset behind action research is not focused on perfection but on how to make improvements. Focusing on perfection is a one-time occurrence and it sets a false expectation that the teacher needs to provide the perfect lessons and that students need to perform flawlessly during their first attempt. However, focusing on improvement is a process that allows the teacher and the students to have the freedom to modify and find new ways to learn and progress. There will never be a perfect way of teaching that works for all students all the time, but with action research, the teacher can observe and revise lessons to best fit students' current situations and learning needs.

Further implications. Having to teach in a classroom with a diverse student population is a struggle for many teachers. The varying skill levels and needs that unique students have makes it difficult for one teacher to assess and address. The results from this study has shown that differentiated instruction is a feasibly and necessary tool for the diverse classroom. Online differentiated lessons can be effective in helping the teacher provide personalizing lessons for students with differing skill levels. The differentiation process allows more students to successfully learn content that is designed for their specific needs. Since all students are unique individuals, there is no ambiguity as to whether differentiation is needed in the classroom and the need for differentiated learning will always exist. The essential question for individual educators is how to effectively implemented differentiation to best meet their students' specific and ever-changing needs.

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List of Appendices

APPENDIX A
Sample Lesson Components

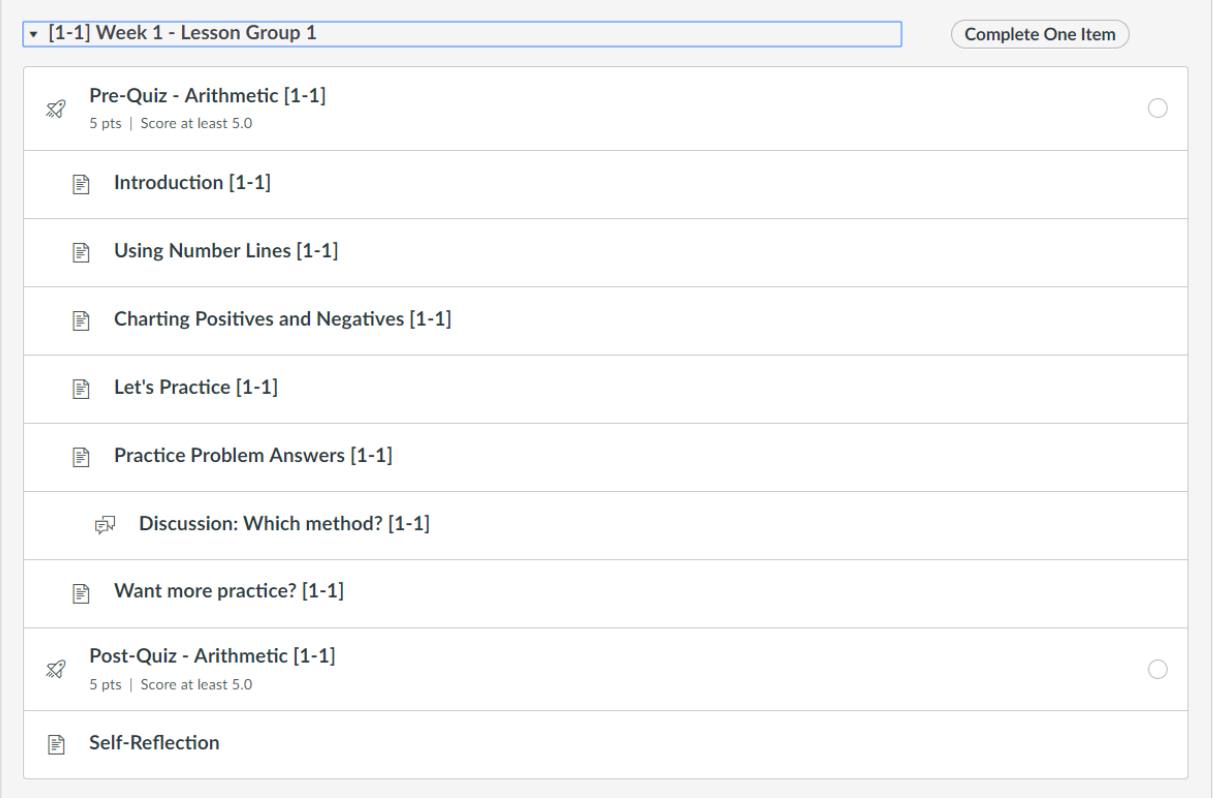


Figure A1. Basic Lesson Structure

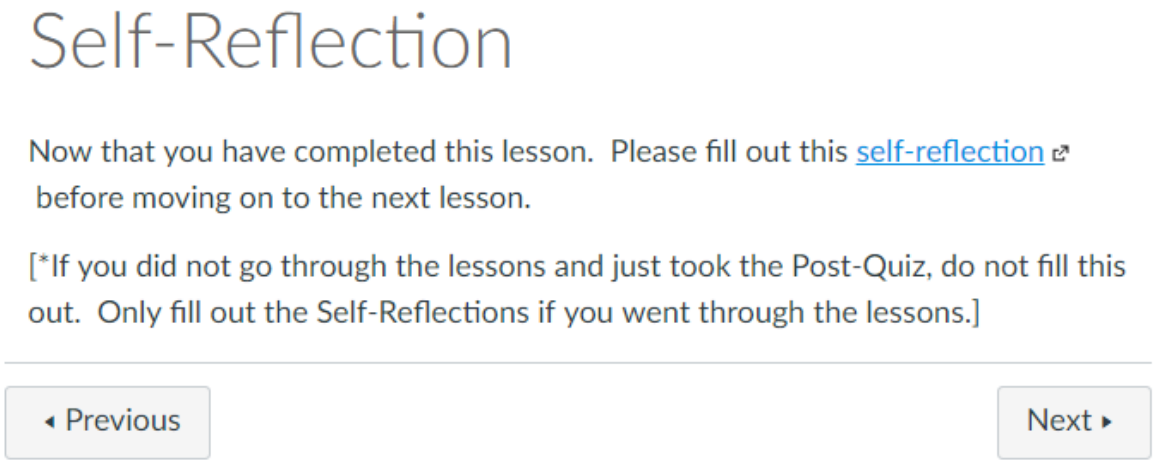


Figure A2. Instructions for Self-Reflection

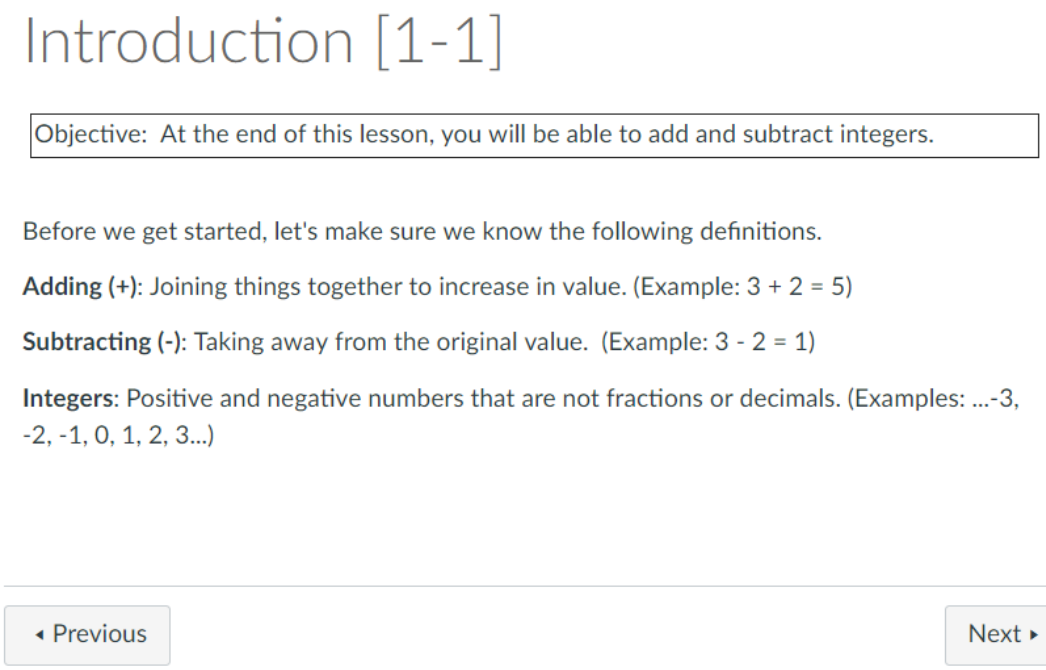


Figure A3. Sample Vocabulary Review

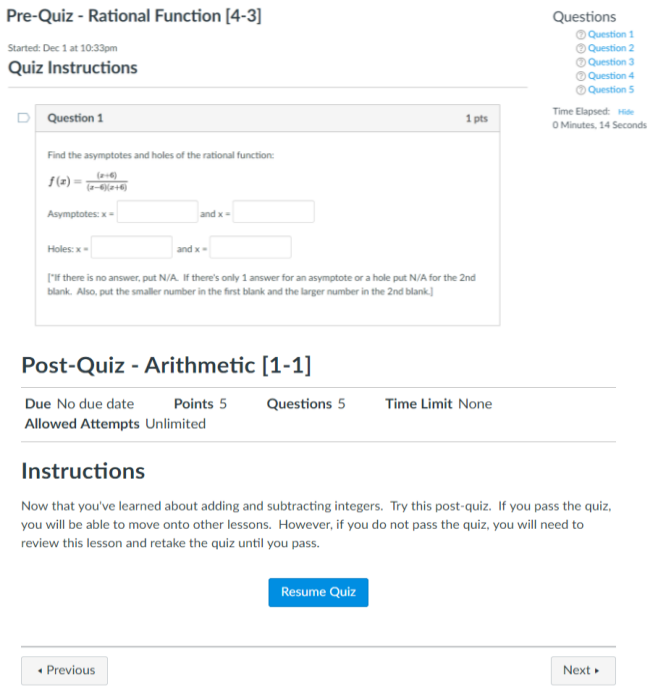


Figure A4. Example of parts of a Pre- and Post-Quiz

Using Number Lines [1-1]

You can use a number line to help you add and subtract.

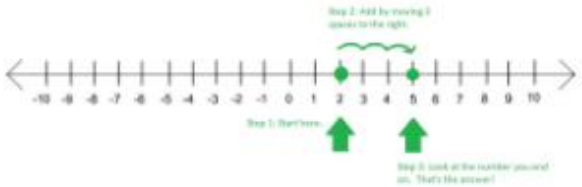
You can do this by:

- Add by moving numbers to the right.
- Subtract by moving numbers to the left.

Let's take a look at some examples.

Adding Example:

2 + 3 = ___



Step 1: Start with 2 on the number line.

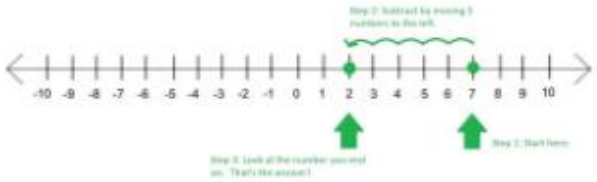
Step 2: Since we are adding 3, move 3 numbers to the right.

Step 3: Look at the number you end on and that is the solution. In this example, 5 is the answer.

Answer: 2 + 3 = 5

Subtracting Example:

7 - 5 = ___



Step 1: Start with 7 on the number line.

Step 2: Since we are subtracting 5, you will need to move 5 numbers to the left.

Step 3: Look at the number you end on and that is the solution. In this example, 2 is the answer.

Answer: 7 - 5 = 2

« Previous

Next »

Figure A5. Lesson [1-1] Content Presentation

Let's Practice [1-1]

Try these problems!

1) 3 + 2 =

2) 9 - 3 =

3) 5 + 2 =

4) 8 - 1 =

5) 6 + 4 =

6) 4 - 2 =

7) 7 + 5 =

8) -1 - 3 =

9) -1 + 4 =

10) -4 - (-2) =

Practice Problem Answers [1-1]

Try these problems!

1) 3 + 2 = 5

Negative Numbers	Positive Numbers
	+ + + + +

2) 9 - 3 = 6

Negative Numbers	Positive Numbers
- - -	+ + + + + + + + +

Figure A6. Lesson [1-1] Practice Component

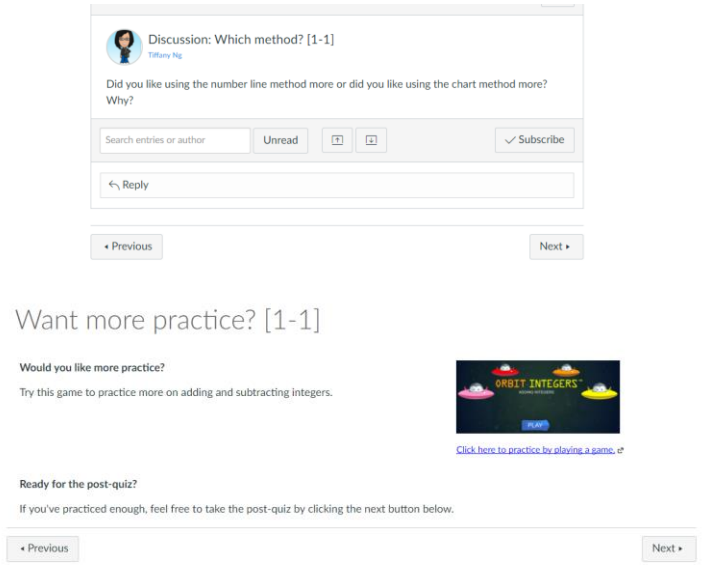


Figure A7. Lesson [1-1] Additional Activities, Practices, and Resources

Lesson Progression

	Level 1	Level 2	Level 3
Week 1	Arithmetic [1-1] Completed	Order of Operation & Solve for x [1-2] Unlocked	Complex Numbers [1-3] Locked
Week 2	Combining Like Terms [2-1] Unlocked	Radical Functions [2-2] Locked	Complex Numbers– Conjugation [2-3] Locked
Week 3	Fraction Arithmetic [3-1] Locked	Radical functions - Rationalize denominator [3-2] Locked	Rationalize with Conjugates [3-3] Locked
Week 4	Distribution & Polynomial Expansion [4-1] Locked	Factoring [4-2] Locked	Rational Functions [4-3] Locked

Figure A8. Lesson Topics and Progression Flowchart.

APPENDIX B
Data Collection Tools

Engagement Level Observation Tool Class Period: ____________

Lesson Group/Date: ____________ Time of Observation: ______ to ______

Time of Sweep (Suggested/Actual Time)			
Student Initials	First 5 mins of class	At 30 mins	Last 5 mins of class
	❑ E1 ❑ E2 ❑ E3 ❑ E4 ❑ D1 ❑ D2 ❑ D3 ❑ D4 ❑ C1 ❑ C2 ❑ C3 ❑ C4 ❑ U1 ❑ U2 ❑ U3 ❑ U4	❑ E1 ❑ E2 ❑ E3 ❑ E4 ❑ D1 ❑ D2 ❑ D3 ❑ D4 ❑ C1 ❑ C2 ❑ C3 ❑ C4 ❑ U1 ❑ U2 ❑ U3 ❑ U4	❑ E1 ❑ E2 ❑ E3 ❑ E4 ❑ D1 ❑ D2 ❑ D3 ❑ D4 ❑ C1 ❑ C2 ❑ C3 ❑ C4 ❑ U1 ❑ U2 ❑ U3 ❑ U4
	❑ E1 ❑ E2 ❑ E3 ❑ E4 ❑ D1 ❑ D2 ❑ D3 ❑ D4 ❑ C1 ❑ C2 ❑ C3 ❑ C4 ❑ U1 ❑ U2 ❑ U3 ❑ U4	❑ E1 ❑ E2 ❑ E3 ❑ E4 ❑ D1 ❑ D2 ❑ D3 ❑ D4 ❑ C1 ❑ C2 ❑ C3 ❑ C4 ❑ U1 ❑ U2 ❑ U3 ❑ U4	❑ E1 ❑ E2 ❑ E3 ❑ E4 ❑ D1 ❑ D2 ❑ D3 ❑ D4 ❑ C1 ❑ C2 ❑ C3 ❑ C4 ❑ U1 ❑ U2 ❑ U3 ❑ U4
	❑ E1 ❑ E2 ❑ E3 ❑ E4 ❑ D1 ❑ D2 ❑ D3 ❑ D4 ❑ C1 ❑ C2 ❑ C3 ❑ C4 ❑ U1 ❑ U2 ❑ U3 ❑ U4	❑ E1 ❑ E2 ❑ E3 ❑ E4 ❑ D1 ❑ D2 ❑ D3 ❑ D4 ❑ C1 ❑ C2 ❑ C3 ❑ C4 ❑ U1 ❑ U2 ❑ U3 ❑ U4	❑ E1 ❑ E2 ❑ E3 ❑ E4 ❑ D1 ❑ D2 ❑ D3 ❑ D4 ❑ C1 ❑ C2 ❑ C3 ❑ C4 ❑ U1 ❑ U2 ❑ U3 ❑ U4

Engagement Behaviors:	Disengagement Behaviors:	Confident Behaviors:	Unconfident Behaviors:
E1 - able to focus and be on task E2 - taking notes E3 - being excited and enthused E4 - other signs of engagement	D1 - sleeping D2 - playing on cell phones D3 - distracted or distracting others D4 - other signs of disengagement	C1 - positive facial expression (ie: smiling or laughing) C2 - relaxed body language (ie: leaning in and engaging themselves with the class) C3 - communicates confidence (ie: makes excited noises, open to ask and give help) C4 - other confident signs	U1 - negative facial expression (ie: frowning, grimacing, or crying) U2 - tense body language (ie: leaning away and withdrawing themselves from the class) U3 - communicates lack of confidence (ie: makes defeated noises, disengages from lesson or is withdrawn) U4 - other unconfident signs

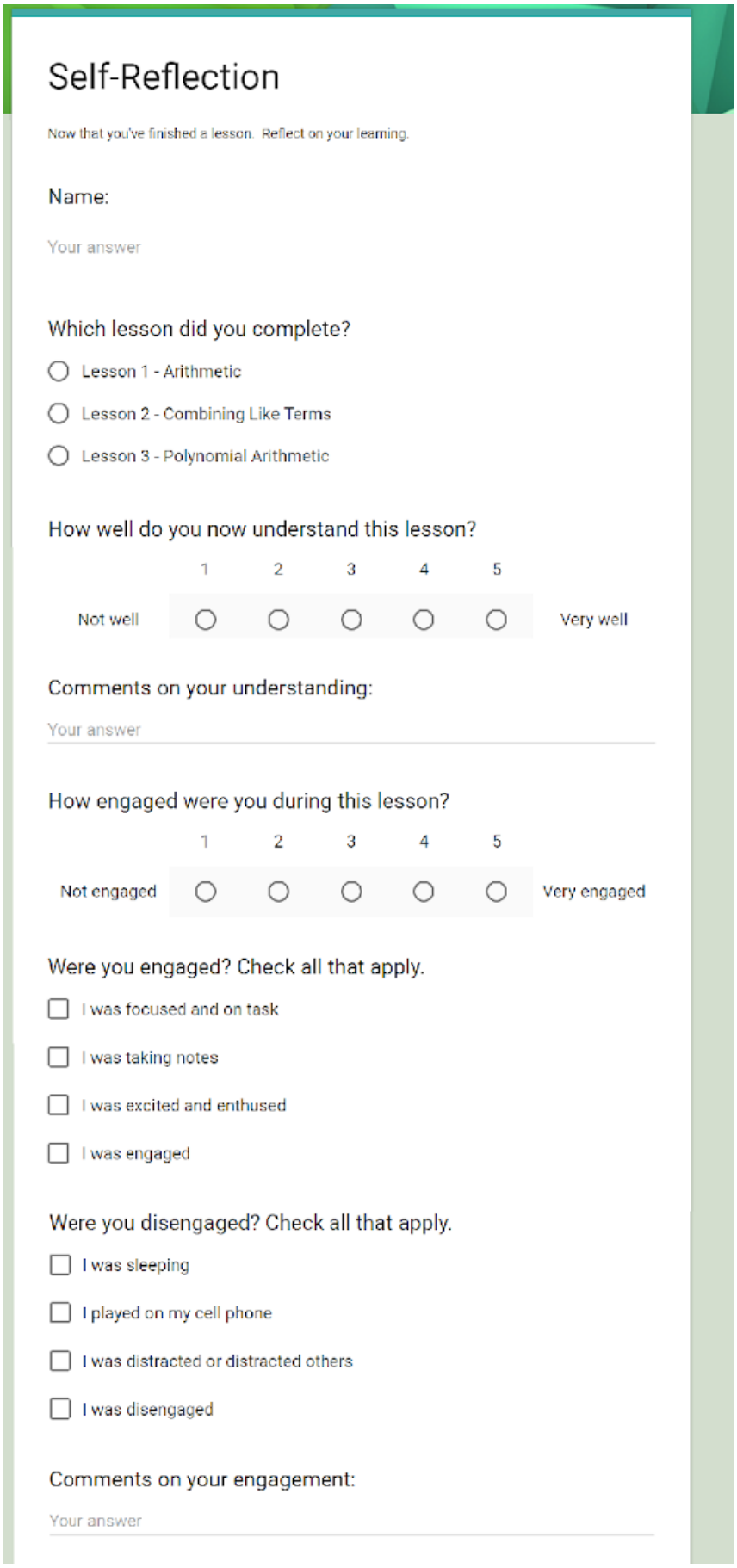
Figure B1. Teacher’s in Classroom Observation Tool.

Research Journal

Class Period: _____ Lesson Group/Date: _____

Which students stood out today?
What captured my attention?
What worked well in class today?
What did not work or could work better?
What can be revised or added?
Other thoughts:

Figure B2. Teacher's Research Journal.



Self-Reflection

Now that you've finished a lesson. Reflect on your learning.

Name:

Your answer

Which lesson did you complete?

- ◯ Lesson 1 - Arithmetic
- ◯ Lesson 2 - Combining Like Terms
- ◯ Lesson 3 - Polynomial Arithmetic

How well do you now understand this lesson?

	1	2	3	4	5	
Not well	◯	◯	◯	◯	◯	Very well

Comments on your understanding:

Your answer

How engaged were you during this lesson?

	1	2	3	4	5	
Not engaged	◯	◯	◯	◯	◯	Very engaged

Were you engaged? Check all that apply.

- ☐ I was focused and on task
- ☐ I was taking notes
- ☐ I was excited and enthused
- ☐ I was engaged

Were you disengaged? Check all that apply.

- ☐ I was sleeping
- ☐ I played on my cell phone
- ☐ I was distracted or distracted others
- ☐ I was disengaged

Comments on your engagement:

Your answer

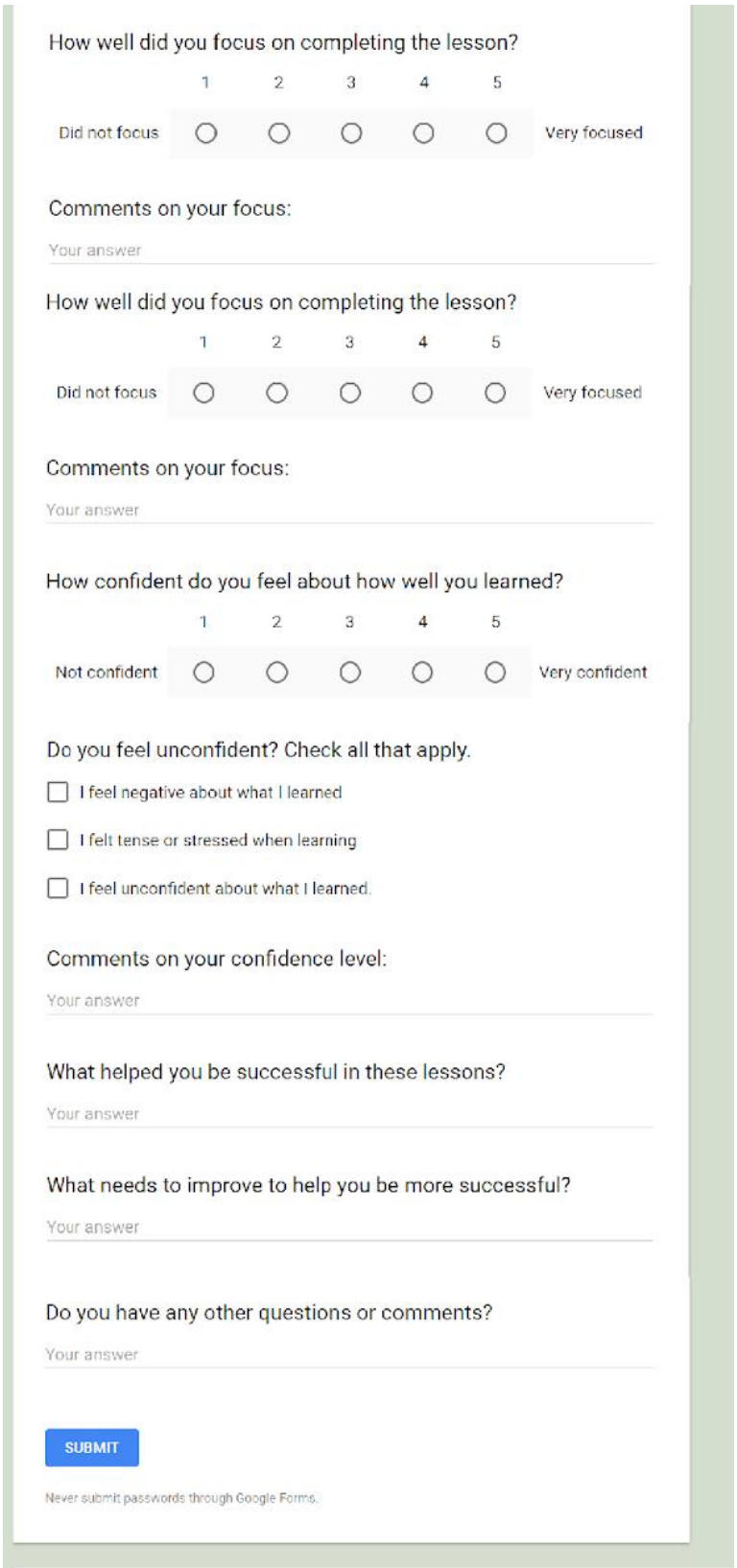


Figure B3. Student's Post-Lesson Self-Reflection.

APPENDIX C
Recruitment Statement

Hello students, I want to invite you to participate in my research study. As you know, I am your 12th grade Pre-Calculus teacher but I am also a graduate student at the University of Hawai'i at Mānoa (UHM), in the Department of Learning Design and Technology. One requirement for earning my Master's degree is to do a research project. The purpose of my research project will be to explore the use of online differentiated math skill lessons. I have created different lessons online for you to work on to improve your math skills at your level and at your own pace. If you chose to be part of this student, I will observe your work in class and analyze it for my project. Everyone in the class will be working on the same thing and there will be no extra work for you if you participate in this study. The only different is that I will make observations of you and collect data from your work to use in my project. This project is voluntary. You can choose freely to participate or not to participate. At any point during this project, you can withdraw your permission and stop participating without any loss of benefits. I recognize that I am the researcher in this project and, at the same time, your teacher. I will ensure that your participation or non-participation in my research project does not impact your grades, class standing, relationship with me, or relationship with San Francisco International High School.

Take some time to read over the assent form.

[Let students read.]

Do you have any questions for me?

[Answer questions.]

Also, please bring the consent form home and talk with your parents about whether you would like to participate. If both you and your parents would like for you to participate please return the signed portion of the consent form and the assent form to me before January 10, 2018.

Thank you.

Figure C1. Recruitment Statement Script that Teacher will follow.

APPENDIX D
Consent and Assent Forms

University of Hawai'i
Parent/Guardian Consent for their Child to Participate in a Research Project
Grace Lin, Principal Investigator and Tiffany Ng, Student Investigator
Project Title: Closing Learning Gaps with Online Differentiated Math Lessons

Hello! My name is Tiffany Ng, and I am requesting your permission for your child to participate in my research project. I am a teacher at San Francisco International High School. I am also a graduate student at the University of Hawai'i at Mānoa (UHM), in the Department of Learning Design and Technology. One requirement for earning my Master's degree is to do a research project. The purpose of my research project will be to explore the use of online differentiated math skill lessons. This project will focus on helping students learn math content that cannot be covered in the regular curriculum; this might be math that they did not learn well in the past or it will be a preview of math they will later learn. I am asking your permission for your child to participate in this project. I also will ask your child if they agree to participate in this project.

Activities and Time Commitment: If you and your child agree for your child to be in the study, I will make observations of your child's work in class and also analyze the work they submit online. During this time, your child will be working on a series of online math lessons created at three different levels. Your child will complete the lessons at their own mathematical level and at their own pace. This will be part of the normal class activity and your child will not be asked to do any additional work. The only difference is that I will be observing and analyzing your child's work and behavior for my research. One example of the kind of observations I will make is, "How has the student's math score changed after working through the lessons?" If you would like to see a copy of all my observation tools and questions, please contact me via the email address listed near the end of this consent form.

Benefits and Risks: There may be no direct benefits to your child for participating in my research project. The results of this project might help me, other teachers, and researchers learn more about how to help students learn math. I believe there is little or no risk to your child in participating in this project.

Confidentiality and Privacy: I will keep all study data secure in a locked filing cabinet in a locked office/encrypted on a password-protected computer. Only my University of Hawai'i advisor and I will have access to the information. Other agencies that have legal permission have the right to review research records. The University of Hawaii Human Studies Program has the right to review research records for this study.

When I report the results of my research project in my typed paper, I will not use your child's name or any other personal information that would identify your child. All data will be aggregated before being reported. If you would like a copy of my final report, please contact me by e-mail.

Voluntary Participation: Participation in this research project is voluntary. Your child can choose freely to participate or not to participate. You can choose freely whether or not your child may participate in this project. At any point during this project, you can withdraw your permission and your child can stop participating without any loss of benefits. I recognize that I am the researcher in this project and, at the same time, your child's teacher. I will ensure that your child's participation or non-participation in my research project does not impact their grades, class standing, relationship with me, or relationship with San Francisco International High School.

University of Hawai'i
Parent/Guardian Consent for their Child to Participate in a Research Project
Grace Lin, Principal Investigator and Tiffany Ng, Student Investigator
Project Title: Closing Learning Gaps with Online Differentiated Math Lessons

Questions: If you have any questions about this project, contact me, Tiffany Ng, by e-mail at ngt@sfusd.edu.

You can also contact my advisor at the University of Hawaii, Dr. Grace Lin, by e-mail at gracelin@hawaii.edu.

You may contact the UH Human Studies Program at (808) 956-5007 or uhirb@hawaii.edu to discuss problems, concerns and questions; obtain information; or offer input with an informed individual who is unaffiliated with the specific research protocol. Please visit https://www.hawaii.edu/researchcompliance/information-research-participants for more information on your rights as a research participant.

Please keep the section above for your records.

Tear or cut here

Signature(s) for Consent:

I give permission for my child to join the research project entitled, *"Closing Learning Gaps with Online Differentiated Math Lessons."* I understand that my child can change his or her mind about being in the study at any time. I understand that I may change my mind about my child being in the study at any time.

Name of Child (Print): _____

Name of Parent/Guardian (Print): _____

Parent/Guardian's Signature: _____

Date: _____

Thank you!

Figure D1. English Consent Form

University of Hawai'i
Assent to Participate in a Research Project - 14 - 17 years of age
Grace Lin, Principal Investigator and Tiffany Ng, Student Investigator
Project Title: Closing Learning Gaps with Online Differentiated Math Lessons

Hello! My name is Tiffany Ng, and I am inviting you to participate in my research study. As you know, I am your 12th grade Pre-Calculus teacher at San Francisco International High School. I am also a graduate student at the University of Hawai'i at Mānoa (UHM), in the Department of Learning Design and Technology. One requirement for earning my Master's degree is to do a research project. The purpose of my research project will be to explore the use of online differentiated math skill lessons. This project will focus on helping you learn math content that normally cannot be covered in class; this might be math that you did not learn well in the past or it will be a preview of math you will later learn.

Activities and Time Commitment: If you agree to be in this study, I will make observations of your work in class and also analyze the work you submit online. During this time, you will be working on a series of online math lessons created at three different levels. You will complete the lessons at your own mathematical level and at your own pace. This will be part of the normal class activity, and you will not be asked to do any additional work. The only difference is that I will be observing and analyzing your work and behavior for my research. One example of the kind of observations I will make is, "How has your math score changed after working through the lessons?" If you would like to see a copy of all my observation tools and questions, please contact me via the email address listed near the end of this consent form.

Benefits and Risks: There may be no direct benefits to you for participating in this research project. The results of this project might help me, other teachers, and researchers learn more about how to help students learn math. I believe there is little or no risk to you for participating in this project.

Confidentiality and Privacy: I will keep all study data secure in a locked filing cabinet in a locked office/encrypted on a password-protected computer. Only my University of Hawai'i advisor and I will have access to the information. Other agencies that have legal permission have the right to review research records. The University of Hawai'i Human Studies Program has the right to review research records for this study.

When I report the results of my research project in my typed paper, I will not use your name or any other personal information that would identify you. All data will be aggregated before being reported. If you would like a copy of my final report, please contact me at the number listed near the end of this consent form.

Voluntary Participation: Participation in this research project is voluntary. You can choose freely to participate or not to participate. At any point during this project, you can withdraw your permission and stop participating without any loss of benefits. I recognize that I am the researcher in this project and, at the same time, your teacher. I will ensure that your participation or non-participation in my research project does not impact your grades, class standing, relationship with me, or relationship with San Francisco International High School.

Questions: If you have any questions about this project, contact me, Tiffany Ng, by e-mail at ngt@sfusd.edu.

University of Hawai'i
Assent to Participate in a Research Project - 14 - 17 years of age
Grace Lin, Principal Investigator and Tiffany Ng, Student Investigator
Project Title: Closing Learning Gaps with Online Differentiated Math Lessons

You can also contact my advisor at the University of Hawaii, Dr. Grace Lin, by at e-mail at gracelin@hawaii.edu.

You may contact the UH Human Studies Program at (808) 956-5007 or uhirb@hawaii.edu. To discuss problems, concerns and questions; obtain information; or offer input with an informed individual who is unaffiliated with the specific research protocol. Please visit http://go.hawaii.edu/jRd for more information on your rights as a research participant.

Please keep the section above for your records.

If you assent to be a participant in this project, please sign the signature section below and return it to Ms. Tiffany.

Tear or cut here

Signature(s) for Assent:

I assent to join the research project entitled, *Closing Learning Gaps with Online Differentiated Math Lessons.* I understand that I may change my mind about being in the study at any time.

Name of Participant: _____

Participant's Signature: _____

Date: _____

Thank you!

Figure D2. English Assent Form

University of Hawai'i

Parent/Guardian Consent for their Child to Participate in a Research Project

Grace Lin, Principal Investigator and Tiffany Ng, Student Investigator

Project Title: Closing Learning Gaps with Online Differentiated Math Lessons

مرحبا إسمي تيفاني نغ وأنا أطلب إذنك لطفلك للمشاركة في مشروع بحثي .أنا مدرس في مدرسة سان فرانسيسكو الدولية الثانو. أنا أيضا طالب دراسات عليا في جامعة هاواي في مانوا (يو انتش ام)، في قسم تصميم التعلم والتكنولوجيا .أحد متطلبات الحصول على درجة الماجستير هو القيام بمشروع بحثي .والغرض من مشروع بحثي أن يكون استكشاف استخدام دروس المهارات رياضيات متباينة على الانترنت .وسيركز هذا المشروع على مساعدة الطلاب على تعلم محتوى الرياضيات التي لا يمكن تغطيتها في المناهج العادية، وهذا قد من خلال الرياضيات أنهم لم يتعلموا جيدا في الماضي أو أنها ستكون معاينة الرياضيات سوف يتعلم في وقت لاحق. أنا أطلب إذنك لطفلك للمشاركة في هذا المشروع .وسأطلب أيضا من طفلك إذا وافق على المشاركة في هذا المشروع .

الأنشطة والتزام الوقت :إذا وافقت أنت وطفلك على أن يكون طفلك في الدراسة، سوف نبدي ملاحظات عمل طفلك في الصف وأيضا تحليل العمل الذي يقدم على الانترنت . خلال هذا الوقت، طفلك سوف يعمل على سلسلة من دروس الرياضيات على الانترنت التي تم إنشاؤها على ثلاثة مستويات مختلفة. طفلك سوف يكمل الدروس على مستوى الرياضية الخاصة بهم وعلى وتيرتها. وسوف يكون هذا جزءا من النشاط الطبقي العادي ولن يطلب من طفلك القيام بأي عمل إضافي. الفرق الوحيد هو أنني سوف أراقب وتحليل عمل طفلك وسلوكه في بحثي. أحد الأمثلة على نوع الملاحظات التي سأقدمها هو" :كيف تغيرت درجة رياضيات الطالب بعد العمل من خلال الدروس؟ "إذا كنت ترغب في رؤية نسخة من جميع أدوات المراقبة والأسئلة، يرجى الاتصال بي عن طريق عنوان البريد الإلكتروني المدرجة بالقرب من نهاية نموذج الموافقة هذا.

الفوائد والمخاطر :قد لا تكون هناك فوائد مباشرة لطفلك للمشاركة في مشروع بحثي .نتائج هذا المشروع قد تساعدني، والمعلمين الآخرين، والباحثين معرفة المزيد عن كيفية مساعدة الطلاب على تعلم الرياضيات .وأعتقد أن هناك القليل أو عدم وجود خطر على .طفلك في المشاركة في هذا المشروع

السرية والخصوصية :سأبقي جميع بيانات الدراسة آمنة في خزانة إيداع مؤمن في مكتب مقفل /مشفرة على جهاز كمبيوتر محمي بكلمة مرور .فقط مستشار جامعة هاواي وأنا سوف يكون الوصول إلى المعلومات .وللوكالات الأخرى التي لديها إذن قانوني الحق في مراجعة سجلات البحوث .برنامج الدراسات البشرية بجامعة هاواي لديه الحق في مراجعة السجلات البحثية لهذه الدراسة.

عندما أبلغ عن نتائج مشروعي البحثي في ورقتي المطبوعة، لن أستخدم اسم طفلك أو أي معلومات شخصية أخرى من شأنها أن تحدد طفلك .سيتم تجميع جميع البيانات قبل الإبلاغ عنها .إذا كنت ترغب في الحصول على نسخة من تقريري النهائي، يرجى الاتصال بي على الرقم المدرج قرب نهاية نموذج الموافقة.

المشاركة الطوعية :المشاركة في هذا المشروع البحثي طوعية .يمكن لطفلك أن يختار بحرية المشاركة أو عدم المشاركة .يمكنك أن، تختار بحرية ما إذا كان طفلك قد يشارك في هذا المشروع أم لا .في أي وقت خلال هذا المشروع، يمكنك سحب موافقتك الخاص بك ويمكن لطفلك التوقف عن المشاركة دون أي خسارة من الفوائد .أدرك أنني الباحث في هذا المشروع، وفي الوقت نفسه، معلم طفلك . سوف أضمن أن مشاركة طفلك أو عدم مشاركته في مشروعي البحثي لا يؤثر على درجاته أو صفه الدراسي أو علاقتي مع لي أو علاقتي مع مدرسة سان فرانسيسكو الدولية الثانوية.

أسئلة :إذا كان لديك أي أسئلة حول هذا المشروع، اتصل بي، تيفاني نغ، عن طريق البريد الإلكتروني في
ngt@sfusd.edu
يمكنك أيضا الاتصال مستشار بلدي في جامعة هاواي، الدكتور غريس لين، عن طريق البريد الإلكتروني في
gracelin@hawaii.edu
يمكنك الاتصال ببرنامج الدراسات الإنسانية في أو :(808)956-5007 لمناقشة المشاكل والمخاوف والأسئلة .الحصول على : المعلومات؛ أو تقديم مدخلات مع فرد مطلع غير منتسب لبروتوكول البحث المحدد .يرجى زيارة هذه
لمزيد من المعلومات عن www.hawaii.edu/researchcompliance/information-research-participants //
لمزيد من المعلومات عن حقوقك كمشارك في البحث او:
uhirb@hawaii.edu.

University of Hawai'i

Parent/Guardian Consent for their Child to Participate in a Research Project

Grace Lin, Principal Investigator and Tiffany Ng, Student Investigator

Project Title: Closing Learning Gaps with Online Differentiated Math Lessons

. احتفظ بهذه النسخة من الموافقة المستنيرة الخاصة بسجلاتك ومراجعتك

https://www.hawaii.edu/researchcompliance/information-research-participants

التوقيع (توقيعات) للموافقة:

أعطي الإذن لطفلي للانضمام إلى مشروع بحثي بعنوان "ثغرات التعلم الختامية مع دروس الرياضيات المتميزة عبر الإنترنت ."أنا أفهم أن طفلي يستطيع أن يغير رأيه عن كونه في الدراسة في أي وقت .أنا أفهم أنني قد أغير رأسي عن طفلي يجري في الدراسة في أي وقت

اسم الطفل : _____

اسم ولي الامر /الوصي : _____

توقيع ولي الامر/الوصي: _____

التاريخ : _____

شكرا لكم!

Figure D3. Arabic Consent Form

University of Hawai'i

Assent to Participate in a Research Project - 14 - 17 years of age

Grace Lin, Principal Investigator and Tiffany Ng, Student Investigator

Project Title: Closing Learning Gaps with Online Differentiated Math Lessons

مرحبا !اسمي تيفاني نغ وأنا أطلب إذنك لطفلك للمشاركة في مشروع بحثي .أنا مدرس في مدرسة سان فرانسيسكو الدولية الثانوية . أنا أيضا طالب دراسات عليا في جامعة ھاواي في مانوا (يو انتش ام)في قسم تصميم التعلم والتكنولوجيا .أحد متطلبات الحصول على درجة الماجستير ھو القيام بمشروع بحثي .والغرض من مشروع بحثي أن يكون استكشاف استخدام دروس المھارات رياضيات متباينة على الانترنت .وسيركز ھذا المشروع على مساعدة الطلاب على تعلم محتوى الرياضيات التي لا يمكن تغطيتھا في المناھج . العادية، وھذا قد من خلال الرياضيات أنھم لم يتعلموا جيدا في الماضي أو أنھا ستكون معاينة الرياضيات سوف يتعلم في وقت لاحق أنا أطلب إذنك لطفلك للمشاركة في ھذا المشروع .وسأطلب أيضا من طفلك إذا وافق على المشاركة في ھذا المشروع.

الأنشطة والتزام الوقت :إذا وافقت أنت وطفلك على أن يكون طفلك في الدراسة، سوف نبدي ملاحظات عمل طفلك في الصف وأيضا تحليل العمل الذي يقدم على الانترنت. خلال ھذا الوقت، سوف تعمل على سلسلة من دروس الرياضيات على الانترنت التي تم إنشاؤھا على ثلاثة مستويات مختلفة. سوف تكمل الدروس على المستوى الرياضي الخاص بك وعلى وتيرة الخاصة بك. وسوف يكون ھذا جزءا من النشاط الطبقي العادي ولن يطلب منك القيام بأي عمل إضافي. الفرق الوحيد ھو أنني سوف رصد وتحليل عملك والسلوك البحتي. أحد الأمثلة على نوع الملاحظات التي سأقدمھا ھو" :كيف تغيرت درجة رياضيات الطالب بعد العمل من خلال الدروس؟ "إذا كنت ترغب في رؤية نسخة من جميع أدوات المراقبة والأسئلة، يرجى الاتصال بي عن طريق عنوان البريد الإلكتروني المدرجة بالقرب من نھاية نموذج الموافقة ھذا.

الفوائد والمخاطر :قد لا تكون ھناك فوائد مباشرة لطفلك للمشاركة في مشروع بحثي .نتائج ھذا المشروع قد تساعدني، والمعلمين الآخرين، والباحثين معرفة المزيد عن كيفية مساعدة الطلاب على تعلم الرياضيات .وأعتقد أن ھناك القليل أو عدم وجود خطر على طفلك في المشاركة في ھذا المشروع.

السرية والخصوصية :ستبقى جميع بيانات الدراسة آمنة في خزانة إيداع مؤمن في مكتب مقفل /مشفرة على جھاز كمبيوتر محمي بكلمة مرور .فقط مستشار جامعة ھاواي وأنا سوف يكون الوصول إلى المعلومات .والوكالات الأخرى التي لديھا إذن قانوني الحق في مراجعة سجلات البحوث .برنامج الدراسات البشرية بجامعة ھاواي لديھ الحق في مراجعة السجلات البحثية لھذه الدراسة.

عندما أبلغ عن نتائج مشروعي البحثي في ورقتي المطبوعة، لن أستخدم اسم طفلك أو أي معلومات شخصية أخرى من شأنھا أن تحدد طفلك .سيتم تجميع جميع البيانات قبل الإبلاغ عنھا .إذا كنت ترغب في الحصول على نسخة من تقريري النھائي، يرجى الاتصال بي على الرقم المدرج قرب نھاية نموذج الموافقة.

المشاركة الطوعية :المشاركة في ھذا المشروع البحثي طوعية .يمكن لطفلك أن يختار بحرية المشاركة أو عدم المشاركة .يمكنك أن ، تختار بحرية ما إذا كان طفلك قد يشارك في ھذا المشروع أم لا .في أي وقت خلال ھذا المشروع، يمكنك سحب موافقتك الخاص بك ويمكن لطفلك التوقف عن المشاركة دون أي خسارة من الفوائد .أدرك أنني الباحث في ھذا المشروع، وفي الوقت نفسھ، معلم طفلك . سوف أضمن أن مشاركة طفلك أو عدم مشاركتھ في مشروعي البحثي لا يؤثر على درجاتھ أو صفھ الدراسي أو علاقتي مع لي أو علاقتي مع مدرسة سان فرانسيسكو الدولية الثانوية.

أسئلة :إذا كان لديك أي أسئلة حول ھذا المشروع، اتصل بي، تيفاني نغ، عن طريق البريد الإلكتروني في
ngt@sfusd.edu
يمكنك أيضا الاتصال مستشار بلدي في جامعة ھاواي، الدكتور غريس لين، عن طريق البريد الإلكتروني في
gracelin @hawaii.edu.
يمكنك الاتصال ببرنامج الدراسات الإنسانية في ٪(808)956-5007 لمناقشة المشاكل والمخاوف والأسئلة .الحصول على :المعلومات؛ أو تقديم مدخلات مع فرد مطلع غير منتسب لبروتوكول البحث المحدد .يرجى زيارة ھذه
لمزيد من المعلومات عن // www.hawaii.edu/researchcompliance/information-research-participants
حقوقك كمشارك في البحث او: uhirb@hawaii.edu
احتفظ بھذه النسخة من الموافقة المستيرة الخاصة بسجلاتك ومراجعتك.
https://www.hawaii.edu/researchcompliance/information-research-participants

University of Hawai'i

Assent to Participate in a Research Project - 14 - 17 years of age

Grace Lin, Principal Investigator and Tiffany Ng, Student Investigator

Project Title: Closing Learning Gaps with Online Differentiated Math Lessons

يرجى الاحتفاظ بالقسم أعلاه لسجلاتك.

إذا وافقت على أن تكون مشاركا في هذا المشروع، يرجى التوقيع على قسم التوقيع أدناه وإعادته إلى: Ms. Tiffany

---

المسيل للدموع أو قطع هنا

توقيع (توقيع) للموافقة:

أنا أؤيد الانضمام إلى المشروع البحثي بعنوان "Closing Learning Gaps with Online Differentiated Math Lessons" أنا أفهم أنني قد تغير ذهني عن يجري في الدراسة في أي وقت.

اسم المشترك: _____

توقيع المشارك: _____

التاريخ: _____

شكرا لكم!

Figure D4. Arabic Assent Form

University of Hawai'i

Parent/Guardian Consent for their Child to Participate in a Research Project

Grace Lin, Principal Investigator and Tiffany Ng, Student Investigator

Project Title: Closing Learning Gaps with Online Differentiated Math Lessons

你好!本人名叫 Tiffany Ng。謹此希望得到你同意孩子參加本人的研究項目。本人是三藩市 國際高中的教師，也是夏威夷大學 Mānoa(UHM)分校"學習設計與技術"專業的畢業生。為獲 取碩士學位，本人必須進行一項研究項目。本人的研究項目將探討學生網上差異性數學技巧 學習班的學習情況。該項目專注於幫助因為不能在平常數學課學到數學內容的學生（包括一 些以前沒學過的數學內容，或是預習即將學到的數學內容）。本人謹此請求你同意孩子參加該 研究項目。本人也將請求得到學生的同意。

研究活動和參與時間: 若你本人及孩子均同意參加該研究項目，本人將觀察你孩子的課堂作 業，並分析其在網上繳交的功課。在這段時間裡，您的小孩将会在线学习三个不同的数学课程，并將以自己的數學水平和自己的速度完成課程。這將是普通班級活動的一部分，除此之外，您的小孩不會被要求進行任何其他工作。本人将会在过程中觀察和分析你孩子的学习进度和行為，以便進行研究。本人觀察的其中一個例子將是：這些網 上課程如何改變學生的數學成績？若想了解本人的觀察工具和問題，請使用以下電郵與本人 聯繫（郵址在接近本同意書最後部份）。

得益與風險: 你孩子的參與也許沒有獲得直接得益。但該研究結果將有助本人、其他教師， 以及研究人員了解如何更好幫助學生學習數學的方法。本人相信，你孩子的參與將存在極少 甚至沒有風險。

保密及私隱: 本人將把所有研究數據安全地放置在一配鎖的辦公室的文件櫃裡，並保存在受 密碼保護的電腦裡。只有本人的夏威夷大學的諮詢員及本人方可取得這些數據。其它有法律 許可的機構也有權檢閱這些研究記錄。夏威夷大學的人類研究計劃機構有權檢閱該研究記 錄。

當本人需以打印紙張呈交本人的研究結果時，本人將不會披露你孩子的姓名或任何其它可識 別你孩子的個人資料。所有數據在呈報前將被整合處理。若想獲得本人報告的最終版本，請 使用以下電郵與本人聯繫（郵址在接近本同意書最後部份）。

自願參與: 參與該研究項目純屬自願選擇。你孩子可自由選擇參與與否。在參與過程中，你 可隨時撤銷同意書，你孩子也可以隨時停止參與而不受任何損失。本人認識到，本人是該研 究項目的研究員，同時也是你孩子的教師。但本人可確保，你孩子參與與否將不會影響其成 績、班級排名，以及與本人和三藩市國際高中的關係。

疑問: 若對該研究項目有任何疑問，請聯絡 Tiffany Ng （電郵：ngt@sfusd.edu ）。

你也可聯絡本人在夏威夷大學的研究諮詢員 - Grace Lin 博士（電郵： gracelin@hawaii.edu ）。

欲討論相關問題及提出疑問和顧慮；獲取相關信息；或需與不屬於該研究機構的知情人員提 出反饋意見，請聯絡夏威夷大學的人類研究計劃部門 - Human Studies Program 【電話： (808) 956-5007，或電郵： uhirb@hawaii.edu】。請瀏覽該網址 (https://www.hawaii.edu/researchcompliance/information-research-participants)， 以獲取更多有關研究參與者權益的信息。

請保留該知情同意書作記錄和參考用途。

University of Hawai'i

Parent/Guardian Consent for their Child to Participate in a Research Project

Grace Lin, Principal Investigator and Tiffany Ng, Student Investigator

Project Title: Closing Learning Gaps with Online Differentiated Math Lessons

同意書簽署人:

本人同意孩子參加名為："Closing Learning Gaps with Online Differentiated Math Lessons"（以網上差異性數學課程縮窄學習差距）的研究項目。本人明白，本人孩子在參 與過程中可隨時改變主意。本人也明白，本人可隨時改變孩子參與該項目的主意。

孩子姓名 (請清晰填寫): _____

家長/監護人姓名 (請清晰填寫): _____

家長/監護人簽署: _____

日期: _____

謝謝合作!

Figure D5. Chinese Consent Form

University of Hawai'i

Assent to Participate in a Research Project - 14 - 17 years of age

Grace Lin, Principal Investigator and Tiffany Ng, Student Investigator

Project Title: Closing Learning Gaps with Online Differentiated Math Lessons

你好!本人名叫 Tiffany Ng。謹此邀請你參與本人的研究項目。如你們所知，本人在三藩市 國際高中12 年級預微積分（Pre-Calculus）科目教師 。本人也是夏威夷大學 Mānoa(UHM)分 校"學習設計與技術"專業的畢業生。為獲取碩士學位，本人必須進行一項研究項目。本人 的研究項目將探討網上差異性數學技巧學習班的學習情況。該項目專注於幫助因為不能在平 常數學課學到數學內容的學生（包括一些以前沒學過的數學內容，或是預習即將學到的數學 內容）。

研究活動和參與時間: 若你同意參與該研究項目，本人將觀察你的課堂作業，並分析你在網 上繳交的功課。在此期間，您將會在三個不同層次上開展一系列在線數學課程。您將以自己的數學水平和自己的速度完成課程。這將是普通班級活動的一部分，您不會被要求進行任何其他工作。唯一的區別是我會觀察和分析你的研究工作和行為。本人觀察的其中一個例子將是：這些網上課程如何改變學生的數學成 績？若想了解本人的觀察工具和問題，請使用以下電郵與本人聯繫（郵址在接近本同意書最 後部份）。

得益與風險: 你的參與也許沒有獲得直接得益。但該研究結果將有助本人、其他教師，以及 研究人員了解如何更好幫助學生學習數學的方法。本人相信，你的參與將存在極少甚至沒有 風險。

保密及私隱: 本人將把所有研究數據安全地放置在一配鎖的辦公室的文件櫃裡，並保存在受 密碼保護的電腦裡。只有本人的夏威夷大學的諮詢員及本人方可取得這些數據。其它有法律 許可的機構也有權檢閱這些研究記錄。夏威夷大學的人類研究計劃機構有權檢閱該研究記 錄。

當本人需以打印紙張呈交本人的研究結果時，本人將不會披露你的姓名或任何其它可識別你 的個人資料。所有數據在呈報前將被整合處理。若想獲得本人報告的最終版本，請使用以下 電郵與本人聯繫（郵址在接近本同意書最後部份）。

自願參與: 參與該研究項目純屬自願選擇。你可自由選擇參與與否。在參與過程中，你可隨 時撤銷同意書，或停止參與而不受任何損失。本人認識到，本人是該研究項目的研究員，同 時也是你的教師。但本人可確保，你參與與否將不會影響你的成績、班級排名，以及與本人 和三藩市國際高中的關係。

疑問: 若對該研究項目有任何疑問，請聯絡 Tiffany Ng （電郵：ngt@sfusd.edu ）。

欲討論相關問題及提出疑問和顧慮；獲取相關信息；或需與不屬於該研究機構的知情人員提 出反饋意見，請聯絡夏威夷大學的人類研究計劃部門 - Human Studies Program 【電話： (808) 956-5007，或電郵： uhirb@hawaii.edu】。請瀏覽該網址 (https://www.hawaii.edu/researchcompliance/information-research-participants)， 以獲取更多有關研究參與者權益的信息。

University of Hawai'i

Assent to Participate in a Research Project - 14 - 17 years of age

Grace Lin, Principal Investigator and Tiffany Ng, Student Investigator

Project Title: Closing Learning Gaps with Online Differentiated Math Lessons

請保留以上部份作記錄用途。

若同意參與該研究項目，請在以下部份簽署，並把已簽署部份交回 Ms. Tiffany。

從此處剪開

同意人簽署:

本人同意參加名為："Closing Learning Gaps with Online Differentiated Math Lessons"（以網上差異性數學課程縮窄學習差距）的研究項目。本人明白，本人在參與過 程中可隨時改變主意。

參與者姓名: _____

參與者簽署: _____

日期: _____

謝謝合作!

Figure D6. Chinese Assent Form

University of Hawai'i

Parent/Guardian Consent for their Child to Participate in a Research Project

Grace Lin, Principal Investigator and Tiffany Ng, Student Investigator

Project Title: Closing Learning Gaps with Online Differentiated Math Lessons

¡Hola! Mi nombre es Tiffany Ng y solicito su permiso para que su hijo(a) participe en mi proyecto de investigación. Yo soy una profesora de la escuela secundaria San Francisco International. Además, soy estudiante de posgrado en el Departamento de Diseño y Tecnología Docente de la Universidad de Hawaii en Mānoa (UHM). Un requisito para obtener mi maestría es hacer un proyecto de investigación. El objetivo de mi proyecto de investigación será explorar el uso de lecciones por internet de habilidades para las matemáticas diferenciadas. Este proyecto se centrará en ayudar a los estudiantes a aprender materias de matemáticas que no se pueden enseñar en el plan de estudios regular, esto podría incluir matemáticas que los alumnos no aprendieron bien en el pasado o será una presentación preliminar de las matemáticas que los alumnos aprenderán más adelante. Por lo tanto, solicito su permiso para que su hijo(a) participe en este proyecto. También le solicitaré a su hijo(a) si él (ella) está de acuerdo en participar en este proyecto.

Actividades y compromiso de tiempo para participar: Si usted y su hijo(a) están de acuerdo con que él (ella) participe en el estudio, entonces observaré el trabajo que su hijo(a) realiza en clases y también analizaré el trabajo que presenta a través de la internet. Durante este tiempo, su hijo trabajará en una serie de lecciones de matemáticas en línea creadas en tres niveles diferentes. Su hijo completará las lecciones en su propio nivel matemático y a su propio ritmo. Esto será parte de la actividad normal de la clase y a su hijo no se le pedirá que haga ningún trabajo adicional. La única diferencia es que estaré observando y analizando el trabajo y el comportamiento de su hijo para mi investigación. Un ejemplo del tipo de observaciones que voy a hacer es: "¿Cómo ha cambiado la calificación de matemáticas del estudiante después de trabajar a través de las lecciones?" Si usted desea ver una copia de todas mis técnicas de observación y preguntas, por favor póngase en contacto conmigo a través de la dirección de correo electrónico que aparece cerca del final de este formulario de consentimiento.

Beneficios y Riesgos: Puede que su hijo(a) no obtenga ningún beneficio directo por participar en mi proyecto de investigación. Los resultados de este proyecto podrían ayudarme a mí, a otros profesores, y los investigadores aprenderán más sobre cómo ayudar a los estudiantes a aprender matemáticas. Creo que hay poco o ningún riesgo para su hijo(a) en participar en este proyecto.

Confidencialidad y privacidad: Mantendré todos los datos de la investigación en un archivador privado y guardado bajo llave en una oficina, y dichos datos estarán cifrados o codificados en un computador protegido con contraseña. Sólo mi asesora de la Universidad de Hawaii y yo tendremos acceso a la información. Otros organismos que tienen autorización legal también tienen derecho a revisar los datos de la investigación. El Programa de Estudios Humanísticos de la Universidad de Hawaii también tiene el derecho de revisar los documentos de esta investigación.

Cuando presente los resultados de mi proyecto de investigación en un informe mecanografiado, no usaré el nombre de su hijo(a) ni ninguna otra información personal que podría identificarlo(a). Todos los datos se recopilarán antes de ser presentados en el informe. Si usted desea una copia de mi informe final, por favor llámeme al número de teléfono que aparece cerca del final de este formulario de consentimiento.

University of Hawai'i

Parent/Guardian Consent for their Child to Participate in a Research Project

Grace Lin, Principal Investigator and Tiffany Ng, Student Investigator

Project Title: Closing Learning Gaps with Online Differentiated Math Lessons

Participación Voluntaria: La participación en este proyecto de investigación es voluntaria. Su hijo(a) puede elegir libremente si desea participar o no. Usted puede elegir libremente si desea que su hijo(a) participe o no en este proyecto. Además, en cualquier momento durante el transcurso de este proyecto, usted puede retractarse de su autorización, y entonces su hijo(a) dejará de participar sin ninguna pérdida de beneficios. Reconozco que yo soy la investigadora de este proyecto y, al mismo tiempo, la profesora de su hijo(a). Como tal, garantizó que la participación o no participación de su hijo(a) en mi proyecto de investigación no afecta sus calificaciones, posición en la clase, relación conmigo o con la escuela secundaria San Francisco International.

Preguntas: Si usted tiene alguna pregunta acerca de este proyecto, por favor comuníquese con Tiffany Ng al siguiente correo electrónico: ngt@sfusd.edu.

Usted también puede contactarse con mi asesora en la Universidad de Hawaii, la Dra. Grace Lin, al siguiente correo electrónico: gracelin@hawaii.edu.

Usted además se puede contactar con el Programa de Estudios Humanísticos de la Universidad de Hawaii para conversar sobre problemas, inquietudes y hacer preguntas; obtener información; u ofrecer comentarios a una persona bien informada que está afiliada con el protocolo específico de la investigación al siguiente número de teléfono o correo electrónico, respectivamente: 1-(808)-956-5007 , uhirb@hawaii.edu

Para mayor información sobre sus derechos como participante en esta investigación, por favor visite el siguiente sitio de la red: https://www.hawaii.edu/researchcompliance/informationresearch-participants

Guarde esta copia con la información del consentimiento con sus documentos personales en caso que la necesite como referencia.

Firma(s) para el Consentimiento:

Autorizo a mi hijo(a) para que participe en el proyecto de investigación titulado, "Eliminar las brechas del aprendizaje con clases por internet de matemáticas diferenciadas." Entiendo que mi hijo(a) puede cambiar de parecer en cualquier y decidir no seguir participando en la investigación. También entiendo que yo puedo cambiar de parecer en cualquier momento y decidir que mi hijo(a) no siga participando en la investigación.

Nombre del alumno (En letra de imprenta): _____

Nombre del padre/madre/apoderado (En letra de imprenta): _____

Firma del padre/madre/apoderado: _____

Fecha: _____

¡Muchas gracias!

Figure D7. Spanish Consent Form

University of Hawai'i

Assent to Participate in a Research Project - 14 - 17 years of age

Grace Lin, Principal Investigator and Tiffany Ng, Student Investigator

Project Title: Closing Learning Gaps with Online Differentiated Math Lessons

¡Hola! Mi nombre es Tiffany Ng y te invito a participar en mi proyecto de investigación. Como ya sabes, yo soy tu profesora de pre cálculo en el 12° grado en la escuela secundaria San Francisco International. Además, soy estudiante de posgrado en el Departamento de Diseño y Tecnología Docente de la Universidad de Hawaii en Mānoa (UHM). Un requisito para obtener mi maestría es hacer un proyecto de investigación. El objetivo de mi proyecto de investigación será explorar el uso de lecciones por internet de habilidades para las matemáticas diferenciadas. Este proyecto se centrará en ayudarte a aprender materias de matemáticas que no se pueden enseñar en el plan de estudios regular, esto podría incluir matemáticas que tú no aprendiste bien en el pasado o será una presentación preliminar de las matemáticas que tú aprenderás más adelante

Actividades y compromiso de tiempo para participar: Si estás de acuerdo con participar en el estudio, entonces observaré tu trabajo en clase y también analizaré el trabajo que presentas a través de la internet. Durante este tiempo, trabajará en una serie de lecciones de matemáticas en línea creadas en tres niveles diferentes. Completarás las lecciones en tu propio nivel matemático y a tu propio ritmo. Esto será parte de la actividad de clase normal y no se le pedirá que haga ningún trabajo adicional. La única diferencia es que estaré observando y analizando su trabajo y comportamiento para mi investigación. Un ejemplo del tipo de observaciones que voy a hacer es: "¿Cómo ha cambiado tu calificación de matemáticas después de trabajar a través de las lecciones?" Si deseas ver una copia de todas mis técnicas de observación y preguntas, por favor ponte en contacto conmigo a través de la dirección de correo electrónico que aparece cerca del final de este formulario de consentimiento.

Beneficios y Riesgos: Puede que no obtengas ningún beneficio directo por participar en mi proyecto de investigación. Los resultados de este proyecto podrían ayudarme a mí, a otros profesores, y los investigadores aprenderán más sobre cómo ayudar a los estudiantes a aprender matemáticas. Creo que hay poco o ningún riesgo para ti en participar en este proyecto.

Confidencialidad y privacidad: Mantendré todos los datos de la investigación en un archivador privado y guardado bajo llave en una oficina, y dichos datos estarán cifrados o codificados en un computador protegido con contraseña. Sólo mi asesora de la Universidad de Hawaii y yo tendremos acceso a los datos de la investigación. Otros organismos que tienen autorización legal también tienen derecho a revisar los documentos de la investigación. El Programa de Estudios Humanísticos de la Universidad de Hawaii también tiene el derecho de revisar los documentos de esta investigación.

Cuando presente los resultados de mi proyecto de investigación en un informe mecanografiado, no usaré tu nombre ni ninguna otra información personal que podría identificarte. Todos los datos se recopilarán antes de ser presentados en el informe. Si deseas una copia de mi informe final, por favor llámeme al número de teléfono que aparece cerca del final de este formulario de consentimiento.

Participación Voluntaria: La participación en este proyecto de investigación es voluntaria. Tú puedes elegir libremente si deseas participar o no. En cualquier momento durante el transcurso de este proyecto, tú puedes retractarte de tu autorización, y dejar de participar sin perder ningún beneficio. Reconozco que yo soy la investigadora de este proyecto y, al mismo tiempo, tu profesora. Como tal, garantizó que tú

University of Hawai'i
Assent to Participate in a Research Project - 14 - 17 years of age
Grace Lin, Principal Investigator and Tiffany Ng, Student Investigator
Project Title: Closing Learning Gaps with Online Differentiated Math Lessons

participación o no participación en mi proyecto de investigación no afecta tus calificaciones, posición en la clase, relación conmigo o con la escuela secundaria San Francisco International.

Preguntas: Si tienes alguna pregunta acerca de este proyecto, por favor comunícate conmigo al siguiente correo electrónico: ngt@sfusd.edu.

Tú también puedes contactarte con mi asesora en la Universidad de Hawaii, la Dra. Grace Lin, al siguiente correo electrónico: gracelin@hawaii.edu.

Además, te puedes contactar con el Programa de Estudios Humanísticos de la Universidad de Hawaii para conversar sobre problemas, inquietudes y hacer preguntas; obtener información; u ofrecer comentarios a una persona bien informada que está afiliada con el protocolo específico de la investigación al siguiente número de teléfono o correo electrónico, respectivamente: 1-(808)-956-5007; uhirb@hawaii.edu

Para mayor información sobre tus derechos como participante en esta investigación, por favor visita el siguiente sitio de la red: http://go.hawaii.edu/jRd

Por favor guarda la sección de arriba con tus documentos personales.

Si estás de acuerdo en participar en este proyecto, por favor firma la sección de firmas que aparece a continuación y devuélvela a (llenar aquí).

Cortar aquí

Firma(s) para el consentimiento:

Estoy de acuerdo en participar en el proyecto de investigación titulado, "Eliminar las brechas del aprendizaje con clases por internet de matemáticas diferenciadas." Entiendo que puedo cambiar de parecer en cualquier momento y decidir no seguir participando en la investigación.

Nombre del participante: _____

Firma del participante: _____

Fecha: _____

¡Muchas gracias!

Figure D8. Spanish Assent Form

APPENDIX E
Data from Observation Tools

Table E1

Engagement Data from Teacher Observation Tool

	First 5 Minutes			At 30 Minutes			Last 5 Minutes		
Week 1	Engaged	Disengaged	Both	Engaged	Disengaged	Both	Engaged	Disengaged	Both
Total Students	19	19	19	20	20	20	19	19	19
Tally	16	2	1	16	1	3	17	1	1
Percentage	84.21	10.53	5.26	80	5	15	89.47	5.26	5.26
Week 2	Engaged	Disengaged	Both	Engaged	Disengaged	Both	Engaged	Disengaged	Both
Total Students	24	24	24	24	24	24	15	15	15
Tally	19	1	4	15	3	6	11	3	1
Percentage	79.17	4.17	16.67	62.5	12.5	25	73.33	20	6.67
Week 3	Engaged	Disengaged	Both	Engaged	Disengaged	Both	Engaged	Disengaged	Both
Total Students	23	23	23	23	23	23	23	23	23
Tally	18	0	5	18	2	4	18	2	3
Percentage	78.26	0	21.74	78.26	8.7	17.39	78.26	8.7	13.04
Week 4	Engaged	Disengaged	Both	Engaged	Disengaged	Both	Engaged	Disengaged	Both
Total Students	22	22	22	22	22	22	22	22	22
Tally	16	2	4	16	2	4	11	4	6
Percentage	72.73	9.09	18.18	72.73	9.09	18.18	50	18.18	27.27
All Weeks	Engaged	Disengaged	Both	Engaged	Disengaged	Both	Engaged	Disengaged	Both
Total Students	88	88	88	89	89	89	79	79	79
Tally	69	5	14	65	8	17	57	10	11
Percentage	78.41	5.68	15.91	73.03	8.99	19.10	72.15	12.66	13.92

All Combined Data	Engagement	Disengagement	Both
Total Students	256	256	256
Tally	191	23	42
Percentage	74.61	8.98	16.41

Table E2

Confidence Data from Teacher Observation Tool

	First 5 Minutes			At 30 minutes			Last 5 minutes		
Week 1	Confident	Unconfident	Both	Confident	Unconfident	Both	Confident	Unconfident	Both
Total Students	19	19	19	20	20	20	19	19	19
Tally	1	4	1	9	3	3	6	4	1
Percentage	5.26	21.05	5.26	45	15	15	31.58	21.05	5.26
Week 2	Confident	Unconfident	Both	Confident	Unconfident	Both	Confident	Unconfident	Both
Total Students	24	24	24	24	24	24	15	15	15
Tally	4	0	0	9	5	0	1	0	0
Percentage	16.67	0	0	37.5	20.83	0	6.67	0	0
Week 3	Confident	Unconfident	Both	Confident	Unconfident	Both	Confident	Unconfident	Both
Total Students	23	23	23	23	23	23	23	23	23
Tally	4	0	0	6	1	1	1	6	0
Percentage	17.39	0	0	26.09	4.35	4.35	4.35	26.09	0
Week 4	Confident	Unconfident	Both	Confident	Unconfident	Both	Confident	Unconfident	Both
Total Students	22	22	22	22	22	22	22	22	22
Tally	2	2	0	4	2	1	4	1	0
Percentage	9.09	9.09	0	18.18	9.09	4.55	18.18	4.55	0
All Weeks	Confident	Unconfident	Both	Confident	Unconfident	Both	Confident	Unconfident	Both
Total Students	88	88	88	89	89	89	79	79	79
Tally	11	6	1	28	11	5	12	11	1
Percentage	12.5	6.82	1.14	31.46	12.36	5.62	15.19	13.92	1.27

All Combined Data	Confident	Unconfident	Both
Total Students	86	86	86
Tally	51	28	7
Percentage	59.3	32.56	8.14

APPENDIX F
Data from Student Self-Reflections

Timestamp	What needs to change to help you be more successful?	Do you have any other questions or comments?
1/24/2018 10:20	more practice	none
1/24/2018 10:26	more time to take notes	no
2/12/2018 10:18	I think we should start to do the canvas lesson earlier.	Students need more time to practice. I suggest that students start to learn the lesson earlier.
2/13/2018 8:29	More practices	Your class was great for me
2/13/2018 8:30	I don't think there is anything important to change, everything is good.	I might come back to learn something or finish the lesson in the future.
2/13/2018 8:31	I think we should include more questions to the lessons in order to get more practices.	I think we should spend more time on those lessons, like starting early or extend the time for practice the lessons.
2/13/2018 10:25	I think we should have more time one on one, and maybe review the base of math.	

Figure F1. Student Comments about Needing More Time.

APPENDIX G
Data from Canvas Quiz Scores

Table G1

Averaged Pre-Quiz and Post-Quiz Scores

Average Quiz Scores		
All Pre-Quiz Scores	**All Final Post-Quiz Scores**	**All Post-Quiz Attempts**
3.25	4.711538462	3.678571

Table G2

Lower and Higher Post-Quiz Scores than Pre-Quiz Scores

	Post-Quiz Score Compared to Pre-Quiz		Total Post Quiz Taken
	Lower Post Quiz Scores	Higher Post Quiz Score	
Total	15	222	237
Percent	6.33	93.67	60.61

Table G3

Student Pre-Quiz Scores

	Lessons Completed		**Lessons Viewed**	
	All	**Exclude Pre-Quiz**	**All**	**Not Yet Passed**
Total	5.54	3.13	6.67	1.13
SD	3.4	1.3	3.48	0.65
Range	11	5	*11*	2

Table G4

Grouped Number of Lessons Students Passed or Attempted

	Number of Students			
	Passed			Attempted
Number of Lessons or Quizzes	Lessons	Pre-Quiz	Post-Quiz	Lessons
From 1 to 2	6	15	8	1
From 3 to 5	7	5	16	10
More than 6	11	4	0	13

Note. The number of post-quiz passed does not include students who passed the pre-quiz and retook the post-quiz. Attempted means that students started that lesson but did not or did not have time to pass the quiz.

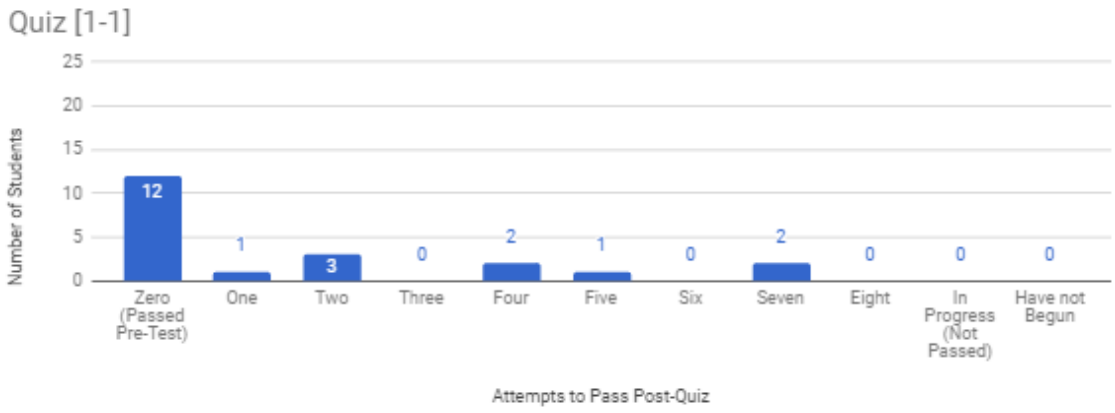


Figure G1. Attempts Students needed to pass Lesson [1-1].

APPENDIX H
Data from Teacher Journal

Week 1:	Observations	Modifications
Set-Up	Set up took a long time. It was difficult for students to create accounts and login	If I were to do it again maybe have students login using google rather than creating an account.
Students	Overall students were engaged	No change.
Lesson	Some students were finished with all 3 lessons or almost finished with all 3 lessons. The timing worked out okay but since so much time was spent on logging in, in the following week when they don't need to create an account and log in they will have extra time left over.	I might need to add an additional lesson for each week.
Student Reflections	Self-reflections were hard to do because some students did not finish a lesson.	Add an option for student who did not complete a lesson.
Canvas Module	1. There were different Canvas specific features that students needed to adjust to and learn 2. Many students wanted to be able to review their quizzes. I originally set Canvas to only let student see their quiz responses once so that they won't just copy the question/answer and pass out b/c they say the answer. However, it does seem like a good way for students to learn from seeing and correcting their mistakes.	I can change it so that students can still view their quiz and incorrect answer but just not see the correct answer.

Week 2:	Observations	Modifications
Set-Up	There were still a lot of login issues. Many student forgot their passwords since it was a week ago. Also, for certain students the login used a "username" rather than their email, which was confusing.	Remind students to write down their username and passwords or email it to themselves. I can also tell students about Canvas' "lost Password?" option. It was pretty easy for most students to use.

Students	Students see this as an individual activity and rather than sitting with their regular group members decided on their own to sit wherever they wanted. This was mainly from 4th period, this caused a lot more students to be distracted and the class environment to be louder.	I'll need to remind students to sit in their seats or sit in an individual location where they can better focus.
Lesson	1. The lesson timing worked pretty well this week for the higher skilled students. I had created an extra lesson for them but maybe because the week 2 lessons were already slightly more difficult than week 1's lessons, there weren't any students that had nothing to do at the end of the class. 2. The "pass quiz" desire is strong for some students and rather than learning the lesson certain students want to pass the pre-quiz so badly they google how to do a topic, learn it, and then try the pre-quiz. This caused them to not even view the lessons.	1. No change. 2. Might need to consider this when viewing pre-quiz scores. Students might have higher pre-quiz scores than if they did not google.
Student Reflections	Fewer response than the previous week. Most responses from students who completed level 1 or level 2 lessons.	No change yet. This might be due to lesson difficulty being increased so less students are finishing lessons to be able to do a reflection.

Week 3:	**Observations**	**Modifications**
Set-Up	There were less login issues. Still had some students struggle but much easier to manage.	If I were to do it again maybe have students login using google rather than creating an account.
Students	Lot more students working together and helping each other this week.	Had to remind students to not help during quizzes.
Lesson	The fractions lesson did not include any teaching on simplifying fractions. Though not required for the lesson, because some practice questions included it, it made it hard for some students to understand.	I thought about adding a page on simplifying fractions but that could not have been done on the spot. I decided to personally explain simplifying fractions to students who struggled. Less than a handful of students needed this support.
Student Reflections	Even fewer comments. Either students don't have enough time to finish a lesson to do the reflection or they're skipping the reflections.	I will need to remind students to do reflections.

Timing	Placement test coming up, 45 minutes per week does not seem to be enough for students. Many students did not have enough time to complete lessons.	Revise day of lesson the following week. Will still do 45 minutes of action research but will give additional days for students to work on the module.

Week 4:	**Observations**	**Reflection & Considerations for Future Lesson & Prototype Designs**
Set-Up	Students know how to use Canvas much better and things are running much smoother.	It takes four weeks for all my students to be able to use Canvas. I wonder if this is the case for most new technology tools or if Canvas is harder to use.
Students	Some student did not want to work on the program. They said they wanted to play a game instead. There was a lot more daydreaming and unfocused students. Students mentioned that it was too hot today.	It might be nice to include more interactive online group math games into the lessons. There were some during the first week but progressively less as the lessons difficulty increased.
Lesson	Some students are a bit overwhelmed not that there are so many lessons that are opened. Since each week 3 lessons are added if students worked on only a few lessons or were absent previously, there seems to be a lot that they did not complete.	Having lessons locked and unlocked when they passed was very helpful for students to be guided. If not they probably would have had a harder time self-selecting which lesson to complete. Now that the data collection is over, it might be nice to have answered revealed to students, that way they can better learn. Also, if I were to do it again, I might only have one quiz rather than a pre and a post quiz. However, for data collection to measure growth, it seems necessary to have both.
Student Reflections	When I reminded students to complete the self-reflections, they said they just want to skip it and move on to another lesson. Only one student did a reflection this week.	Since so little student reflection data was collected for each module, I will add a course reflection using the same google form for the class to complete.
Timing	Due to the placement test approaching at the end of the week, I changed the day we did the action research to an earlier day in the week. It was also done during the end of a 100 minute class rather than a 45 minute class.	This might have contributed to the lack of motivation and increase in frustration this week than the previous weeks. With a 100 minute class, this was very different from the micro learning approach I used to design this course. Also, I'm finding that this course might work better as something students do at home rather than something done in class. Part of the

		benefit of micro learning is the flexibility for learners to access the content when and where they want it rather than during a set time frame.

Figure H1. Summary of Observations and Modification from Teacher's Journal.