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The Effects of Student Constructed Formative Assessment in the Elementary Classroom

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Abstract

This action research project studied how student-created formative assessments in mathematics would affect student confidence and perceived math ability. Students participated in a four-week study. The researcher conducted this study in September and October of 2021. The seven participating students were from an Upper Elementary classroom in a private Southern California Montessori school. The intervention consisted of a student-constructed survey taken weekly and a group analysis of the anonymized data collected from the said survey. Additional data sources included parent surveys, end-of-intervention student surveys, and classwork observational tally sheets. This study found that students gained further awareness of their work choices by completing the student-constructed formative assessments and reviewing the data. In the future, educators could conduct further research regarding the impact of using student-created formative assessment long-term and with a wider variety of subjects.

Keywords: formative assessment, student-constructed, student-created, Montessori

Robust assessments, both formal and informal, are essential to healthy classrooms. For children to thrive, both they and their teacher must have some way to ascertain their learning progress. Throughout the year, teachers give numerous formative assessments to do just that. As a Montessori and constructivist educator, I strive to use many different tools of assessment to recognize the growth and understanding of my students.

I work in a private AMI (Association Montessori Internationale) Montessori school near a major city on the West Coast of the United States. In this school, I work in an Upper Elementary classroom with children ages 9 to 12, most of whom are white and from financially privileged backgrounds. Our community strongly values the work of whole child education yet often requests further data about academic achievement. Traditionally in Montessori classrooms, much of formative assessment is done through observation. Observation creates a good amount of qualitative data to be shared with parents and families. Nevertheless, I sensed a desire for more quantitative information about what progress in their learning children have made, especially in the core subjects of mathematics and language. My school's families do not want testing culture, but they do want to understand the progress their child has made.

In my action research project, I am attempting to split this difference with the children. Much as the children create their own learning, they will work with me to create their own assessment. After the children design and utilize a weekly assessment, we will use the gathered data from one month to analyze and look for trends together. This data is an insight into their current progress. This formative assessment data is created by and for the children. To create a cohesive and efficient research project, I chose to limit my sample size to only my sixth-year students, ages 11 and 12, and focus on mathematics, as it is the subject in which I see considerable desire for concrete, quantitative data, both in parents and children.

This action research project aims to discover whether student-created and student-tracked data can be helpful as a tool of formative assessment in an Upper Elementary Montessori classroom and, if so, provide details of the process for other educators.

Theoretical Framework

The Constructivist Learning Theory or Constructivism is integral to the methodology of my action research. Constructivism is a general theory that several different thinkers influence: John Dewey, Jean Piaget, Maria Montessori, and Jerome Bruner, to name a few. The framing of this specific action research will rely heavily on Lev Vygotsky's influence on constructivism. Vygotsky was a Russian social scientist who came up with the socio-cultural theory in the 1930s (Jaramillo, 1993). Vygotsky's theory predates the naming of constructivism as a learning theory; however, his work was used to create the larger umbrella of constructivist learning theory. For Vygotsky, learning is non-linear and reliant on social and cultural experiences. These learning experiences allow the child to self-discover and self-construct their learning (Jaramillo, 1993). To create learning, the role of a constructivist teacher is to facilitate or guide these learning experiences. As such, the children in a constructivist classroom create meaning for themselves through collaborative, hands-on experiences.

Vygotsky's theories mesh well with my classroom culture. At my school, the teachers are called guides, the classroom is called an environment, and our job is to assist the children in their individual and holistic development. I work at a Montessori school, which is constructivist by its adherence to Montessori principles. However, beyond the day-to-day connection I feel to Vygotsky's work, this framework will help guide my action research project because it directly delivers the intervention method necessary to address the problem. I have noticed that a lack of clear assessments and data creates confusion about the children's academic performance, especially in mathematics. Parents and children are all unsure about what is expected, and many go to outside sources to obtain this information. Vygotsky's theory finds that learning is non-linear much of the time and, as such, common assessment models, such as paper and pencil tests, do not give a complete or accurate view of student understanding. Nor do most common assessment models explore the socio-cultural context of that learning. Instead, using the constructivist learning theory, any intervention needs to be an assessment model that honors the children's social, emotional, and intellectual self-construction.

Using the constructivist learning theory lens, the intervention will hinge on a formative assessment created by the children themselves. The interventions used in this study will be based on Vygotsky's theory that learning is non-linear, rooted in experience, and informed by social and cultural mores. The children will work collaboratively to construct a flexible assessment and analyze the data acquired in community. This work means that the students are not only creating an assessment but a whole socio-cultural experience of assessment. Because the intervention is grounded in a socio-cultural experience and acknowledges the ups and downs of learning, it has the potential to be a strong constructivist approach to formative assessment in mathematics.

Literature Review

Formative assessment takes many forms in different classroom contexts (Dixson & Worrell, 2016; Films Media Group, 2008). Throughout the literature, it became clear that to create a constructivist and systematized formative assessment model that will provide clear data, as is the goal of my intervention, a teacher must have a clear vision of formative assessment within a constructivist philosophy context. Once the teacher has this clarity, they can help to guide the student's learning and assessment experience. This literature review aims to bring clarity of information around formative assessment within a constructivist model, especially as it connects to the Montessori classroom and student understanding.

Defining Formative Assessment

Formative assessment contains multitudes, and a simple definition is challenging to ascertain. Harris (2016), as part of their research, looked through the highlights of the history of formative assessment since the ‘60s. According to Harris, there is no consensus around formative assessment’s implementation, use, and value. Ultimately, they found the term ‘formative assessment’ to refer to both the specific tool being used and the whole process (Harris, 2016). This process could be broken into parts such as having a goal, collecting data, and then using that data to adapt teaching methods to reach the initial goal, it is important to note that this process is frequently teacher-led (Films Media Group, 2008). However, in an interview with Gewertz (2015), Stiggins advocated for more student control and voice in assessment, specifically formative assessment. Stiggins believed that formative assessment is a process through which the children can begin to hone in on what they are supposed to learn.

The formative assessment process is often referred to as ‘feedback.’ However, William (2011) notes that the key to feedback is that it requires a system that not only obtains information but also uses that information moving forward. Quality formative assessment is the gathering of data and the use of that data (Crossouard & Pryor, 2012; William, 2011; Films Media Group, 2008). Formative assessment is a process that helps to gather information about learning that gives both the learner and the educator information to determine the best next steps.

Formative Assessment and the Montessori Classroom

The goal of a Montessori education is the optimal development of the whole child (Marshall, 2017). In Montessori practice, it is imperative that the children themselves choose their work. After the adult has presented how to do a learning activity, the child is invited to work at their own pace and on their own schedule during the offered work time. Through this choice of work, the child begins to create their knowledge and, eventually, the adult they are to become (Montessori, 1966). These child-led learning practices align with larger constructivist thought, as constructivism purports that people make their own understanding, which will differ from person to person (Sharkey & Gash, 2020). As such, each individual is the true expert on their learning in both Montessori and broader constructivist theories (Montessori, 1966; Sharkey & Gash, 2020).

According to Montessori (1966), this self-directed work is to be observed by the guide objectively and scientifically; this observation is used to lead the children onto the next appropriate lesson for the children's development. Observation is a critical assessment tool, not only for Montessori educators but for all educators when using formative assessment (Harris, 2016; Films Media Group, 2008). Observation is a strong starting point for formative assessment, but more varieties of assessment could benefit a classroom by giving further data points (Crumpler, 2017; Films Media Group, 2008).

It is important to note that Montessori classrooms do not end their work with academics. Moral, social, and academic development are all within the purview of the Montessori prepared environment, which works to aid the development of the whole person (Marshall, 2017). Moreover, this focus on the whole child often benefits student motivation (Jansen & Bartell, 2013). So, for any formative assessment to have a meaningful role in a Montessori classroom it must be created with the development of the whole child in mind. One effective method to merge assessment and the development of the whole person is through an assessment model that allows for more student agency (Crumpler, 2017; Gewertz, 2015).

Assessment for Student Self-Construction

According to Dixon and Worrell (2016), formative assessments provide an understanding of student growth when they answer the following questions: “What is working?” “What needs to be improved?" and "How can it be improved?" This clarity of purpose is key to assessments giving valuable potential feedback for all stakeholders, including (but not limited to) teachers, students, and parents. Without clear standards, a formative assessment cannot obtain precise data (Harris, 2016; Gewertz, 2015; Films Media Group, 2008).

For the assessment to honor students' self-construction, there must be more than just clear standards. Students must have access to the assessment in authentic, meaningful ways (Gewertz, 2015). Good formative assessments obtain valuable information about students, excellent formative assessments allow the locus of control to remain with the students and keep the students motivated and believing in their abilities (Gewertz, 2015). This could be done in several ways. Self-reflection and data tracking openly with the students honors the children's' efforts (Crumpler, 2017; Smith-Ellis, 2018). Smith-Ellis (2018) observed more motivation and stamina in their student's work when they tracked the growth of the class through formative assessment. Sharing information with the students is one way the teacher can begin to decenter themselves in the assessment process. This decentering is key to the children feeling genuinely cared for and leads to further motivation in the children, according to Jansen and Bartell (2013).

Crossouard and Pryor (2012) note that this decentering is the recognition that in the process of formative assessment the educator and learner are forever shifting roles. Through effective formative assessment, the learner educates on their knowledge thus far, and as such, the educator learns from the learner where their work must take up (Crossouard & Pryor, 2012). The foundation of constructivism is likewise a shifting of roles: intelligence organizes experiences by organizing itself; then, as more of the world reveals itself to the learner, intelligence must again shift (Sharkey & Gash, 2020). So, perhaps constructivist formative assessment is found in the shifting; it is the moment where the student is teaching on their learning, and the intelligence is reflecting what it has gleaned from its experiences.

Conclusion

Formative assessment often lives somewhere between practice and theory. Strong formative assessments recognize that it is an ongoing process that centers on the students' self-knowledge (Gewertz, 2015). Montessori is a self-directed curriculum. As such, so too must the assessment of that curriculum be self-directed. As children construct their knowledge, they should help construct clear assessments of their work. Much of the literature reviewed focused on the theory behind this work, fewer on the practice of it. Both Harris (2016) and Crossouard & Pryor (2012) specifically noted the problem of educators struggling to match assessment methods with the theories they support. Because collaboration with learners is key to the constructivist and Montessori theories of education, it is perhaps more challenging to find consistent, vital methodologies that work with various learner populations. However, this centering of the learners is essential, both in Montessori philosophy and in formative assessment best practices.

Methodology

Based on my literature review and theoretical framework, it is crucial to honor the whole child, even in assessment models. Therefore, the methodology for the intervention itself should be student-directed. So, for my intervention, sixth-year students created a self-directed formative assessment in mathematics. Then, using the data collected from the assessment, the children and I reviewed and analyzed the progress as a group. The formative assessment created by students was a four-question survey that included both quantitative and qualitative responses; this survey was given to students weekly. At the end of the intervention, the students completed an end-of-intervention survey created by me. Beyond the data collection method and data created by the students, I also created a tally sheet to help observe students' use of work time, filled out once daily by both myself and my classroom's assistant. Parents were also surveyed during the intervention.

Participants

The students participating in the intervention included seven students, all 11 or 12 years old. Three of the students identify as girls, three students identify as boys, and one student identifies as non-binary. All the children included in the study are white, and most are from a privileged financial background. The children are predominantly from the West Coast, though one child has only recently moved to the United States from Europe. Three of the students participating have been in Montessori schools for most, if not all, of their schooling; the rest joined Montessori at the Upper Elementary level (4^{th} – 6^{th} grade). This participant group is a small and selective sample size, so a further study could be done using self-directed formative assessment with a more extensive and more diverse community of children to see how results might compare.

Developing the Formative Assessment

In drafting the assessment, students were first explained the project, that it was being done as part of my master's work, and that the assessment should include some form of quantitative data for later tracking. We discussed potential questions and how to incorporate quantitative data into questions (such as using a 1 to 10 scale). Then the children broke into teams of two (one student was absent that day) to create some questions they would like to see on the assessment. We gathered the next day again with all students present. Coincidentally, some of the questions were, in some form, asked by each group, and these were the questions that ended up making it onto the final draft. The questions are: 1. "How much math did you do this week?" 2. "How much do you enjoy math, on a scale of one to ten?" 3. "Do you feel you are making progress in math, on a scale of one to ten?" 4. "What is your favorite kind of math?" Any researcher or teacher attempting to help their students create their own formative assessment surveys could use these questions as a jumping-off point; however, the final questions should come from the students themselves for an assessment to be truly student-directed.

Data Collection

Each week, the children would respond to these questions on a paper copy of the survey (Appendix A) and bring their survey to me during their Tuesday one-on-one check-in done with each student in the class. The survey was completed for a total of four weeks. In these check-ins, we discuss the child's progress in class, follow-up work that needs to be completed, and any lessons the children would like to request. I noted any mathematics lessons requested during these meetings with the sixth-year students in the intervention. These mathematics lesson requests, or lack thereof, were then compared to their responses on the survey. These check-ins are a measure of accountability in our classroom. The children did not have questions or concerns about the surveys at that time.

Throughout the four weeks of the intervention, my classroom assistant and I tallied the kinds of work being done in the classroom. As children in a Montessori classroom have the freedom to choose their work, this tally process aimed to record the affect (if any) that the intervention had on work choices being made. The tallying happened at different times each day, with the assistant and me tallying at different times to get a truly random sampling. We tallied both the children completing the survey and the rest of the class with the hopes of ascertaining whether the formative assessment affected the classroom beyond the confines of the children actively participating in the intervention. Based on observation, the children were noted on the tally sheet (Appendix B) to be either working on a mathematics-related activity, working on a non-mathematics-related activity, or not actively working.

After four weeks, all the assessments were collated into an anonymized data sheet (Appendix C). The seven children involved with the intervention and I met to review the data. Together we made line graphs charting the changes over time in response to the first question: “How much math did you do this week?” They then split into groups of two and three to create a graph based on one of the other three questions on the survey; each group chose a different question to focus on. One week later, we gathered to review each graph. Together we chose a child to follow along the graph, noting how their responses progressed week to week and how their answers to one question compared to another. The children were observed to be very engaged, with little distractibility while they analyzed the graphed data.

The children were then given an end-of-intervention survey (Appendix D) to complete independently. I asked each child to write in complete sentences. These surveys were completed and given back to me by the end of the school day.

Family Perspectives

Beyond the work with the children, I was also curious to get a fuller picture of the child’s interest and knowledge in mathematics from the family’s perspective. Initially, my goal was to give a parent survey (Appendix E) at both the start and the end of the intervention to see if any shift had occurred in the family’s perception. However, parents struggled to return surveys promptly. Surveys were sent one week prior to the start of the intervention using Google Forms. Only two of the seven families filled the survey out prior to the intervention. After a reminder email and some technical issues, I sent home a paper copy of the survey to the remaining five families. I got the survey back from four of those five, several of them weeks into the assessment. As I no longer had these surveys as baseline data and instead had data from staggered points of the intervention process, I decided not to send a survey to families at the end of the intervention. Instead, the data collected will be analyzed in a more generalized way and compared to see how family perceptions and student self-perceptions compare.

Conclusion

With the tools of data collection used, I hope to learn about the following variables: how parent and student perception of knowledge and interest in mathematics align or diverge; how student perception of their math knowledge and interest aligns or diverges from amount of math happening in the classroom; and what narrative the students themselves see in the data collected from the surveys. As a follow-up to this research, I would be curious to see how this self-directed assessment affected students’ feelings of empowerment, confidence, or anxiety. However, this is beyond the scope of this research project.

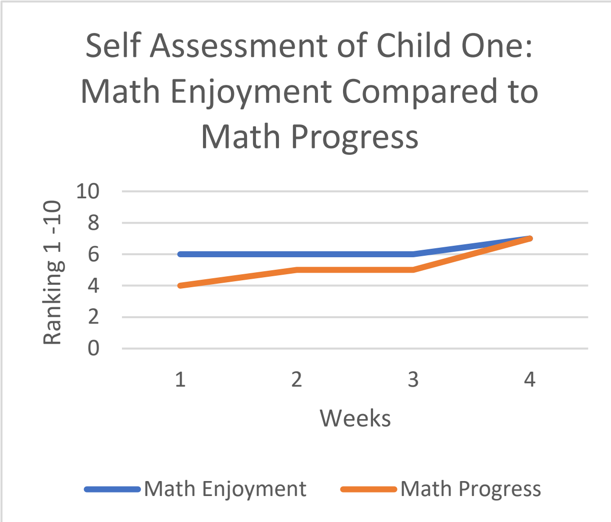
Analysis of Data

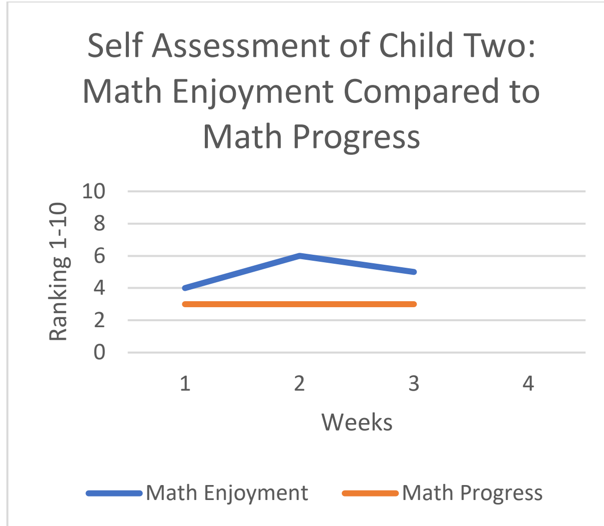
The purpose of this study was to determine what effect regular, student-led formative assessment would have in an Upper Elementary Montessori classroom on sixth-year student and teacher understanding of mathematics confidence and knowledge construction. This study was completed in a private Montessori school in Southern California near a large metropolitan area with seven 11- and 12-year-old students. The study was completed at the very start of the school year within the first five weeks. The children and I worked together to create a weekly survey to examine their relationship with mathematics. At the end of one month, we met again to analyze the data collected, and the students took an end-of-intervention survey. Throughout the intervention, my classroom assistant and I collected data on the different works chosen in the classroom. During the intervention, parents were also surveyed about their understanding of their child's relationship with mathematics to get a complete picture.

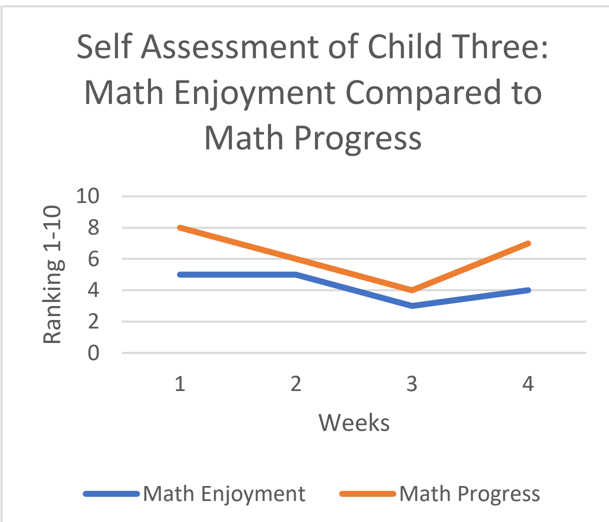
Student-Constructed Survey Results: Individual

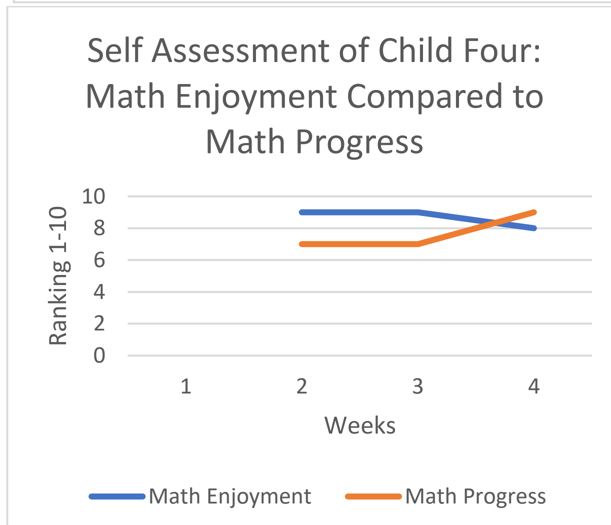
The core of this intervention was the student made formative assessments (Appendix A). These assessments were designed by the students working collectively. The surveys included the following questions: 1. "How much math did you do this week?" This question was ranked on a scale from less than one hour to more than four hours. 2. "How much do you enjoy math, on a scale of one to ten?" 3. "Do you feel you are making progress in math, on a scale of one to ten?" 4. An opened-ended short response question asked – "What is your favorite kind of math?"

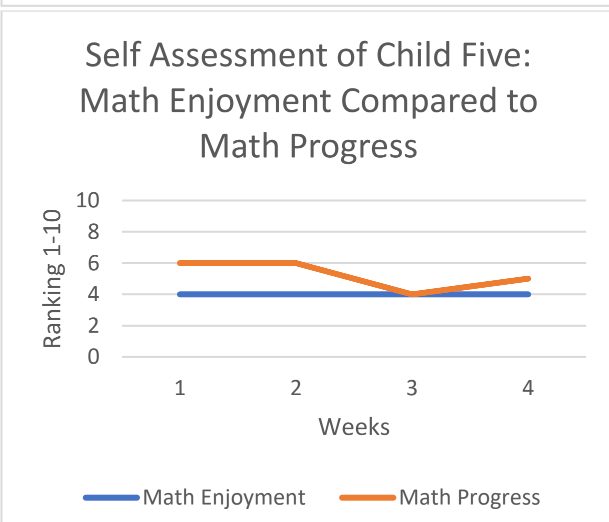
During the assessment collection, the children were asked individually if they had any questions or needed any help with completing the surveys. The children never asked any questions or for further help; they seemed confident in completing their survey. This confidence could connect to the fact that they themselves designed the survey. This potential connection parallels my literature review in which Gewertz (2015) notes that formative assessment which centers learners bolsters student belief in their abilities. Though the experience of taking the survey was similar for all seven students in this regard, the assessments themselves show the difference in each child's experience with mathematics (See Figures 1, 2, 3, 4, 5, 6, and 7).

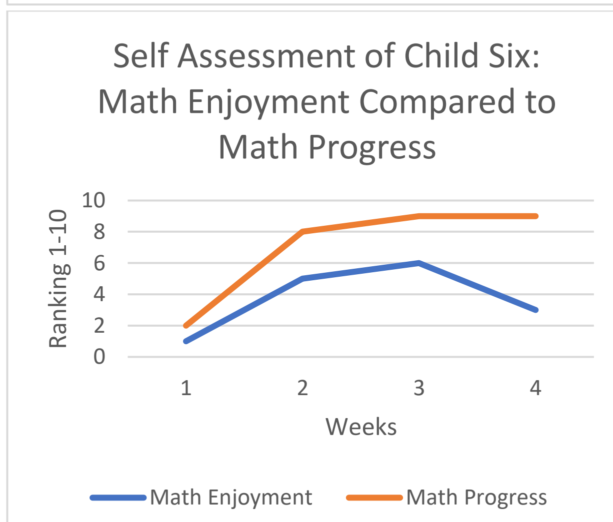

Self Assessment of Child One: Math Enjoyment Compared to Math Progress
Ranking 1 -10
10
8
6
4
2
0
1
2
3
4
Weeks
Math Enjoyment
Math Progress

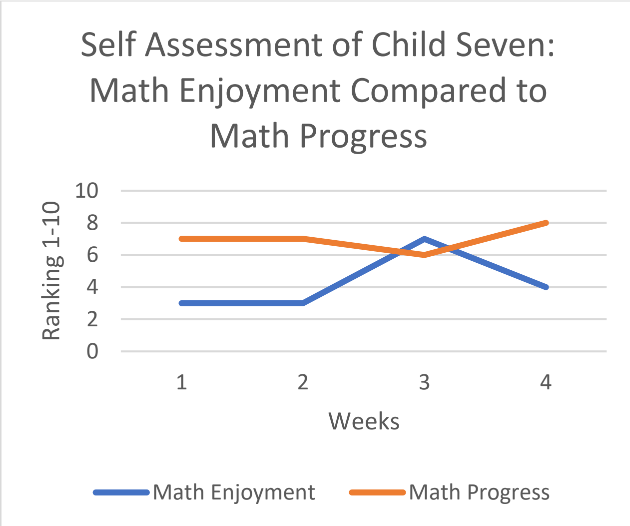

Self Assessment of Child Two: Math Enjoyment Compared to Math Progress
Ranking 1-10
10
8
6
4
2
0
1
2
3
4
Weeks
Math Enjoyment
Math Progress


Self Assessment of Child Three: Math Enjoyment Compared to Math Progress
Ranking 1-10
10
8
6
4
2
0
1
2
3
4
Weeks
Math Enjoyment
Math Progress


Self Assessment of Child Four: Math Enjoyment Compared to Math Progress
Ranking 1-10
10
8
6
4
2
0
1
2
3
4
Weeks
Math Enjoyment
Math Progress


Self Assessment of Child Five: Math Enjoyment Compared to Math Progress
Ranking 1-10
10
8
6
4
2
0
1
2
3
4
Weeks
Math Enjoyment
Math Progress


Self Assessment of Child Six: Math Enjoyment Compared to Math Progress
Ranking 1-10
10
8
6
4
2
0
1
2
3
4
Weeks
Math Enjoyment
Math Progress



Figures 1, 2, 3, 4, 5, 6, and 7. Self-assessed formative assessment comparison between the responses to questions "How much do you enjoy math on a scale of 1 to 10?" and "Do you feel you are making progress in math on a scale of 1 to 10?"

Above are the graphs of individual responses for each child who participated in the creating and using the self-assessments. These charts demonstrate how the children's perception of their enjoyment of and progress in mathematics shifted throughout the month of the intervention. These charts indicate that the children are split on whether they feel more positively about their progress or their enjoyment of mathematics; however, the children are relatively stable within themselves about which is more substantial. Only twice in all 26 total surveys given did an individual child switch which is higher, progress or enjoyment (Child 4 on Week 4 and Child 7 on Week 3); other than that, the stronger of the two remains. Also, only twice in all 26 total surveys did the perceived progress and enjoyment of mathematics match up (Child 1 on Week 4 and Child 5 on Week 3). As all four of these fluctuations from the norm take place on a later week, week three or four of the intervention, these changes in attitude could be due to the intervention itself.

Six of the seven children felt their progress stagnated from weeks two to three, either giving the same ranking or ranking their progress lower on week three than week two. All children who completed a survey on week four saw a higher ranking of perceived progress from week three to week four. Another researcher might find value in maintaining this intervention beyond a month to see if this upward trajectory continued throughout a more extended period; however, as is, this data is not enough to make any conclusive argument. This data aligns with the previous findings from Smith-Ellis (2018), who observed more progress over time as students completed assessments. This intervention was completed during the first few weeks of the school year. As such, the fluctuations could be because students are back at school after having spent months away from school for the summer.

Question: What is your favorite kind of math?	Week 1	Week 2	Week 3	Week 4
Child 1	No Response	**Division**	**Division**	**Addition of Fractions**
Child 2	Addition and Subtraction	Addition and **Multiplication**	Addition and **Multiplication**	No Response
Child 3	**Multiplication**	**Multiplication**	Addition	**Multiplication**
Child 4	No Response	Mode, Median, and Mean	PEMDAS	PEMDAS
Child 5	**Geometry**	No Response	None	**Flashcards**
Child 6	**Multiplication**	**Division**	**Multiplication**	Addition or **Multiplication**
Child 7	No Response	**Long Multiplication**	**Long Division**	**Long Division**

Figure 8. Reponses to the question "What is your favorite kind of math?" Any responses that match up with lessons being given in class during the month of the intervention have been bolded.

The survey also looked at the qualitative data of favorite subjects in mathematics. Figure 8 shows that six of the seven children chose a concept that they were currently working on in class and had been given as a lesson as their favorite math work. The only child that did not choose as a favorite mathematical concept one currently being given as lessons in the classroom during the duration of the intervention was Child 4. Child 4 also had the highest rankings of enjoyment and perceived progress in mathematics, according to Figure 4 when compared with Figures 1, 2, 3, 5, 6, and 7. Perhaps their confidence and enjoyment of math motivated them to look beyond the lessons given in class at the time of intervention leading them to practice and enjoy math in a more independent way.

Overall, the individual survey results suggest that though each child has a unique relationship to mathematics, some trends emerged. These include a strong understanding of self, confidence in their responses, and that the lessons given in the classroom likely impact the kinds of math students enjoy doing.

Student-Constructed Survey Results: Averaged Group

In addition to analyzing individual student responses, I averaged this data across the four collection weeks to better look at trends across the participant group.

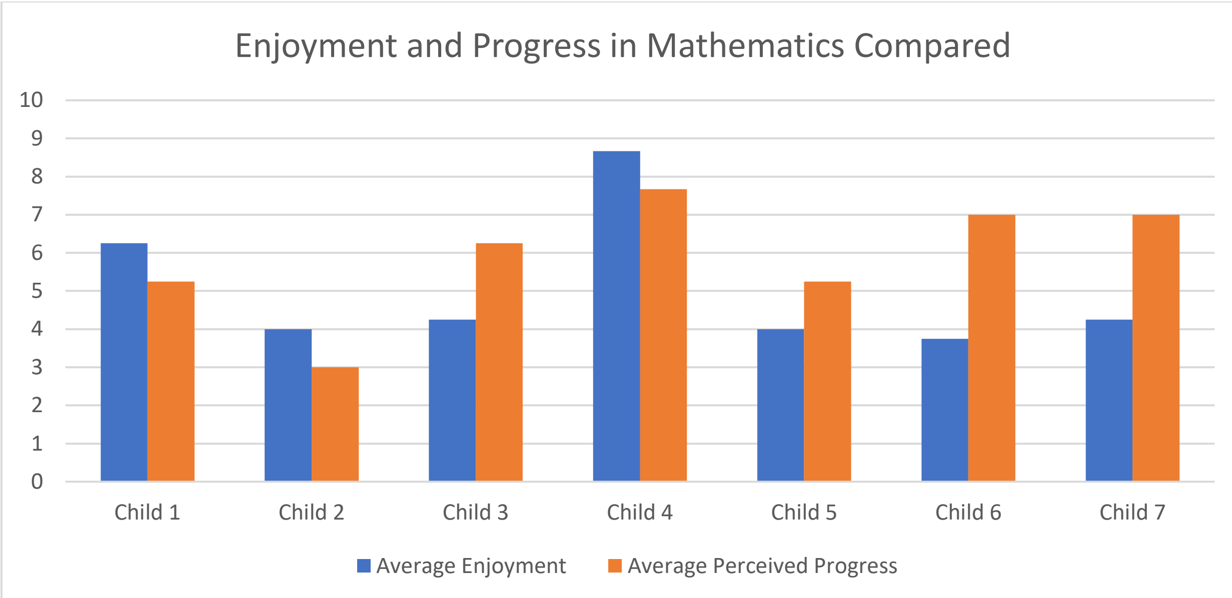


Figure 9. Four weeks averaging of each child's ranking of their enjoyment in mathematics and their perceived progress compared.

This chart shows again the split between children's perceived enjoyment and progress in math. Much like in Figures 1 through 7, we can see that each child's relationship to mathematics is unique. However, Figure 9 indicates that if a child's enjoyment is more than perceived progress, the difference between the two is slight (around one ranking point). In contrast, if the child's perceived progress is higher than enjoyment, the difference between the two may be wider (as much as three ranking points). It is possible that if perceived interest is high, it follows that more progress will be made, as the child may feel more internally motivated to practice mathematics.

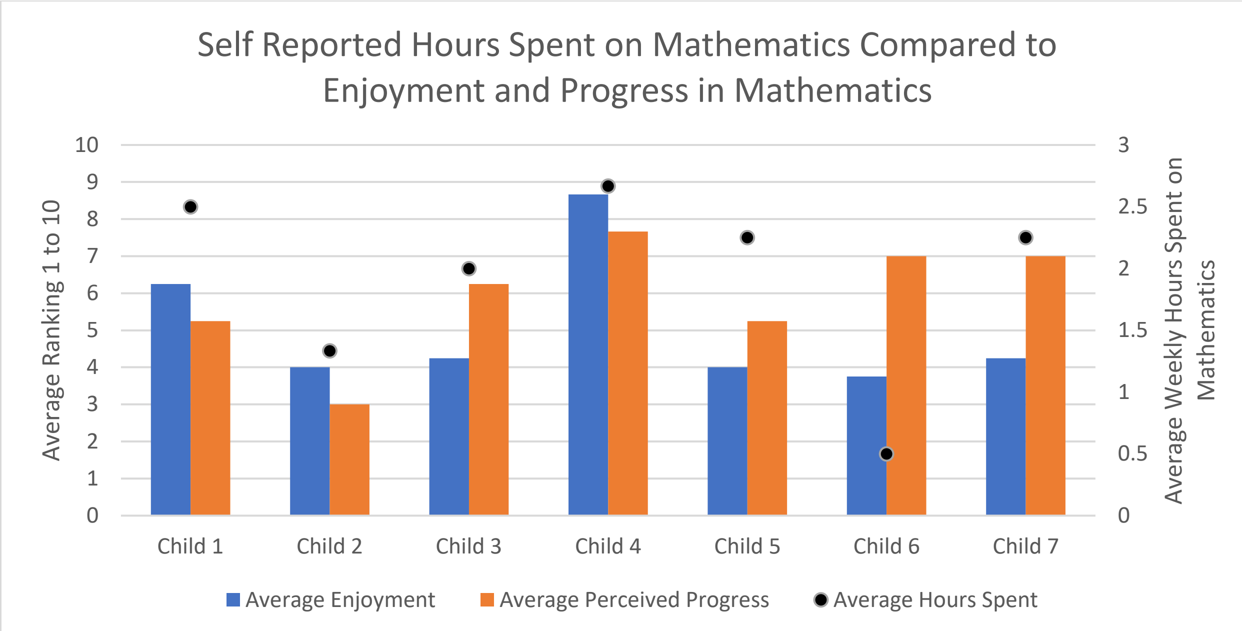


Figure 10. Four weeks averaging of each child's ranking of their enjoyment in mathematics and their perceived progress compared. This bar graph is overlaid with the four weeks average weekly hours spent on mathematics of each child, as shown by black dots. The hours spent can be found on the second y-axis.

Figure 10 illustrates that those who averaged more time spent on math work also often perceived themselves to be making more progress on average. However, Child One and Child Six do not follow this pattern. Child One reported the second highest average time spent working on math yet has the third lowest belief in their progress. However, they also have the second highest enjoyment of math, which may account for a high average amount of time spent on mathematics. Child Six reported the second highest in their sense of progress while also reporting the lowest amount of time spent on math work. Child Six also indicated both the lowest enjoyment of math and the lowest time spent on mathematics of any student. For these two children, instead of their average perceived progress aligning with their average time spent on math, it appears that their average time spent on math is better aligned with their average enjoyment of math. Further research could be done into the connection between students' feelings towards math, time spent on math work, and perceived progress on math work.

According to this data, the relationship between perceived progress and time spent on mathematics is strong. The data also supports that for children who enjoy math more than they sense progress, progress is tied to that enjoyment, while for children who feel they are making progress more than they enjoy math, those two things correlate less.

Student-Constructed Survey Effects and Outcomes

Throughout the intervention weeks, both my classroom assistant and I tallied once daily the observed work choices of the students using a tally sheet (Appendix B). This tallying was done at randomized times throughout the morning and afternoon work cycles. This data is meant to serve as a snapshot of the types of work chosen by students throughout the intervention.

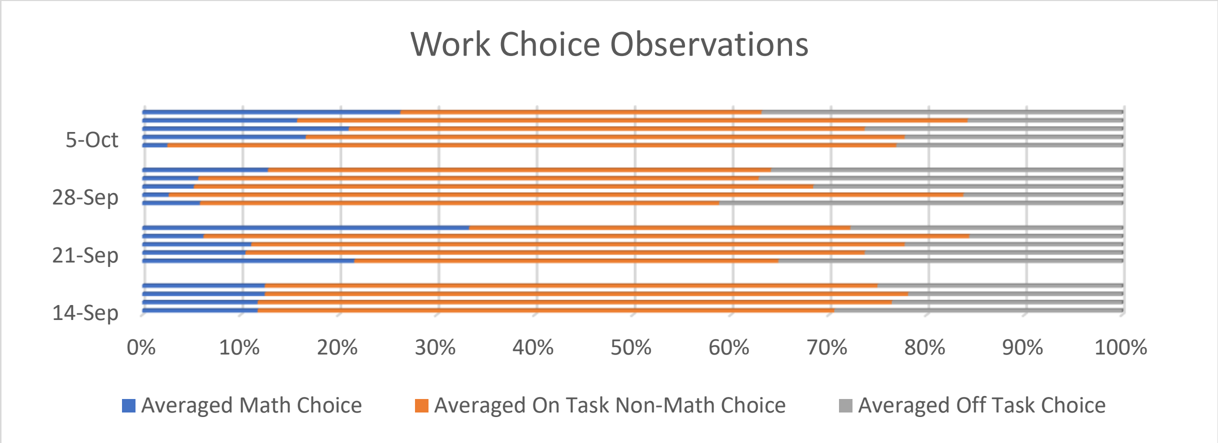


Figure 11. Averaged choice tallies as a percentage of work being done during independent work time. Tallies were completed by myself and my classroom assistant throughout the month-long intervention.

On each day of the intervention, the most popular choice was work that was on task, but not mathematics. Our classroom covers various topics and subject areas, so many different works can be considered on task. However, four days stand out as having over 20% of students working on math-related tasks. All the days with at least 20% of the classroom working on math work were days where at least one math lesson was given. The day with over 30% of the classroom working on mathematics, I gave four math lessons in one day. This was the highest number of math lessons I had given in one day this whole school year.

The student-created formative assessment was given on Tuesdays (the labeled day on the y-axis), a day I often give very few (1 or 0) lessons because I am spending most of my day doing one-on-one check ins with each student. However, the children do not seem to do math either more or less on Tuesdays than any other day. Fridays seem to be the most popular day of the week to do math compared with the other days. According to Figure 11, there is no strong connection between the surveys given and a change in overall work choices being made in the classroom. At least, there does not appear to be, based on this small snapshot of work choices being made, a more in-depth tallying and observation methodology may yield further data on this point.

After four weeks of taking the survey, the children were given anonymized data from the surveys (Appendix C). After having practiced with the children, small groups of children made charts in response to one of the questions on the survey. Together, we compared and analyzed these graphs. Each child took a turn to help ‘tell the story’ of one of the children’s month of mathematical assessment. This data tracking or analysis was done as a way of further decentering the teacher, which is key to student-led assessments per Jansen and Bartell (2013). The students quickly took to the idea and were adept at reading the graphs. The children discussed different reasons why a student’s survey may have shifted the way it did. All seven children were able to participate in this post-mortem. Further study would need to be done on how this type of data analysis affects student learning. Though both the positive experience of my students and Smith-Ellis' (2018) experience of increased student motivation when data is shared shows promise.

Six of the seven children (one child was quarantined due to the Covid-19 pandemic and could not participate in the end-of-intervention survey) took an end-of-intervention survey (Appendix D). This survey asked the following short answer questions: 1. "How did it feel to reflect on mathematics weekly?" 2. "Do you think your relationship with mathematics changed during the last month? Why or why not?" 3. "How was your understanding of your personal mathematical progress affected by taking a weekly survey?" 4. The survey ended by asking for any further comments or thoughts on the process.

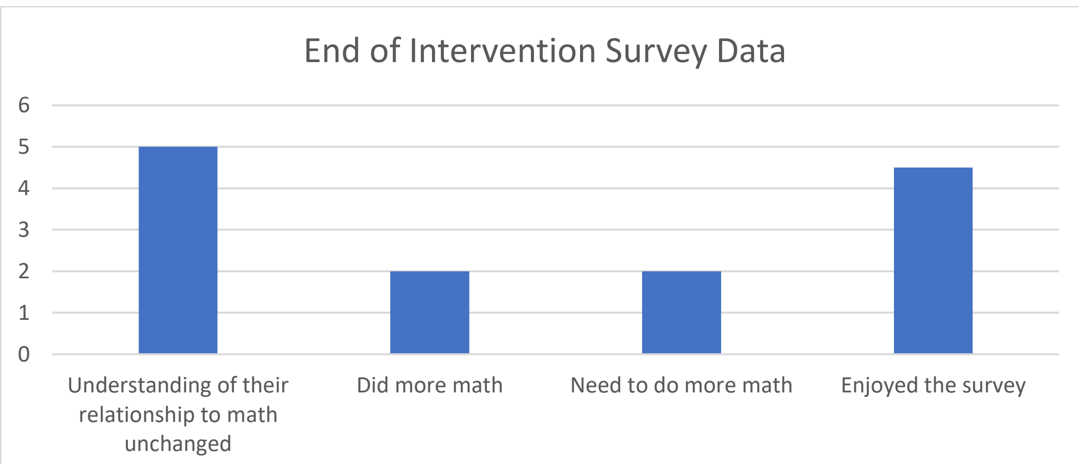


Figure 12. End of intervention survey responses made by more than one participant.

This chart illustrates that most of the student participants enjoyed taking the survey, though they felt it did not change their understanding of their relationship to mathematics. However, two children felt they did more math than they otherwise would have because of the survey and two children noted that the survey made them feel they needed to do more math. Perhaps this shows that though the children did not feel their understanding of their relationship to mathematics had changed, it did make them more aware of it.

According to data collected, the children of our classroom chose a variety of work through the month of the intervention. According to Figure 11, work choices were more likely to be math when math lessons were given that day. The sixth-year children expressed enjoyment in reflecting on their mathematics practice, both in their observed interested in the data analysis work. Over half the students surveyed made note that they enjoyed doing the weekly assessments.

Parent Knowledge

Initially, I planned to survey parents prior to and after the intervention using the same survey (Appendix E). However, there were some technical issues, and parents struggled to get the survey back to me in a timely manner, so I decided to instead rely on one parent survey that was responded to throughout the duration of the intervention. Note that I did not get a survey back from one family, and, as such, they will not be included in the graphs.

The parent survey included questions on their perceived understanding of their child's enjoyment of mathematics, their child's mathematics knowledge, and the frequency with which their child chooses mathematics work. The parent survey was written prior to the student-created assessment. As such, it uses a different ranking system. The parent survey is on a strongly agree to strongly disagree ranking, rather than 1 to 10 as much of the student survey was. To compare the two surveys, I gave the parent responses numerical value, as follows: strongly agree 10, agree 7.5, neutral 5, disagree 2.5, and strongly disagree 0. I was then able to collate and compare the data between the parent's assessment and the student's self-assessment.

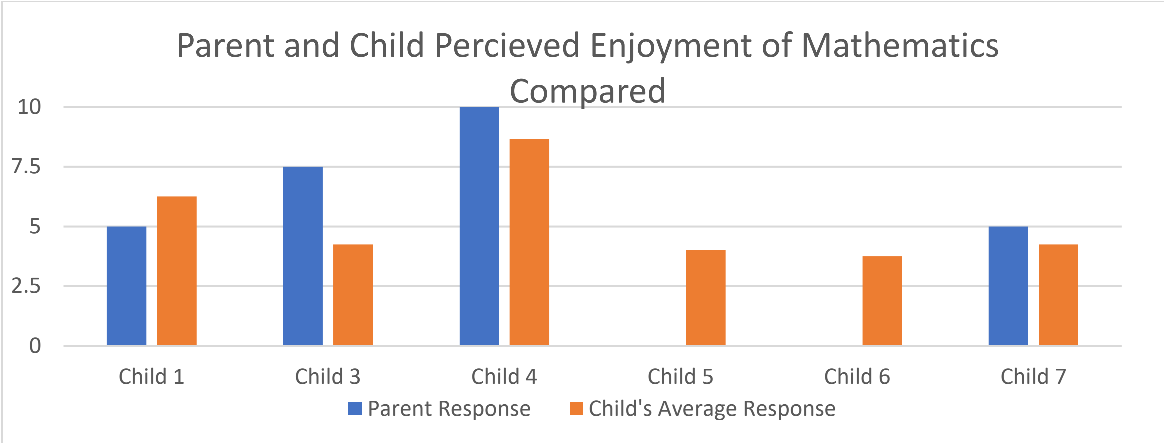


Figure 13. Student responses based on averaged self-assessment survey responses and parent responses based on the response to the following prompt "My child enjoys working on mathematics."

The data indicates that most parents have a relatively good understanding of their child's interest in math. However, two families felt their child "strongly disliked" math when their averaged child's self-assessment showed the child to have more interest in math than parents perceived and that these children were instead ranking relatively consistently with their peers. However, math can be a challenge for these two children, and both have had rather emotional responses to math in the past. Perhaps these emotions only give part of the story, though it may be the story that most affects their parents.

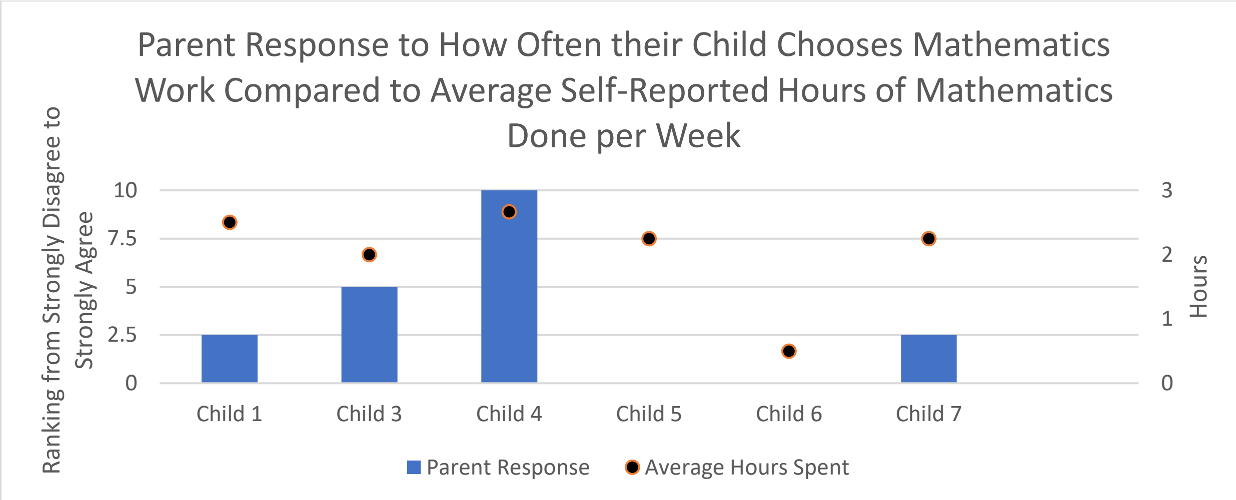


Figure 14. Parent's response to the prompt "My child often chooses mathematics work" as compared to the reported averaged weekly hours of math work for each student. Note that there are two different y-axes.

In Figure 14, we can see that five of the six parents underestimated how often their child chooses math compared to the average amount of time doing math work self-reported by students. If Figure 11 is only a snapshot of the classroom, it is important to remember that parents also have their own limited snapshot of their child's work. Parents may not observe mathematics work being chosen at home or may not hear stories from their children about mathematics work being done at school, so their perception is potentially skewed.

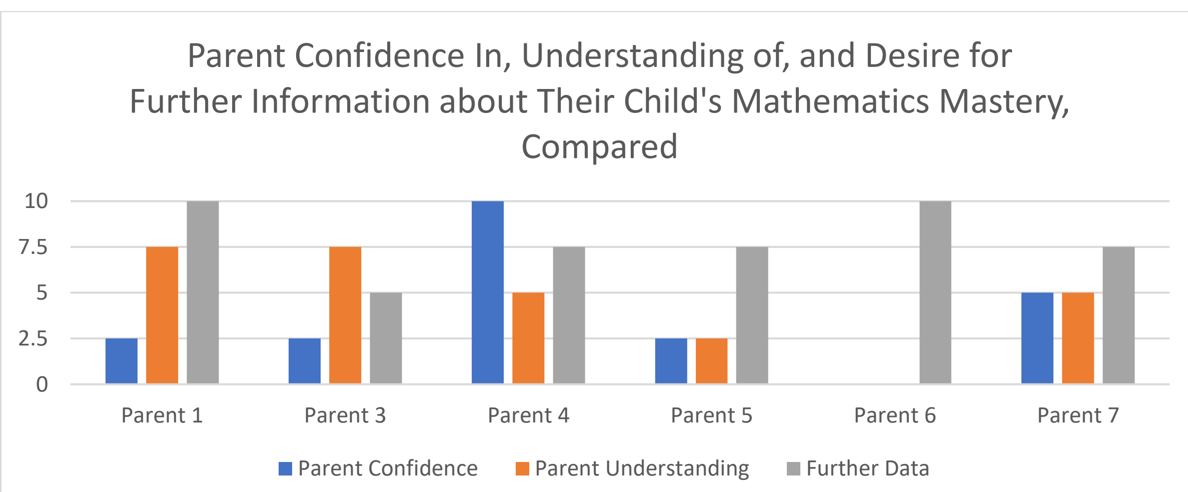


Figure 15. Comparing parent responses to the following prompts: "I feel confident in my child's mathematics knowledge," "I understand my child's mastery of mathematics," and "I would like further quantitative and qualitative data on my child's understanding of mathematics."

Per Figure 15, all parents felt neutral or agreed with the desire to receive more information about their child's mathematics work. Five out of six parents surveyed felt neutral or negative confidence levels in their child's mathematics ability. Whereas the parents felt quite split on their understanding of their child's mathematics mastery. However, in looking at Figures 13 and 14, it is clear there is some room for growth in helping parents better understand their child's mathematics work. According to Figure 13, though many parents have a relatively good idea of their child's interest in mathematics; according to Figure 14, most are unaware of the time their child is putting into mathematics throughout the week, as self-assessed by the students.

It is beyond the purview of this study to determine how further data given to parents would affect the student's mathematics work but could be an area for future study. All in all, parents generally want more information, and the data shows that the information they do have does not fully align with the perceptions of the children themselves.

Conclusion

This intervention gave me a strong understanding of the children's own sense of their mathematics relationship and journey. These formative assessments offered much valuable feedback on the work of the children. Nevertheless, it did not seem to encourage additional math work for many participants, and the work choices made in the classroom broadly seem unaffected by the survey. However, two of the children noted it made them work more on math, while two others said that though it made them aware of that need, they did not take the next step to do more math work. Moreover, as shown in Figure 10, the amount of time spent on mathematics strongly correlates to perceived progress on the self-assessment. Perhaps for student-created formative assessments to help children progress in mathematics through further work time, that link needs to be made more explicit, as this type of intervention may bring awareness but not give clear next steps for all children.

Many of the trends mirrored what was happening in the classroom, as discussed with Figures 8 and 11. This research has helped me see the affect I can have on the classroom work choices based on lessons given and that giving the children time to reflect on their work, though it may not affect their relationship to mathematics, may help them be more aware of it. Additionally, most participants said they enjoyed the experience of taking the weekly student-created formative assessment, and they had confidence in their ability to do so effectively. For parents, the surveys could provide data that may lead to better understand of their child's choices and abilities. Though the children did not feel their understanding of their relationship towards mathematics changed throughout the intervention, their relationship with mathematics itself did change. Looking at Figures 1 through 7 we can see that no relationship with mathematics was completely steady or stagnant. This is a reminder that all relationships have room to change, even with the children who most hate or most feel stuck in mathematics.

Discussion and Action Plan

This study attempted to determine how sixth-year student and teacher understanding of mathematics confidence and knowledge construction would be affected by regular, student-led formative assessment in an Upper Elementary Montessori classroom. For this study, I worked with seven different students, my entire sixth-year population, to create a survey. Each week of the intervention, the students took the survey individually and handed it in at their once weekly one-on-one check-in. This time gave the students a chance to reflect on their mathematics work. At the end of the intervention, the students and I looked over the anonymized data and analyzed it together. The children were interested and engaged in this data analysis work and most of the children said they enjoyed the process of taking the weekly survey they created.

In addition to the student-created self-assessment, other tools of data collection were used in this intervention to give a fuller picture. Parents of the students completed a survey about their sixth-year child's relationship to mathematics. My classroom assistant and I tallied daily the work choices being made in the classroom. Lastly, the children took an open-ended end-of-intervention survey to determine their feelings about the past month's assessment taking. With these other data collection methods, I was able to get a clearer picture of how the intervention affected the children's understanding of their mathematics work and relationship to it.

When looking at each child's responses to the survey, it becomes clear that each child has their own unique, slightly shifting relationship to mathematics. However, within themselves, they have a clear view of this relationship. This can be seen in both the steadfastness with which each child maintains either a higher progress or enjoyment score (see Figures 1 to 7) and in the end-of-intervention survey responses which overwhelmingly showed a belief that their understanding of their relationship to mathematics had remained unchanged through the course of the intervention (see Figure 12).

Nevertheless, though each individual child's relationship to mathematics was distinctively their own, some patterns emerged. The data showed that mathematics lessons being given in the classroom impacted most of the children's interest in mathematics. This is significant because in a Montessori classroom the children are free to choose their own work and could easily choose mathematics work that came from sources other than the current lessons being given. Yet, the children responded to the question of their favorite area of mathematics on the survey predominantly with lessons being given in the classroom and mathematics work choices were more commonly seen being made by children on days when mathematics lessons were given in the classroom (See Figures 8 and 11).

This connection between lessons and time spent on mathematics is important to note as the data collected indicated that children who spent more time on mathematics per week felt a stronger sense of progress in their mathematics work than those who spent less time on their mathematics work. Across the children in the intervention, this correlation was stronger between enjoyment and time spent on mathematics (See Figure 10). However, this perceived progress seems to have little effect on the enjoyment of mathematics.

All in all, not only did I gain valuable insight from the formative assessment, but according to data collected, many students enjoyed taking the survey, were interested to learn the results, and most parents would like further data as well (See Figure 12 and 15).

This action research project was intentionally limited in scope to dig deeper in a specific topic with a specific group of students. However, the literature and my intervention's resulting data encourage me to further explore formative assessment with a somewhat broader scope.

While initially researching the topic of student-constructed formative assessment, it became clear the value of formative assessment to a healthy classroom. Formative assessment allows the teacher to understand the learner's knowledge construction better (Harris, 2015). Traditionally in the Montessori classroom, we predominately rely on observation as the basis of our formative assessments. While observation is hugely valuable, alone it is limited, and a wider variety of assessment models can benefit a classroom (Crumpler, 2017). One of the key challenges with observational assessment is that the locus of controlling the assessment model remains with the teacher yet giving students independence and control over their own learning is core to the Montessori method. So, allowing students to create their own assessment model gives them a chance to practice self-efficacy and aids in the development in the child as a whole; this is a natural fit in a Montessori classroom (Gewertz, 2015). Smith-Ellis (2018) particularly discussed the value of students creating self-assessments and its role in increasing motivation and guiding self-reflection in the learner. Much of this research came to fruition in this work.

The week with the most consistent upward swing of both sense of progress and enjoyment of mathematics for the students was from week three to week four. This growth was exciting, but week four was the end of the intervention. As such, moving forward I would be interested to broaden the use of a student-created assessment for more than just one month's time. It would be fascinating to see if the momentum upwards would continue, as the last week of data collection and literature seem to indicate. Beyond that, I feel this is an intervention that could benefit more than just sixth-years and could be introduced to the whole class effectively.

As an educator, it was helpful to get information on the perceptions of my students' learning in a specific way weekly. Our weekly check-ins are a valuable time to discuss the goings-on of the classroom, but these deeper, quantifiable investigations into their relationship with a particular area of study is harder to do through mere conversation or observation. These surveys could be one additional tool to get a view into a student's progress. Because of this, I question the value of creating too broad a topic for student surveys, though I do believe learning about student perceptions beyond mathematics would be beneficial. Perhaps this means the student-created assessments could cover a few different ‘need-to-know’ subjects or one subject could be covered and then every couple of months the topic of the assessments could shift.

Beyond the benefit of the data for the teacher, the data can also be shared with the children and caregivers. The students were interested to see the data collected and seemed to enjoy digging into the changes in perceptions over time. Parents, too, desire more information on their student’s progress. Parents and students would likely benefit from having another window into their child or peers’ learning, even if only to note the uniqueness of each learner’s sense of progress.

Overall, the intervention led me to see the value of multiple formative assessment models in a classroom, that data can be effectively student led, and that the dissemination of that data to students is a worthy use of time. I feel that student-created self-assessments had a positive effect on my classroom and that broadening the student participant pool and lengthening the timeframe of assessment use would make these positive effects more pronounced.

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Appendix A

Student-Created Weekly Mathematics Survey

Name ____ Date______________________

How much math did you do this week? (Circle below)
<1 hour about 1 hour about 2 hours about 3 hours about 4 hours >4 hours

How much do you enjoy math on a scale of 1 to 10? (Circle below)
One being I do not like math at all, 10 being I love math.
1 2 3 4 5 6 7 8 9 10

Do you feel you are making progress in math on a scale of 1 to 10? (Circle below)
One being I am making no progress, 10 being I am progressing very well.
1 2 3 4 5 6 7 8 9 10

What is your favorite kind of math?

Appendix B

Observational Tally Sheet Used by Myself and my Classroom Assistant

Daily Tally Math Work Choice:	Date: On Task, Non-Math:	Time: Off Task:
Daily Tally Math Work Choice:	Date: On Task, Non-Math:	Time: Off Task:
Daily Tally Math Work Choice:	Date: On Task, Non-Math:	Time: Off Task:

Appendix C

Final Anonymized Data Sheets

Question: How much math did you do this week?	Week 1	Week 2	Week 3	Week 4
Child 1	About 1 hour	About 2 hours	About 3 hours	About 4 hours
Child 2	About 1 hour	About 2 hours	About 1 hour	No Response
Child 3	About 3 hours	About 3 hours	About 2 hours	Less than 1 hour
Child 4	No Response	About 2 hours	About 3 hours	About 3 hours
Child 5	About 2 hours	About 2 hours	About 2 hours	About 3 hours
Child 6	Less than 1 hour	Less than 1 hour	Less than 1 hour	Less than 1 hour
Child 7	About 1 hour	About 3 hours	About 3 hours	About 2 hours
Question: How much do you enjoy math on a scale of 1 to 10?	Week 1	Week 2	Week 3	Week 4
Child 1	6	6	6	7
Child 2	4	6	5	
Child 3	5	5	3	4
Child 4		9	9	8
Child 5	4	4	4	4
Child 6	1	5	6	3
Child 7	3	3	7	4

Question: Do you feel you are making progress in math on a scale of 1 to 10?	Week 1	Week 2	Week 3	Week 4
Child 1	4	5	5	7
Child 2	3	3	3	No Response
Child 3	8	6	4	7
Child 4	No Response	7	7	9
Child 5	6	6	4	5
Child 6	2	8	9	9
Child 7	7	7	6	8
Question: What is your favorite kind of math?	Week 1	Week 2	Week 3	Week 4
Child 1	No Response	Division	Division	Addition of Fractions
Child 2	Addition and Subtraction	Addition and Multiplication	Addition and Multiplication	No Response
Child 3	Multiplication	Multiplication	Addition	Multiplication
Child 4	No Response	Mode, Median, and Mean	PEMDAS	PEMDAS
Child 5	Geometry	No Response	None	Flashcards
Child 6	Multiplication	Division	Multiplication	Addition or Multiplication
Child 7	No Response	Long Multiplication	Long Division	Long Division

Appendix D

End-of-Intervention Survey

Name________________________ Date__________________

How did it feel to reflect on mathematics weekly?

Do you think your relationship with mathematics changed during the last month? Why or why not?

How was your understanding of your personal mathematical progress affected by taking a weekly survey?

Other comments or thoughts about this process you would like to share:

Appendix E

Parent Survey Given Prior to Intervention Start

Parent Survey using Google Forms:

Scale of Strongly Disagree, Disagree, Neutral, Agree, Strongly Agree:

- My child enjoys working on mathematics.
- My child often chooses mathematics work.
- My child feels confident in their mathematics knowledge.
- My child is motivated to practice mathematical concepts.
- I feel confident in my child's mathematics knowledge.
- I understand my child's mastery of mathematics.
- I would like further quantitative data on my child's understanding of mathematics.
- I would like further qualitative data on my child's understanding of mathematics.

Short Answer Questions:

- Please tell me a little bit about your child's current understanding of mathematical concepts.
- Please tell me a little bit about your child's current feelings about the study of mathematics.
- Anything else you would like to add:

Before intervention only:
Please observe your child and their engagement with mathematics over the next few weeks. In about one month, I will send out another survey and ask for your thoughts and observations of their work. Thank you for your time and thoughtful responses!