Open-Ended Questions as Math Homework

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Abstract

This is an action research project which used mixed-methods to address both parental self-efficacy in mathematics and the development of appropriate homework for upper-elementary students. Literature was reviewed in the fields of self-efficacy, ethnomathematics, open-ended questions, and the role of homework in elementary schools. Participants (N=11) were asked to answer four open-ended math questions with their children, and at those times to also communicate social-emotional regulation strategies. Participants' perceptions regarding homework and their mathematical self-efficacy were investigated using Likert surveys, long form questions, and interviews. Participants found the intervention fun, motivational, relaxed, and practical. Conclusions drawn are that open-ended math questions are likely to improve parent self-efficacy in mathematics, that open-ended questions are good vehicles for social-emotional learning, and that homework and social-emotional support from adults should be a routine and an expectation in elementary classrooms. It is recommended that further research seek the perspectives of marginalised members of the community, particularly English language learners and Indigenous peoples.

Key Words: Mathematics, Homework, Elementary, Parent, Self-Efficacy, Self-Regulation, Action Research, Mixed-Method

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As an elementary-school teacher, I have often heard parents express feelings along the lines of 'I'm just not a math person' or 'I don't *get* today's math'. I knew, from personal experience, just how powerfully parents influence their children, and so I began to worry that parents might be negatively influencing their children's feelings towards math. I value mathematics both for its transformative power and for its creative artistry (Lockhart, 2009), and I want my students and their parents to feel capable in applying maths in life and work.

I have also noticed that many of my students' parents expect their children to be doing homework once they reach upper elementary (grades 4, 5, and 6; age 9-12). Yet, I had heard from my colleagues that homework in upper elementary wasn't particularly effective at improving academic performance. This research sought to address both those issues.

Research Aims and Objectives

I begin by illuminating some aspects of myself which contributed to this research. Bourdieu (2003) resonated with my own search for truth, understanding, and efficacy when he wrote that:

> One knows the world better and better as one knows oneself better, that scientific knowledge and knowledge of oneself and of one's own social unconscious advance hand in hand, and that primary experience transformed in and through scientific practice transforms scientific practice and conversely. (p. 289)

This research was conducted in Treaty 6 and Métis Region 4, in *amiskwacîwâskahikan* (Edmonton, Alberta; Canada). Here live, and have lived, the Cree, Saulteaux, Blackfoot, Métis, Dene, Nakota Sioux, as well as settler people like myself. The land has been a home, meeting grounds, gathering place and travelling route for its peoples. We are incredibly privileged to

learn from thousands of years of both scientific and embodied knowledge, wisdom, and experience; we have a responsibility to learn what we can, in meaningful ways, and then to share that learning.

I am a cisgender white male who grew up in rural Alberta, the son of two teachers, themselves the first university educated members of their families. We are descendants of Ukrainian immigrants who settled the prairies of the Canadian portions of Turtle Island. My great-great grand parents settled near Bellis, Alberta and Wakaw, Saskatchewan when those areas were still part of a region called the North-West Territories, pre-1905. I attribute my fondness for and connection to the land and its peoples to my family's long connection to this area; whenever I smell sage and pine, I feel a sense of 'homeness'. I attribute my pragmatism and work ethic, in part, to the generations of hard work my families put into developing a life for themselves here.

My parents' educations, their academic abilities, and productive dispositions led me to do well in school early on. These early advantages and successes helped me to achieve academic success, which in turn led to further success, all leading to a high self-efficacy in mathematics and an appreciation of it. I did my homework regularly, as was expected, and did it well, which was also expected. However, I never grew to value homework, and rather resented it as I could learn well enough by participating in class; I felt homework to be simple busy-work. These biases, combined with the assertions of my elementary-school-teacher colleagues, that homework didn't help student academics, in turn led me to eschew assigning homework in the early years of my teaching career. This decision was often met by excited students and skeptical parents.

I did much of my schooling in French-Immersion programs; I lived in Japan for a year; and I trained and worked as an anthropologist/archaeologist. Through living in, moving through, and explicitly studying cultures I've grown aware of the multiplicity of ways of living and perceiving the world, and that my own perceptions have limits and biases. So, the skepticism of my students' parents led me to question my biases and ask whether some form of homework might be appropriate for my context, especially if the community values it and desires it. I had also remarked that several of my students' parents had told me things to the effect of, 'Oh, I'm just not a math person, so it makes sense that Johnny isn't', 'I was never good at math, so I can't help her at home', or 'I don't understand today's math and I don't want to confuse him with my old-school way doing math'. Both of these problems, the desire for homework and an apparent low-self efficacy in mathematics in my many of my students' parents, sat uneasily with me for several years. I began to search for ways to address these problems.

As a classroom teacher, I want to be intentional about what content and programs I deliver to my students. I want to create a curriculum (of which homework is a part) that is relevant and meaningful to my students' lives; one based on their needs and experiences (Aoki, 1993; Chung, 2009). My classroom often has a diversity of cultures and experiences within it with families from all settled continents, including but not limited to Indigenous peoples of North America, Slavic peoples, Brazilian families, African families, Middle-Eastern families, Asian and South-East Asian families. I want my curriculum to engage with that diversity, to build self-efficacy in my parent group, and to include an appropriate form of homework for my students. I therefore I had the idea to 'kill two birds with one stone'. In discussing my problems, I eventually asked 'Might assigning open-ended questions as math homework build mathematical self-efficacy in parents?' and 'How might parents feel about open-ended math

questions, as a means of helping their children develop study habits?' My hope was that by assigning open-ended math questions, to be completed by my students in collaboration with their parents, parents would increase their mathematical self-efficacy and thereby positively impact their children's disposition towards math, and eventually their later academic achievement. Furthermore, I had hoped that during these homework sessions, parents could communicate self-regulatory strategies and study habits, instead of focusing on academics directly.

The paradigm through which I conduct this research is that of pragmatism, as described by Klenke et al. (2016). In short, I feel that reality is equivocal, yet filtered by culture. I hold that knowledge is gained by experience and that it carries both objective and subjective truths. Much like Bandura (1977a, 1977b, 1997), I value the pragmatic effect that research can have; I value research, pedagogies, and strategies which improve the lives of my students, their families, and society at large. I recognise that there are a multitude of cultures, both in my classroom and out of it, so I want my pedagogy to be responsive to that. I want to incorporate the cultures of my milieux without tokenising, essentializing, or exploiting for convenience; indeed, several researchers have cautioned against just that (Brandt & Chernoff, 2015; Donald et al., 2011; Reyes & Norman, 2021; Ruef et al., 2020; Taeao & Averill, 2020). Therefore, I try to structure activities in such a way that my students and their families can authentically incorporate their cultures and perspectives into my pedagogy, without interjecting my own agendas or interpretations. In that vein, open-ended questions have become a critically important tool I use to make space for the multiplicity of cultures in my classroom to express their mathematical competencies.

In the development of my research design, I had planned to incorporate a web-based delivery and feedback mechanism. Because my intervention did not include such a mechanism, I

will expand on my reasoning and the research around such web-based mechanisms in my literature review.

Literature Review

In my literature review, I compiled and analysed research and perspectives on self-efficacy, open-ended math questions and their links to culturally responsive pedagogy, and appropriate elements to include when planning homework for upper-elementary students.

Self-Efficacy

As self-efficacy is a concept central to my research, I thought it appropriate to include a brief review of it. Preceding self-efficacy, earlier researchers were sometimes split into academic 'camps', studying either *behavioural* or *cognitive* processes (Santrock et al., 2010). The most well-known example of behaviourist study is that of Ivan Pavlov and his *classical conditioning* experiments, wherein he demonstrated dogs salivating in response to a bell rung, used to signal imminent feeding. Classical conditioning led to the theories of *operant conditioning* (Santrock et al., 2010). B.F. Skinner built theories based on operant conditioning experiments by E.L. Thorndike, wherein cats were put into puzzle boxes and their behaviours observed. Skinner classified stimuli that could influence behaviour: reinforcements and punishments, both positive and negative.

Self efficacy is a concept developed by Alfred Bandura as part of his Social Cognitive Theory (Bandura, 1977a, 1977b) in direct opposition to operant conditioning:

> A theory that denies that thoughts can regulate actions does not lend itself readily to the explanation of complex human behavior. Although cognitive activities are disavowed in the operant conditioning framework, their role in causal sequences simply cannot be eliminated. (Bandura, 1977a, p. 10)

His theory explains and predicts human behaviour through a model wherein "continuous reciprocal interactions between cognitive, behavioural, and environmental determinants. Within the process of reciprocal determinism lies the *opportunity for people to influence their destiny* [emphasis added]" (Bandura, 1977a, p. vii). This aspect, self-determinism, is one to which I am philosophically attached and is one which Bandura expands upon:

> The value of a theory is ultimately judged by the power of the methods it yields to effect changes. Self-efficacy theory provides explicit guidelines on how to enable people to exercise some influence over how they live their lives. A theory that can be readily used to enhance human efficacy has much greater social utility than theories that provide correlates of perceived control but have little to say about how to foster desired changes. (Bandura, 1977a, p. 10)

Like Bandura, I feel it important to impart a sense of agency in my students; to that end, I also intend to influence their parents/guardians. If parents feel efficacious, they're more likely to communicate that orientation to their children (Kitsantas et al., 2011; Schuk & Pajares, 2002).

Current researchers, educators, and psychologists have applied Bandura's models and theories, and often fuse concepts of behaviour and cognition, as outlined in *The Zones of Self Regulation* (Kuypers, 2011). Researchers have drawn a link between parent self-efficacy and children's self -regulation strategies (Ferretti et al., 2019; Purdie et al., 2004; Zarychta et al., 2021). Other researchers have noted, through experimental data and meta-analyses, that self-efficacy is one of the best predictors for job satisfaction and performance (Judge & Bono, 2001). Research has also drawn an explicit link between parents' academic self-efficacy and their children's academic achievement (Bandura et al., 1996; Purdie et al., 2004). Some authors have suggested that self-efficacy be subsumed as a concept into *cognitive behavioral approaches*

(Zlomuzica et al., 2015) or *motivation* (Martin, 2007)**.** However, Bandura, himself, has been critical of motivation theories, describing them as a showing little consistency or linkages to competence (Bandura, 1997).

Self-efficacy, grounded within social-cognitive theory, is therefore a useful concept for researchers and practitioners seeking to empower their communities, and thereby ameliorate their lives. Self-efficacy stemmed from earlier behavioural models but added an emphasis on self-determinism and cognitive factors. Though it may be subsumed into more recent models, those models may lack cohesiveness or clear links to client competency.

Open-Ended Math Questions

Critical to my research is the concept of open-ended math questions. Open-ended math questions are intended to help people become more comfortable and confident when using math, and have been widely recommended to educators (Amidon et al., 2020; Betts, 2019; Lemley et al., 2019; Sole, 2018). In particular, they are accessible because open-ended math questions are written with a 'low barrier to entry', so that anybody can answer them; they can be challenging because they have a 'high ceiling', where answers can be as complex and creative as the answerer desires (Small, 2020).

An example of an open-ended math question might be, 'How might you measure a pumpkin?' Even the most mathematically disinclined individual is likely able to answer such a question with at least one method, such as 'weigh it on a scale' or 'wrap a measuring tape around it'. More efficacious and able individuals might apply creativity and answer 'measure the relative brightness of its hue' or 'submerse it in water to measure the displaced volume'. And, as you will see below, open-ended math questions can also be culturally responsive.

Ethnomathematics

In my survey of literature, I was directed towards an investigation of *ethnomathematics*. Coined in the 1980s by Dr. Ubiratán D'Ambrosio, a Brazilian mathematician and philosopher, ethnomathematics is the interaction between mathematics and culture; it is both a field of study and a pedagogy (Arismendi-Pardi, 1999). Arismendi-Pardi (1999) further asserts that ethnomathematics should incorporate political, social, and cultural issues because mathematics has histories and cultures; that it reflects the conflicts and integrations between cultures. In other words, there's no one *math*, or *correct* way of being numerically competent. Learning mathematics is *not* a universal, linear progression. Nor is it acultural. Mathematics is embedded within culture and reflects culture, and everyone learns mathematics in their own way, shaped by the cultures they are embedded within.

D'Ambrosio (1990) conceived of and presented ethnomathematics as a tool for social justice. He held that it could be used as a critique of civilisation, civilizing, and colonisation. In his view, Western society's dominant paradigms relied on scientific rationalism. Negative self-esteem was strong in minority groups learning mathematics because of mathematics' strong connection to European culture and thought; as such, it amounts to an initiation rite. Researchers and educators hope that teaching from an ethnomathematics perspective increases respect between cultures, pride in all cultures who have contributed to mathematics, that it improves pedagogies by making mathematics more relatable, and that it promotes inclusion through a constructivist paradigm.

Relatively recently, researchers have advocated for a greater inclusion of ethnomathematics in the classroom (Brandt & Chernoff, 2015). Their view was that the incorporation of ethnomathematics promotes social justice and empathy in students, that it serves marginalised members of society (particularly English language learners and Indigenous

students), and that it promotes creativity and deeper conceptual understanding. These effects should then accrue into greater academic self-efficacy, which in turn promotes student academic achievement (Bandura et al., 1996; Cosmoiu & Rizeanu, 2020). I feel that open-ended questions, being open to the respondent to answer in ways they feel most appropriate, are important tools within an ethnomathematics perspective. Other researchers came to the same conclusion, noting that culturally-responsive efficacious teachers (amongst other qualities) "believed that mathematics instruction should be student-centered, *open-ended* [emphasis added], inquiry-based, highly interactive, and impromptu, based on students' needs and interests" (Berry III & Thomas, 2017, p. 1205).

Ethnomathematics, both a field of research and a pedagogy, is a way that mathematics educators and researchers such as me can respond to diversity in a meaningful and inclusive way. Of relevance to my study is that the incorporation of open-ended questions promotes self-efficacy in those with culturally diverse mathematical thought. Furthermore, open-ended questions in an ethnomathematical pedagogy can serve as a vehicle for the exchange of ideas and concepts between the cultures of my classroom community.

The Role of Homework in Upper Elementary

Meta analyses have shown that homework is indeed effective at promoting academic achievement, but not so much for elementary students (Hattie, 2009; Hattie et al., 2017). In my context, though there is an expectation that some form of homework be assigned to students in upper elementary, but I found in the literature no consensus on what form of homework is most effective. An earlier synthesis of research between 1987 and 2003 likewise found no consensus (Cooper et al., 2006). To increase the efficiency and comprehensiveness of my proposed method,

I surveyed literature surrounding web-based homework and homework as tool to promote self-regulation strategies,

Web-Based Homework

I had desired to include a digital delivery and feedback mechanism as homework in my school context is increasingly entering the digital realm, and online communications are the primary form of communication between our families and staff. Homework is, perhaps, being delivered digitally because students tend to need timely feedback to feel that their homework is valuable (Wilson & Rhodes, 2010), and digital tools can support that. For example, rapid feedback was attributed to be the reason student academic achievement improved when testing web-based homework (Mendicino et al., 2009). Some schools have promoted the use of officially sanctioned messaging platforms and blog sites (Davis, 2010); in the absence of official tools, some students create their own (de Beaufort, 2017). Given the benefits of web-based homework, it seemed natural to include a digital component to my homework idea. However, my participants' likely have a heightened awareness of status in online interactions (Twenge, 2017), so I deemed the risk of cyberbullying and negative interactions to be acute. I decided to limit feedback in this research to the feedback parents received from their own children and the converse.

In lieu of web-based delivery. my hope is that by motivating *some* parents or students through the selection of high quality, values-specific questions, the majority of my participants will be 'pulled along'; this social 'pulling-along' is a noted social phenomenon in the context of schools (Xu et al., 2017). Parent-participants actively taking part in the homework-interventions would positively influence other parents to participate in doing homework through subtle social pressure during social interactions.

Homework as a Tool to Teach Self-Regulation

As noted previously, homework is not a particularly effective strategy to improve the academic achievement of elementary aged students. After my students age and move on to junior high school and high-school, it is likely that the amount of homework *completed* matters most (Cooper et al., 2006). Since learning to create a workspace, set aside time, and regulate emotions are cognitive tools that help students to complete homework (Kitsantas et al., 2011), such cognitive strategies have become a central aspect to my development of relevant and age-appropriate homework. Appropriateness for my context seems therefore to be homework which teaches students *how to complete homework,* to prepare them for completing academic homework in junior and senior high school.

Researchers have found that families are important in assisting students to develop self-regulatory strategies and study habits (Jianzhong Xu & Corno, 2003). The fact that students' beliefs and motivations are highly influenced by their parents' (Twenge, 2017) cemented for me the importance of addressing parent participation in homework for elementary students. Recent research has shown that "both parent-reported goal emphasis and perceived parental goals are important for explaining children's outcomes and that children might not be explicitly conscious of some of their parents' perceptions but nonetheless might be influenced by the general climate at home" (Madjar et al., 2016, p. 183). As to whether elementary school students can be taught meta-cognitive strategies towards self-regulation, research has shown that such lessons can indeed be effective (Ramdass & Zimmerman, 2011).

Research Design

Being a mathematically appreciative individual, I felt pre-disposed towards quantitative analysis. I initially planned to survey my students' parents before and after delivering open-

ended math questions as collaborative homework, then to analyse the data to determine effect size. However, given the likely limited number of participants, such analysis could not be considered entirely valid (Creswell & Guetterman, 2019). Indeed, researchers in the field of homework have encourage the use of qualitative inquiry:

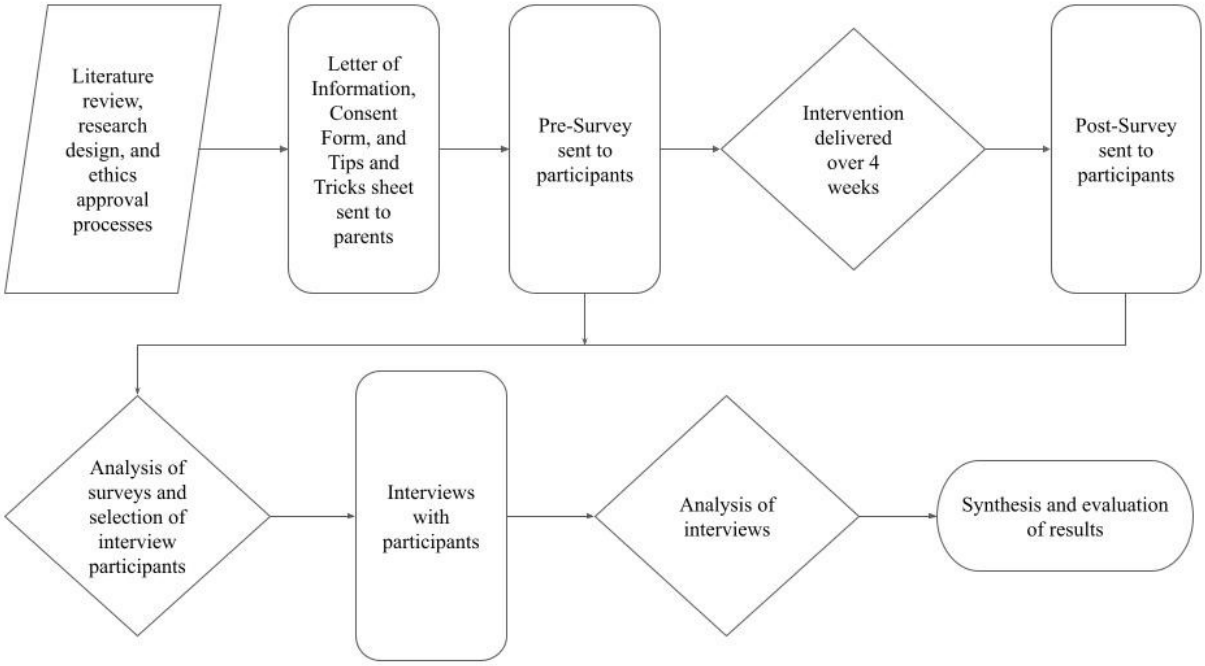
> We would encourage, as well, the use of mixed research models that incorporate qualitative analyses-to examine the homework process, moderators, and mediators of its effects, along with its intended and unintended consequences-in experimental designs. Such studies provide a rich tableau and complementary sources of knowledge for guiding yet another generation of research, policy, and practice. The long-term and cumulative effects of homework remain a largely unmapped terrain. (Cooper et al., 2006, p. 54)

A mixed-method framework would mitigate the limitations of my sample size, and provide qualitative depth to my analysis of my participants responses.

Therefore, I decided to proceed along with a mixed-methods research framework (Figure 1), using Likert surveys to quantify perceptions regarding mathematical self-efficacy, adapted from May (2009), with qualitative questions as complements (Appendix A). Quantification of participants' growth in efficacy provided stratified sampling for deeper qualitative inquiry using recorded interviews; I wanted to interview a parent who showed little or no growth in apparent self-efficacy, one who showed moderate growth, and one who showed significant growth. A research proposal was created and sent to the Concordia University of Edmonton Ethics Board for review. After minor changes and clarifications, it was approved and then forwarded to Edmonton Public Schools for approval. In mid-November 2021, after minor changes and clarifications, it was approved by both boards. Shortly thereafter, I began soliciting parent participation.

Figure 1

Visual Diagram of the Mixed-Method Design



There was a bias in the selection process in that parents who could not understand the English language well were not accommodated. I believed that automatic translation software was not sufficiently capable to convey the nuances and depth of academic communication, and access to paid translation services was limited. Furthermore, my stratified sampling was limited to nonprobability sampling, as I did need to select individuals for interviews based on availability and willingness to be interviewed.

Before delivering the homework interventions, I asked my participants (N=11) to rate their efficacy in mathematics, using a combination of Likert survey questions based on the work of May (2009) and supplementary long-form questions to provide qualitative depth (Appendix A). To support parents in their efforts to introduce study habits and self-regulation, I provided to parents Appendix D, a 'Study Habits: Tips and Tricks' sheet. It included tips on motivation, pacing, and modeling regulatory strategies. Then, on weekly basis, I assigned to families an

open-ended math problem as homework, to be completed by parent and child working together (Appendix E). After answering four questions over four school-weeks, I asked my participants to complete a second survey (Appendix B). Ten participants returned both their pre- and post-intervention surveys. To determine stratification of my participants, I created a scatterplot, wherein the effect size of each participant (the difference between their pre- and post-intervention survey scores) was graphed. I then visually identified groups for the selection of interview participants. From each group, one participant was to be chosen by random draw for a recorded interview (Appendix C). If the group had only a single member, I contacted them.

To analyse survey written responses, passages that illustrated each participants' views were recorded in a table and then synthesised. To analyse recorded interviews, transcriptions of the recordings were made, reviewed by the interviewed participant, and then annotated by colour coding passages according to theme. Emergent themes were then synthesised in a separate document. To be culturally responsive, all participants were given the option of either choosing a pseudonym or using their proper name; their choices are reflected in the findings below. Responses quoted below have had only minor edits to improve readability and protect the names of participants' children.

Findings

Pre-Intervention surveys indicated that all my participants reported either high or very high mathematical self-efficacy. Where a score of -24 would be very low self-efficacy, -12 low, 0 neutral, 12 high self-efficacy, and 24 very high, the average score of my participants was 18.417 and the mode was 23 (n=3). Participants almost universally expressed an enjoyment of math, that they valued it, and that they did well in school. Several parents wrote how they took breaks when frustration mounted, and several scheduled relaxed times to do homework.

The average score of the post-intervention survey was 17.7, and the mode was 16 and 22 (*n*=2). One participant did not complete their post-intervention survey. In my analysis of the surveys, I compared participants pre-survey scores to their post-survey scores (Figure 2) and used the difference to determine strata for selection of interview participants. Most participants (*n*=8) reported that the intervention had a negligible effect; these participants' scores had differences of -1, 0 and +1, compared to their initial reported score. Participant Helena recorded a strongly positive reaction of +7 and participant Chelsea reported a moderately negative reaction of -3. As Helena and Chelsea had results distinct from the group, they were selected for follow-up interview; a third interviewee was selected from the majority group. Themes that emerged in the analysis of the post surveys written responses were that participants found doing open-ended questions with their children fun, motivational, relaxed, and practical.

Figure 2

Differences between Participants' Pre and Post Survey Scores

Both Chelsea and Helena agreed to a recorded interview, as did participant Oscar. Oscar's score fell in the majority negligible-effect category, and their name was chosen by random draw. In the interviews, all participants expressed high self-efficacy in, and a positive

relationship with, mathematics. Each described mathematical competency as being an expectation, either of their families or of their culture. Two of the participants described a perceived disconnect between 'real world math' and academic math and felt that open-ended math questions were useful in bridging that gap. This was reflected in participant Chantelle's written response on her post-intervention survey, "[open-ended math questions] give practical skills, more ways to come to the correct answer", and in Helena's interview wherein she stated, "I believe [this homework] showed us the importance of math and how it can be used in daily life and how we can solve math problems in a practical way."

All three interviewed participants perceived in their children a need for adult support with homework. All three mentioned that they felt an adult needed to be there to either motivate their child to study math, explain mathematical problems or processes, or to provide appropriate limits for their child's creativity. Two participants felt that social-emotional learning guides were explicitly needed, and that it would have been better if they were communicated regularly, perhaps alongside the questions. Participant Oscar saw strong value in communicating a growth mindset, believing it important to academic and personal growth. Whether a growth mindset positively impacts academic achievement as has been asserted (Blackwell et al., 2007), or whether it does not (King & Trinidad, 2021; Li & Bates, 2020) may require further scrutiny. Oscar further connected the framework to gamified learning, expressing a hope that such tools could be used to increase mathematical fluency in the community, while Helena expressed a hope that homework "would keep the children away, a little bit more, from the electronic stuff, which is a challenge; especially during winter."

In summary, my participants all had high mathematical self-efficacy, expressed that they valued it, and that they desired that their children would develop the same. In response to my

intervention, most of my participants did not report a significant increase in their mathematical self-efficacy. Participants did express that they felt the intervention's inclusion of social-emotional learning was appropriate and important.

Discussion

Given that most parents did not report an improved self-efficacy, one might conclude that the intervention failed in one of its objectives (improve parent-self efficacy in mathematics). However, I argue that this is not that the case. The homework method that I have developed is appropriate for my teaching context, and that it is ready for adoption, adaptation and refinement.

Héfer Bembenutty (2011) suggested in their review of self-efficacy and self-regulation in homework that "future research should continue to consider innovative interventions to promote more frequent homework submission as well as higher quality of homework." (p. 470). The method that I have investigated increased the quality of homework through its open-ended and multifaceted nature and promoted more frequent homework submission through the purposeful inclusion of family members.

The drop in the average score noted in the post-intervention survey is statistically inconsequential, as it amounts to an average difference in score of 1.7 (the difference between pre-intervention survey and post-intervention survey). If one excludes participant Helena, with their outlying high difference, the average difference drops to 1.111. That difference is equivalent to most participants adjusting their Likert selections slightly on one question of the twelve. What is more important is the participants' written responses, which lend insight into the framework.

All but two of the participants expressed positive remarks in their written responses, responding to the post-intervention survey (N=10). Participant Izzy had this to say, "The novel approach made the math interesting. The approach was relaxed, fun, and made me and my child

consider the options and solutions." Furthermore, seven of the participants directly or indirectly referred to how homework time was used to engage in social-emotional learning. As an illustration of that, participant Chelsea had this to say in our interview:

> I'm definitely familiar and comfortable with homework and can do it no problem. I'd say it's been like a struggle with [her child]; he definitely doesn't like homework so that's a learning curve for me and I guess it's made it a little more challenging and frustrating from like, being on the parenting side of it. […] I think it helped, I guess, me see the value in trying to persevere through getting him to sit and try to do the math questions, then see that it could be fun once we get over that initial hurdle. […] I think I definitely appreciate, like the importance of setting a routine. Again, especially with [her child], like he needs that consistency and that's definitely something that I think we seem to be lacking in our house.

A similar feeling was expressed by participant Helena:

> The tips and like, you know the trick, those are really good. We used them and some of them we've not really, I've never really heard of them or anything like that. So, we kind of practiced it together, doing the tricks. It's kind of hard to get [my child] to do homework, but you know, when we sit together and try to do stuff then he's more encouraged and you know, it was good actually, very good and we learned quite a bit.

Given the limited number of open-ended math questions answered by my participants (N=4), the effect of my homework design was likely limited. Knowing the busy lives of my students' families and being conscientious of the cumulative stress of living two years in a global pandemic, I felt that more frequent questions would be too much to ask of my students and their families at the time of the research. Likewise, the duration of the intervention (4 weeks) was a

necessity precipitated by my need to complete the research by the conclusion of the school year. Even with a short duration, my interventions were interrupted by an abrupt extension of holidays to address rising COVID-19 infections in our locale. Furthermore, as most of my participants expressed already high efficacy in mathematics, it can be reasonably assumed that further improvement would be limited by a plateau effect. Therefore, the solicitation of low or neutral self-efficacy participants should be a priority in future research that seeks to improve parent self-efficacy, as should the prioritisation of marginalised members of the community (Gorski, 2019).

Emergent Themes

Through my use of qualitative instruments (open questions and interviews), I was able to gain insight into my participants' reactions to the intervention. Themes emerged in my analysis of written responses and recorded interviews, most notably a focus on fun and gamification, and a desire for feedback and accountability instruments.

Earlier, I referred to research which indicated that it is likely the amount of homework *completed* which matters most in improving academic achievement (Cooper et al., 2006). Related to completing more math, in our interview, participant Oscar attributed, in-part, his self-efficacy in mathematics to his early participation in games that include math:

> When you asked about my relationship with math and I said that I feel like I'm sort of a 'native speaker'. I do think a lot of that just comes from just a very common interaction with Math. You know that I played, started playing D&D when I was nine; I guess [my child's] age. And I think just there's you know there's just there's not a lot of complicated math in D&D, but there's just a lot of just going to do *math* [emphasis in voice], and I think that that leads to other things because you just sort of, you know, if the foundation is so rock solid that you're just very comfortable with it. […] Like *that's* [emphasis in

voice] what I wish. That, that seems to be missing, just from so many people. And I don't think that's a, that's not a like a genetic thing. I think that's just a, it's just a practice thing.

Given the utility and near omnipresence of the World Wide Web in 2022, it would stand to reason that my homework method may have been more effective if it had incorporated a web-based platform through which parents and students could receive feedback, and timely communications made to address concerns or misunderstandings. As noted earlier, students express a desire for feedback on their homework (Wilson & Rhodes, 2010) and rapid feedback mechanisms inherent in web-based homework were attributed with successful homework (Mendicino et al., 2009). Addressing that theme, participant Chelsea suggested in our interview that some sort of an accountability measure might improve the framework, “If I told him Mr. Tannas is going to look at it, even if you didn't look at it, even if you collected it, I think I would have liked that.”

Structured after-school spaces for science, technology, engineering and math have been found to promote student self-efficacy in those fields and helped to build relationships between students and supportive adults (Schnittka et al., 2016), so perhaps structuring homework in the form of a web-based game or forum might be an effective alternative feedback method. Indeed, some authors have suggested that because math and social skills are so important, that they be taught together in a Universal Design for Learning framework (Walker & Hunt, 2012). A web-based game or forum where families share their conclusions, methods, and reactions to weekly open-ended questions might have the added of advantage leveraging the community to provide relevant, culturally embedded feedback; it would also alleviate, in part, the need for a teacher to review and provide feedback on students’ homework.

Conclusions

Open-ended math questions might indeed be used to improve parent self efficacy, as they're demonstrably effective at improving student self-efficacy. However, this research was inconclusive as to whether open-ended questions reliably improved parent self-efficacy. There were some obvious successes where participants clearly indicated that the questions made them feel more efficacious, but the research was limited by the self-efficacy level of most participants and by the short duration of the intervention. Participants did clearly express that they found open-ended questions useful in bridging an apparent gap between academic math and 'real world math' through authentic problems and problem solving. As well, most parents found the framework useful as a vehicle for social-emotional learning, particularly the setting of routines and expectations. The research confirmed the importance of having adult support as students learn math and homework.

Another conclusion that I draw from this research is the importance of regularly communicating social-emotional learning as a part of a homework routine. Homework completion may be more likely when students perceive it as an expectation, with messaging authentically embedded within local cultures and valued by supportive adults around the child.

Alberta's Commission on Learning has noted that better linkages are needed between schools and Indigenous parents (2003). To that end, decolonisation of math homework might include having families share their cultures' conceptions of mathematics, their methods, and their values within the framework of a web-based game or forum which includes open-ended questions. Due to the limitations noted earlier and the need to co-create initiatives with marginalised members of society, the solicitation of low-self efficacy parents, in particular

English language learners and Indigenous parents, should be a priority in further action research and in studies regarding the perceptions of homework and/or parent's mathematical self-efficacy.

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Appendix A: Pre-Intervention Survey Questions with Weighting

Question	Strongly Agree	Somewhat Agree	Neither Agree Nor Disagree	Somewhat Disagree	Strongly Disagree
Math makes me nervous	-2	-1	0	1	2
I can do math	2	1	0	-1	-2
I can help my child with math	2	1	0	-1	-2
I can explain math problems	2	1	0	-1	-2
I can use math to solve problems in everyday life	2	1	0	-1	-2
I feel stressed when doing math	-2	-1	0	1	2
I worry that I won't be able to help my child in math	-2	-1	0	1	2
I believe I am the kind of person who does well in math	2	1	0	-1	-2
Math is a creative pursuit	2	1	0	-1	-2
Solving problems mathematically can be fun	2	1	0	-1	-2
I feel confident using math outside of a school setting	2	1	0	-1	-2
I value mathematics	2	1	0	-1	-2

Longform Questions:

How do you feel about math?

How do you feel about helping your child with math homework?

If homework is a source of stress, how do you manage it?

Appendix B: Post-Intervention Survey Questions with Weighting

Question	Strongly Agree	Somewhat Agree	Neither Agree Nor Disagree	Somewhat Disagree	Strongly Disagree
Math makes me nervous	-2	-1	0	1	2
I can do math	2	1	0	-1	-2
I can help my child with math	2	1	0	-1	-2
I can explain math problems	2	1	0	-1	-2
I can use math to solve problems in everyday life	2	1	0	-1	-2
I feel stressed when doing math	-2	-1	0	1	2
I worry that I won't be able to help my child in math	-2	-1	0	1	2
I believe I am the kind of person who does well in math	2	1	0	-1	-2
Math is a creative pursuit	2	1	0	-1	-2
Solving problems mathematically can be fun	2	1	0	-1	-2
I feel confident using math outside of a school setting	2	1	0	-1	-2
I value mathematics	2	1	0	-1	-2
Open-ended math questions helped me feel more capable in math	2	1	0	-1	-2
The Tips and Tricks sheet helped me feel more capable in math	2	1	0	-1	-2

Longform Questions:

What are your reactions to the homework piloted in this study?

Has this study changed how you feel about math or homework?

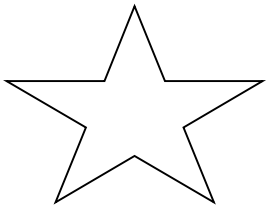
Appendix C: Interview Questions

1. Would you tell me about your relationship with math?
2. How about your relationship with homework?
3. If at all, how did the homework in this study affect your feelings towards math?
4. How do you feel about homework now?
5. How useful was the Study Habits: Tips and Tricks sheet?
6. Do you feel that this homework framework should be continued?
7. If at all, how would you modify this homework framework?
8. Is there anything you would like to share about math, homework, or this study?

Appendix D: Study Habit: Tips and Tricks and Rational for Homework

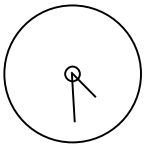
Study Habits: Tips and Tricks

Kids need feedback relatively quickly to feel homework is valuable (Wilson & Rhodes, 2010): Praise them when they've displayed behaviours like perseverance, creative thinking, or a growth mindset

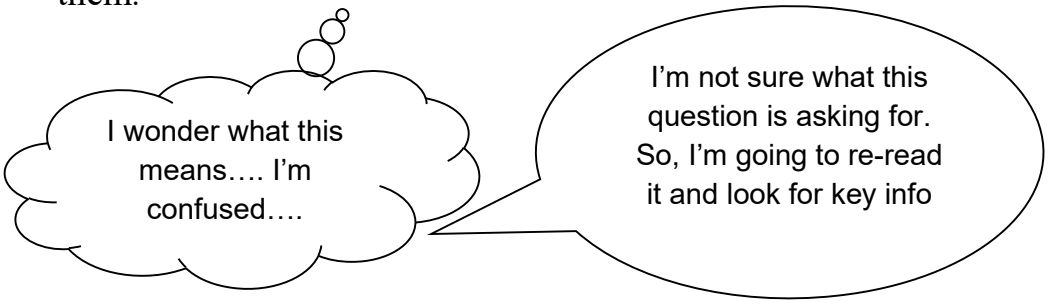


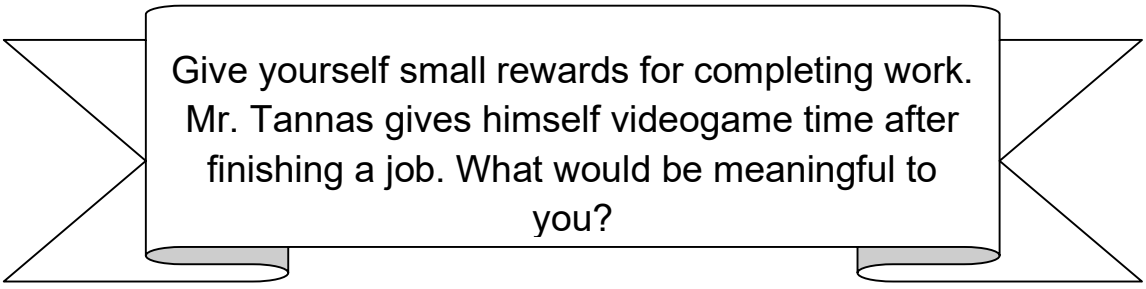
- To model a growth mindset, instead of saying, 'I don't get it', say 'I don't get it *yet; I'm going to work at this*'.
- Be proud of your products and the effort you've applied.

- Set a specific time and/or day for doing homework; pre-scheduling and setting aside time for something shows that you value it
  - Do homework and other difficult chores when you have energy; rest and relax when you're tired



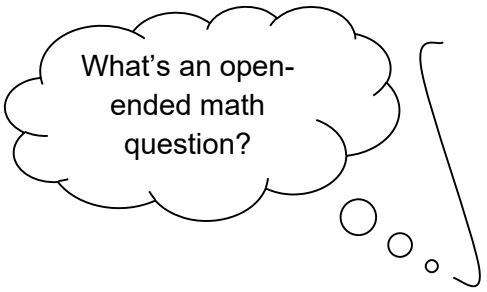
- The way to climb a mountain is one step at a time; break your task into small, manageable chunks
- Minimize distractions; focus on the task at hand
- Share your thinking; talk through problems, ideas, and strategies as you use them.





Rationale for this homework

- Homework in upper elementary isn't a particularly effective means to support elementary students' immediate academic achievement (Hattie et al., 2017)
    - It *is*, however, a useful tool to help students learn how to manage their workspace, set aside time, and regulate the negative feelings that can be associated with doing homework (Jianzhong Xu & Corno, 2003)
- Later on in their school careers, it's likely the amount of homework *completed* that matters most (Cooper et al., 2006)
    - Learning to create a workspace, set aside time, and regulate emotions are cognitive tools that help students to *complete* homework (Kitsantas et al., 2011), and I believe they are important life skills
- Open-ended math questions are a great way to help people become more comfortable and confident when using math (Amidon et al., 2020; Betts, 2019; Lemley et al., 2019; Sole, 2018)
    - Open-ended math questions have a 'low barrier to entry' (anybody can answer them), and a 'high ceiling' (answers can be as complex and creative as the answerer desires) (Small, 2020)



Good question!

An open-ended math question is one which can be answered in many ways, with many possible answers.

Here's an example:

How might you measure a pumpkin?

Possible answers include: weigh it on a scale; use measuring tape to measure how wide it is; put it in a bath to see how much water it displaces; measure how orange it is using colour swatches; use a ruler to see how tall it is; measure the length of its vine; etc.

There are many ways to think of problems, and many ways to solve them.

Appendix E: Open-ended math questions

Question are from and inspired by Marian Small (2020).

1. Create 4 patterns where the 10^{th} shape is a green triangle. Make the patterns as different as you can. Explain what makes each one a pattern.
2. Show an amount of money using 28 coins, including 13 quarters. How many other coins (not 28) might you have used to represent that same amount? Explain
3. Think of five-digit numbers where the sum of the digits is 24. List 10 or more possible numbers. Order them from least to greatest.
4. Which do you think does not belong? Why?
    a. 4×23
    b. 3×33
    c. 5×21
    d. 7×14