International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Developing TactiMath Flips for Subtraction and Addition

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ABSTRACT

This study aimed to develop TactiMath Flips, an instructional material for learners with visual impairments in an inclusive classroom. This qualitative research study utilized a product development design. In achieving the goals of this study, the participants selected were experts such as SPEd teachers and engineers. A total of ten (10) experts were interviewed personally. Specifically, five (5) SPED teachers from Consolacion Central Elementary School and five (5) engineers served as the participants of the study. Data was gathered by conducting interviews. The collected data was analyzed using the thematic analysis method of Braun and Clark which resulted in seven (7) themes. The study results revealed that TactiMath Flips in an inclusive classroom are most effective in enhancing the learning experiences of learners with visual impairments, however, certain suggestions and recommendations were given by the SpEd teachers and Engineers to improve the TactiMath Flips, it doesn't have any hazardous substances and materials that can harm the learners, it is safe to use. With embossed number shapes and braille dots, the TactiMath Flips is effective and accessible to learners with visual impairment in an inclusive classroom. Challenges include students' readiness and potential distractions for learners with disabilities. To improve the TactiMath flips, researchers' recommendations include adding an audio feature and improving the quality of the braille dots.

Keywords: Visual impairment, Braille, Mathematics, Addition, Subtraction

INTRODUCTION

It is essential to develop and design a product or tool tailored for visually impaired students to enhance how they grasp the basic concept of addition and subtraction, since addition and subtraction are also the building blocks of more advanced mathematical skills (Igirisa et al., 2019). Utilization of adapted materials and different methods should be included in teaching mathematics (Dheesha, 2022). Substantial numbers of students with visual impairment continue to attend mainstream schools. However, typical educational environments can provide challenges for students with visual impairments and their sighted classmates, particularly when teaching and studying mathematics (Bayram et al., 2015). Previous study has found that students with visual impairments are often given less opportunity to encounter advanced mathematical ideas than their sighted classmates (Bateman et al., 2018; Emerson & Anderson, 2018; Stylianidou & Nardi, 2019).

Digital-based learning and technology are driving major advances in mathematical education right now. Lack of accessible resources to aid in the development of mathematical conceptual knowledge may present

unique difficulties for students with visual impairments (VI). "Mathematical achievement among blind and severely visually challenged individuals is and has always compared to students who have sight, their performance has been incredibly low" (Kapperman and Sticken, 2020, page 1).

As stated by Kapperman and Sticken, a lot of blind people are actually unable to do mathematical operations in "real-life" settings, including multiplying a recipe by two or calculating change. As a result, it makes sense that compared to children who are sighted, many children with VI are given fewer opportunities to encounter the application of mathematical ideas in everyday communication (Bateman et al., 2018; Emerson & Anderson, 2018).

Such issues can be resolved if learners with visual impairments are provided with appropriate academic support and access to multi-representational instructional materials; their academic performance will improve (Scalise et al., 2018). With this, according to the American Foundation for the Blind, students with visual impairments usually learn through alternative learning methods such as braille, assistive technologies, auditory information, and tactile learning. A tool called Number Blocks in a study titled "The Learning Potentials of Number Blocks" is used, it integrates learning, immediate feedback, and physical involvement. A class of seven or eight year olds and their math teacher are the participants in this study. As per Majgaard et al. (2011), the study's authors, Number Blocks increase children's comprehension of place value by enabling them to engage in numerical experimentation. The study's researchers discovered that the blocks aided in learning in a number of ways. The blocks supported and included kids of all academic levels while fusing play and mathematics. Important information that helps students develop their mathematical concepts and methods can be accessed with the help of vision (Emerson & Anderson, 2018; Hershkowitz, Markovits, Rosenfeld, Ilani, & Eylon, 2018). Words that represent visual events are used to express several fundamental mathematical concepts (Jones, 2018).

Concrete materials, also known as manipulatives, refer to objects that the learners can touch and move which can foster engagement since it allows the learners to have hands-on learning experience (Hidayah et al., 2021, as cited in Dinsmoor, 2022). Using Manipulative Materials" involved interviewing 10 mathematics teachers about their experience in teaching primary schools for the visually impaired in Malaysia. In the study, they have revealed that manipulative materials can increase the learner's understanding in mathematics. The study has also identified braille and tangible materials such as marbles as some of the types of manipulative materials that are suitable and teachers commonly use in teaching mathematics to learners with visual impairments in the primary level (Bari, 2015)

According to Bell and Silverman (2019, as referenced in Steinbach, 2022), students who are blind or have visual impairments do poorly in mathematics compared to their classmates. Furthermore, understanding fundamental mathematical concepts by young children with visual impairments is identified as one of the educational trends and challenges (Singla & Vandana, 2022). Thus, research emphasizes the importance of various techniques and resources for teaching mathematical concepts to students with visual impairments. The aim of this research study is to develop a learning material for teaching basic subtraction and addition that is accessible for learners with visual impairment.

METHODOLOGY

Research Design

This research focuses on Product Development Design, a structured process that transforms ideas into tangible products to meet market needs as well as to test the effectiveness of the product. Gartner describes it as the journey of turning concepts into valuable solutions. The term "solutions" captures the outcome of

product development, as a successful product should address consumer needs.

Sampling Design, Informants, Environment

This research study employed convenience sampling. The sampling design allowed the researchers to select individuals that can provide relevant data and information to the research study while considering the geographical proximity and their availability on the scheduled time. In achieving the goals of this study, the participants selected were experts such as SPEd teachers and engineers. A total of ten (10) experts were interviewed personally. Specifically, five (5) SPED teachers from Consolacion Central Elementary School and five (5) engineers served as the participants of the study.

Research Subject

The primary research subject is the product that was created. Its usability and suitability in the context of education was evaluated based on the feedback of the teachers and experts from their observations.

Research Instrument

The researchers are the primary instrument; in qualitative research, an interview is frequently used as a data collection method. An interview between the researchers and the participants was conducted to collect their responses. Tegan George (2022) stated that an interview is a method used in qualitative research to gather data by asking questions. It involves a conversation between the interviewer and one or more individuals, where the interviewer asks the questions. Furthermore, a semi-structured interview was utilized with a predetermined set of eight guide questions. To further explore the responses of the participants, the researchers prepared semi-structured interview questions with open-ended questions regarding their comments, recommendations, and perceptions towards the TactiMath Flips.

Data Gathering Procedure

Before conducting the study, approval was obtained from the university's Ethics Review Committee through submitting necessary documents. Participants of the study were selected through convenience sampling. For the first stage, the researchers gathered data by conducting a comprehensive review of published journals and related literature on existing products of learning materials. Through the comprehensive review of published journals on the internet, the researchers were able to identify areas for improvement and enhancement. Based on the findings, the researchers started to develop the product "TactiMath Flips" with the initial stage as planning and the second stage as the making of the actual learning material. For the second stage of the data gathering procedure, the researchers reached out to selected experts, from special education teachers and engineers. But before reaching out to the SPED teachers directly, an approval was obtained from the school principal first. The researchers also coordinated with the participants regarding their available time in scheduling the interview. Researchers gathered data through an interview with a total of eight (8) semi-structured open-ended questions. The whole duration of the interview was also recorded with the consent of the participants. Lastly, the participants received a token in the form of school supplies and food from the researchers for their willingness to be part of the study.

Data Analysis

The researchers utilized a research technique called thematic analysis to find and analyze themes or patterns in a set of data; it often resulted in fresh perspectives and understanding (Elliot, 2018). This helped the researcher to identify, extract, synthesize, and apply information from journal articles to create the product. The researchers also gathered data through evaluation; the data came from the experts' comments and suggestions. The use of the analysis was to identify the areas of improvement through the interview itself to help understand how well items perform relative to expectations and other objectives. The second

statement of the problem involved comments and suggestions from the experts. The third statement of the problem considered how the findings would be applied to enhance the product- whether through redesign, feature additions, or other modifications. This assessed the researchers to identify the weakness or areas for improvement in the current product as to potential benefits, market impact, or user satisfaction. Through the thematic analysis approach, the researchers would be able to study the product's applicability, grasp students' viewpoints, and contextualize experiences.

Ethical Consideration

In this research study, several ethical factors were considered. First, the participants were provided with a written consent form before the interview to confirm that the study's conduct was voluntary. To ensure the confidentiality of the participants, the researchers utilized coding during the procedure of the data analysis. Participants were individually assigned a code, such as Teacher 1 and Engineer 1 to protect their identities. Additionally, the participants were told that they are allowed to withdraw from the study at any time without facing any consequences. And lastly, the information that has been acquired was treated strictly, safely, and with complete confidentiality.

RESULTS AND DISCUSSION

Results

Table 1 presents the codes, sample verbatim responses, categories, and themes identified to support the study's findings.

Codes and Sample Verbatim Responses	Categories	Themes	Description of the Themes
● Embossed number shape "*...kani numbers embossed siya"(SpEd teacher 3)* ***English Translation:*** *..."The numbers are embossed" (SpEd teacher 3)* *"...*maka touch pud sila kung unsa diay porma siya sa numbers, og sa kani operations." (*SpEd* teacher 3) ***English Translation:*** *They can touch the shape of the numbers and the mathematical operations" (SpEd teacher 3)* ● Tangible tiles " *bisag dili bitaw ka kuan ang bata like dili kabaw mo counting, just like kanang ana-on lang nimo ang tile maka kuha na sila og 1,2,3" (Teacher 2)* ***English Translation: "****Even if the child doesn't know how to count, just by flipping the tile they can get the concept of 1, 2, 3" (SpEd teacher*	Tactile engagement	*Theme 1: Enhancing Learning Experience*	This theme explored how the product can enhance the learning experience.

2) ● Large braille dots *"With your product kay uhmm… I've seen kay kuan siya noh dagko ang braille dots dali siya ma identify sa mga bata..." (SpEd teacher 4)* ***English Translation:** "With your product I've seen that the braille dots are large making it easy to identify by the learners.." (SpEd teacher 4)*			
● Child's readiness to learn "*E-throw niya ang material ba kay basin di pa siya ready mo kuan if ang bata kay dili jud siya ganahan mo manipulate sa kani na thing"* (SpEd teacher 1) ***English translation:** "The challenge is if the child will throw the material because the child isn't ready to manipulate the thing"* (SpEd teacher 1) ● Not fit for ASD and ID students "If *ever gani adto ta sa ID og ASD kuan ma distract sila ani mga braille codes…" (Sped teacher 3)* ***English translation:** "For learners with intellectual disability and autism spectrum disorder they will be distracted with the braille codes.*" (SpEd teacher 5) ● Requires teacher supervision "*need jud og assistance sa teacher kung mag use og in-ana kay basin nya og kung wala ra… mag sige ra sila og touch touch nya wala ra… wala ra sila'y na learn. (.SpEd teacher 5)* ***English translation:** "it really needs the assistance from the teacher so the students will really learn and not just touch (the product)"*	Engagement Barriers	*Theme 2: Possible challenges in using the product.*	This theme explored the possible challenges while using the product.

(SpEd teacher 5)			
• Accessible for VI *"Yes, accessible siya kay kung ingon ana nga for example kato imong gi ingon nga kuan para sa mga blind, nay man guy, unsay tawag ana oy… braille." (Engineer 1)* ***English translation:*** *"Yes, it is accessible for the blind people, since there is braille."* *(Engineer 1)* • Self-directed learning *"…user friendly jud siya kay maka touch jud sila nya and then anytime pud maka gamit pud ang bata most especially if example busy ang teacher, maka gamit ra pud nila." (Teacher 3)* ***English translation:*** ***"****The product is user friendly because they can touch it and anytime the child can also use it most especially if for example the teacher is busy, the students can use it."* *(Teacher 3)*	Accessibility	*Theme 3: Product's accessibility and user-friendliness*	This theme explored the accessibility and user-friendliness of the product.
• Braille codes *"…the braille code, specially sa mga totally blind gamit jud kaayo. (SpEd teacher 2)* ***English Translation:*** ***"****…the braille code, especially to students who are totally blind. This is so useful.*" *(SpEd teacher 2)* *"For me it is the Braille code. Braille code can be a significant help because that part of the product helps them identify what number card they are flipping. Also, It allows them to learn and practice math problems independently…" (Engineer 4)* • Divider "*…ay makahibaw pud sila nga ay kani naa nako sa pikas kay tungod ani kay lihok lihok baya sa kamot ilaha so*	Key features	*Theme 4: Significant Features of the Product*	This theme explored the significant features of the product that is helpful for students.

makahibaw na sila ah ok 1 digit ra diay siya, in ana here pud makabaw pud sila sa ones og tens. Ang diri diay dapita kay ones nya diri dapita kay tens." (SpEd teacher 3) ***English Translation:*** *"...they will also know that this will be the next step because of the divider since the VI students need to touch and move their hands and they will know that this is 1 digit or they will also know that this is ones or tens." (SpEd teacher 3)*			
• No sharp edges *"There are none, since there are no sharp edges and the product is smooth." (Engineer2)* *"murag wala man kay dili man siya sharp kuan sharp edges" (SpEd teacher 1)* ***English Translation:*** *"I think none because the edges are not sharp." (SpEd teacher 1)* *"Kung edging sya hait.. kung hait siya harmful gyud kay ang mga bata man gud more on mag sigeg gunit gunit." (SpEd teacher 5)* ***English Translation:*** *"If (the dividers) edge are sharp of course it is harmful because the students are more on holding/touching (things)."(SpEd teacher 5)* • No harmful volatile materials used *"...not sure if sa paint...wala ba siyay organic compounds." (Engineer 3)* ***English Translation: "****...not sure if the paint doesn't have organic compounds." (Engineer3)*	Product safeness	*Theme 5: Product's feature safeness*	This theme explored the safeness of the product's features.
• Use of sandpaper for VI *"Pwede sad ni siya kuan sandpaper, embossed jud siya, sandpaper ang diri atleast ma feel niya ang kuan kay ang mga VI ganahan kay na sila naay mga feel diri ig ana nila, sandpaper ang sa diri sa number. Kana ra akong ma suggest" (SpEd teacher 1 and 2)* ***English translation:*** *"I can also suggest*	Product physical enhancement	*Theme 6: Improve User Experience and Engagement*	This theme explored the ways on how the product can be enhanced, focusing on meeting the needs of the users.

embossed sandpaper in forms of numbers because students who are VI like to feel and touch. That's what I can suggest." ● Increase number range *"... Kuan siguro mo suggest siguro ko 1-20 siguro wala ra ni suggest ra ko. Ang answer is ma abot man jud siyag 19 e butang lang nato, kay usahay ma boringan sila sige rag 1-10 ..." (SpEd teacher 3)* ***English translation:*** *"I think I will suggest from 1- 20, I'm just suggesting. The answer will reach 19, let's put it that way because sometimes they will be bored if it will be just until 1-10."* ● Decrease product size *"... for the learners siguro too big ra siya..." (SpEd teacher 4)* ***English translation:*** *for the learners, I think it's too big for them.* *" ...gamayan gamayan lang kay dako rajud siya and then e kuan lang ninyo nindot nindot naman gyud siya so pagamayan gamayan lang." (SpEd teacher 5)* **English translation:** "*...it will be much better if it is a little more handy for the students, so maybe make the product a little smaller."* *"Am, okay rman siya, peru para nako kani is taas, kaning glass bitaw (The divider), ou taas ra kayo gamay, murag mag lisod og kuan ang (ang blind). Am sakto ra iyang size, or maybe if naa moy kuan, pwede rapud buhatan Ninyo gamay." (Engineer 1)* ***English translation:*** *"The product is okay, but for me this part is too tall, this glass part (The divider) it is a bit too tall in size, I guess the blind people would have a hard time accessing it. With regards to its size, it is okay, or maybe if you have something to change, it's also okay for you to create something smaller."*			

● Increase durability *"Kani kay kuan man e-glue gun, … kay ni kala man." (Engineer 2)* ***English translation:*** *"This part right here (The divider) is showing signs of instability, since glue gun was used."* *"ah, siguro first kay ang quality sa materials…uh though okay siya but if ako I prefer siguro metal since unsa ni siya? Plastic…much better if steel, mas durable sad siya…" (Engineer 3)* ***English translation:*** *"...maybe first is the quality of the materials though it's okay but if it were me, I would prefer maybe metal since what is this? Plastic, much better if you use steel, it's also more durable."* ● Improve the consistency of braille dots space and size *"Kani lng guro sya, kani gali (braille dots) esame sya." (Engineer 5)* ***English translation:*** *"This one (braille dots) make the braille dots the same in diameter/size."*			
● For ID, number representation *"sa VI okay rajud siya pero if sa kuan sa ID is kuan lang siya dili lang guro braille codes, objects lang siguro." (SpEd teacher 1 and 2)* ***English translation:*** *"To students who are VI it is totally fine but to students who have ID, I suggest objects below the numbers instead of braille codes."* ● Incorporating audio feature *"... It is very good if you enhance the product with one more feature. Just like putting an audio to it because Aside from feeling the Braille code with their hand, it will also allow the visually impaired students to hear an audio upon flipping or touching the number to understand the concepts better." (Engineer 4)* ***English translation:*** *"If i were to give a*	Product accessibility enhancement	*Theme 7: Accessibility and Inclusivity Improvement.*	This theme explored how the product can be enhanced in terms of inclusivity and improvement.

suggestion about your product, It is very good if you enhance the product with one more feature. Just like putting an audio to it because Aside from feeling the Braille code with their hand, it will also allow the visually impaired students to hear an audio upon flipping or touching the number to understand the concepts better."			

Twenty-two (22) significant statements were extracted from the interview transcripts of the 10 participants. There were 19 codes that were grouped into seven categories, which emerged as seven themes. Based on what the participants said, specifically the SPED teachers, the "TactiMath Flips" are most useful for learners with visual impairment. However, there are also drawbacks that were identified by the engineers regarding its physical attributes that need to be improved, such as the consistency of the braille dots' size and spacing.

Discussions

Theme 1. Enhancing Learning Experience

Results showed that the selected SPED teachers found the TactiMath Flips as an effective learning material in teaching subtraction and addition. These were supported by the responses of the SPED teacher that:

"*...they can touch the shape of the numbers and the mathematical operations…" - SpEd teacher 3*

""Even if the child doesn't know how to count, just by flipping the tile they can get the concept of 1, 2, 3" - SpEd teacher 2

"With your product I've seen that the braille dots are large making it easy to identify by the learners" - SpEd teacher 4

This means that the SPED teachers found the TactiMath Flips effective in enhancing the learning experience of the learners because of its features such as the embossed number shapes and mathematical operations, tangible tiles that can be used for counting, and the large braille dots which can promote tactile engagement. This confirms that tactile engagement enhances the learning experience of learners with disabilities through improving a child's concentration and engagement to the lesson (Hart 219; McBride 2023). One of the features of the TactiMath Flips is that it has tangible tiles that can be used for counting. Manipulatives enable students to establish a connection between mathematical concepts and their educational experience (McBride & Plaster, 2021). Tactile learning enhances the learning experience of learners, especially learners with visual impairments who rely on their sense of touch.

Theme 2.Possible challenges in using the TactiMath Flips

Results showed that the selected SPED teachers have identified possible challenges when using the TactiMath Flips. They find TactiMath Flips useful for learners with visual impairment in teaching basic subtraction and addition but also entails possible challenges to other learners with other types of

disabilities. These were supported by the responses of the SPED teachers that:

"The challenge is if the child will throw the material because the child isn't ready to manipulate the thing" - SpEd teacher 1

"*...it really needs the assistance from the teacher so the students will really learn and not just touch (the product)" - SpEd teacher 5*

"For learners with intellectual disability and autism spectrum disorder they will be distracted with the braille codes." *- SpEd teacher 5*

This means that although the TactiMath flips are beneficial to the learners, it may not be the same for learners with intellectual disability and autism spectrum disorder. One of the features of the "TactiMath Flips" is that the numbers come with translation in braille dots. There is a high chance that the braille dots may distract and cause confusion to some learners. This confirms that for learners on the autism spectrum who may have tactile defensiveness and are over responsive to visual stimuli the braille dots can possibly disrupt their learning experience and negative sensorial experiences have been found to impact their learning negatively (Jones et al., 2020). Color schemes can affect the mood, learning ability, and function of learners with autism and some colors can cause extreme behavioral changes to the learners such as agitation, irritability, confusion, distress, anger, and aggressiveness (Nair et al., 2022). Additionally, the braille dots may cause confusion to learners with intellectual disabilities as they may confuse it as a representation of the number presented in a specific number tile. With that, using it with the assistance from the teacher is necessary to ensure learning outcomes are achieved.

Theme 3. Product's accessibility and user-friendliness

Results showed that the TactiMath Flips product is accessible and user-friendly for students who are visually impaired. According to Rotmann et. al. of 2020 VIs can demonstrate their mathematical knowledge, perceive their own growth in mathematics, and gain some much needed confidence in their ability to succeed in technical fields of education when given opportunities to engage independently.

The product being accessible can improve the learning experience for visually impaired students by providing them with equal opportunities to engage with educational materials. This can lead to better academic outcomes and foster a more positive learning environment.

These were supported by the responses of the SpEd teachers and engineers that:

"*...it is really for VI students most especially because of the braille codes and they can touch the forms of the number and the operations."- SpEd teacher 3*

"...it is user friendly especially to students with VI, I can highly recommend your product because of the braille codes of course.."- SpEd teacher 2

"Yes, it is accessible for the blind people, since there is braille."- Engineer 1

This means that the SpEd teachers and Engineer believed that the TactiMath Flips product is accessible

and user friendly to visually impaired students due to the braille codes. “Given an inclusive assessment showing growth over time with opportunities for VIs to engage independently, VIs can demonstrate their mathematical knowledge to those around them.” (Rotmann et. al. 2020) Every student, regardless of their abilities, should have equal access to education and resources. By making a product accessible to visually impaired students, you're fostering inclusivity and ensuring that they can participate fully in educational activities. Excluding visually impaired students from accessing educational resources effectively denies them opportunities for learning and personal development. “It is important that the adaptation and creation of new tools does not outpace what goes on in the classroom, the demands of the materials in any diagnostic task should match the needs of the student.” (Rottmann et al., 2020) It's essential to recognize and address these ethical considerations by ensuring that products are accessible to all users. In conclusion, ensuring that a product is user-friendly and accessible to visually impaired students is not only a moral imperative but also makes good business sense, enhances user experience, expands market reach, and fosters inclusivity and equality in education.

Theme 4. Significant Features of the Product

Results showed that braille codes and dividers are the features of the TactiMath Flips that the SpEd teachers and engineers find most helpful for learning addition and subtraction to students with visual impairment. They mentioned that all features of the product are important, however, they saw the braille codes and the dividers stand out as the most significant feature of the TactiMath Flips. According to Castellano and Kosman (2020), readiness skills is a must because that is how learners know and are able to subtract, add, and perform mathematical operations, that is also how learners learn how to count and recognize the numbers using braille codes.

These were supported by the responses of the SpEd teachers and engineers that:

“…the braille code, especially to students who are totally blind. This is so useful.”*- SpEd teacher 2*

“For me it is the Braille code. Braille code can be a significant help because that part of the product helps them identify what number card they are flipping. Also, It allows them to learn and practice math problems independently…” -Engineer 4

“…they will also know that this will be the next step because of the divider since the VI students need to touch and move their hands and they will know that this is 1 digit or they will also know that this is ones or tens.” -SpEd teacher 3

This means that the SpEd teachers and Engineers believed that the significant feature of the TactiMath Flips are the braille codes and the dividers for a successful acquisition of learning basic mathematical concepts, the addition and subtraction among students with visual impairment. This is confirmed by Kashmer describing that the braille code is ”sufficient” in mathematics.“. The embossed braille codes on each tile helps students with visual impairments to identify what number they are touching. One teacher said that with the clear dividers the learners would be able to know what will be their next step because of the divider since learners with visual impairment need to touch and move their hands and that they will also know that, that is 1 digit or that is one or tens. Tactile learning tools such as the TactiMatch Flips with braille codes and clear dividers are crucial for enhancing the learning experience of learners with

visual impairments in addition and subtraction.

Theme 5. Product's feature safeness

Results showed that the SpEd teachers and engineers did not find any features of the TactiMath Flips that are harmful to the students. They find the product safe because features don't have any edge potential for learners to come into contact with sharp or jagged surfaces that can cause harm. Both wooden and plastic materials can become unsafe when they have sharp edges; they warp, crack, and break also (Edu,2024). These were supported by the responses of the SpEd teachers and engineers that:

"I think none because the edges are not sharp." - SpEd teacher 1

"If (the dividers) edge are sharp of course it is harmful because the students are more on holding/touching (things)." - SpEd teacher 5

"...not sure if the paint doesn't have volatile organic compounds."- Engineer 4

"There are none, since there are no sharp edges and the product is smooth." - Engineer2

This means that the materials used in the product are harmless for the learners and doesn't have any hazardous substance. This confirmed that epoxy all purpose are versatile two-part materials consisting of a resin and a hardener. When combined, according to Fitzgerald (2023) these two parts create a chemical reaction that causes the mixture to harden into a durable and glossy non-toxic finish. TactiMath Flips features do not have any sharp objects/edges and are non-toxic for learners that hinders them in learning addition and subtraction. Number tiles, dividers, and the base are intended to be an eased edge (top+bottom) to avoid the risk of accidental cuts or injuries especially for learners with visual impairments and also provide a comfortable grip or touch surface reducing the strain on the learner's hands and fingers. Metal rods are bent to ensure safeness of the product, by bending, it redistributes the stress and load-bearing capacity along the curved shape, making it less prone to breakage or failure under pressure. The learning material, TactiMath Flips, prioritize the safety and well-being of the learners from the absence of sharp edges and non-toxic materials to the eased edge design of the number tiles, dividers, and base.

Theme 6. Improve User Experience and Engagement

From the cumulated responses of the participants, the results showed the suggestions of the experts, wherein the product could improve the user's experience and engagement if the embossed number on the tiles would be in a form of a sand paper, for according to them, the visually impaired students prefers when they could feel and touch something. The recognition of tactile images for young visually impaired individuals is improved through the use of varied materials with different textures (Theurel et al., 2013). Another suggestion to improve the product is to increase the number range of the tiles at least up to 20. This is because according to them, the students might get bored if it were only 1 to 10. Also, the foundation for mastery and competency in numbers to 100 lies within the basic mastery of addition and subtraction to 20 (Low, 2020). Additionally, they also suggested that the product should be decreased in size for it to be handy for the students. In line with this, a lot of students with or without special needs excel in their achievement progress using instructional materials that are intently aligned with the principles of best

practices for special needs students (Olsen, 2008). Moreover, they also suggested increasing the product's durability since there is a part of it that is unstable, just like the dividers. According to the Oregon Department of Education (2023), improvements in the students' learning outcomes can be yielded from high-quality instructional materials. Also, high quality classroom materials fosters an effective professional development and draws out productive student conversations. (Russell et al., 2022). And lastly, they also suggested improving the consistency of the braille dots in terms of its space and size. Specific measurements govern the height of each raised letter and corresponding Braille dot, as well as factors such as dot diameter, spacing between dots, and horizontal and vertical cell separation (Le, 2022). And according to Braillo (2021), inconsistent heights and low profile braille dots are difficult to read. These are supported by the responses of the experts that:

"I can also suggest embossed sandpaper in forms of numbers because students who are VI like to feel and touch. That's what I can suggest." - SpEd Teacher 1 and 2

"I think I will suggest from 1- 20, I'm just suggesting. The answer will reach 19, let's put it that way because sometimes they will be bored if it will be just until 1-10." - SpEd teacher 3

"...it will be much better if it is a little more handy for the students, so maybe make the product a little smaller." - SpEd teacher 5

"This part right here (The divider) is showing signs of instability, since glue gun was used." - Engineer 2

"This one (braille dots) make the braille dots the same in diameter/size." - Engineer 5

This means that the responses that came from the SPED teachers and the Engineers are aimed at improving the user's experience and engagement. And this can be accomplished through adding tactile elements on the product, such as sandpaper textures. This could also be accomplished through expanding the number range of the product up to 20 to prevent boredom and support foundational skills in mathematics. Also, making the size of the product a little smaller makes it more manageable for students to navigate. Another way to help accomplish this is by enhancing its durability, this ensures longevity and stability, which is crucial for an effective learning material. And consistency in braille dots' size and spacing should also be considered, for this improves readability, which addresses the challenges faced by visually impaired students. Overall, these suggestions aim to develop and create a high-quality, accessible, and effective instructional material that would help students with visual impairment better understand the concept of addition and subtraction.

Theme 7. Accessibility and Inclusivity Improvement

From the cumulated responses of the participants, the results showed the suggestions of the experts that would improve the accessibility and inclusivity of the product. The experts suggested an addition of number representation, this is for the ID students. Objects or technologies that are tangible are considered particularly significant materials in helping children with intellectual disabilities, this enables them to access significant interaction through physical manipulation (Falcão, 2016). And they also suggested

incorporating an audio feature to the product, this is to allow the visually impaired users to be able to hear an audio, which would enable them to improve their understanding of the addition and subtraction concept. In relation to this, to facilitate the educational development of students with hearing loss and visual impairments, it is believed that using visual and audiovisual materials are very important. (Akay, 2021). These are supported by the responses of the experts that:

"To students who are VI it is totally fine but to students who have ID, I suggest objects below the numbers instead of braille codes." - SpEd teacher 1 and 2

"If I were to give a suggestion about your product, It is very good if you enhance the product with one more feature. Just like putting an audio to it because Aside from feeling the Braille code with their hand, it will also allow the visually impaired students to hear an audio upon flipping or touching the number to understand the concepts better." - Engineer 4

This means that the responses that came from the SPED teachers and the Engineers are aimed at improving the product's accessibility and inclusivity, and this could be done through adding number representation, which is beneficial for those who have intellectual disability and would allow them to have a tangible and an interactive learning experience. And another way for this to be accomplished is through incorporating an audio feature. This specifically caters to visually impaired users. Generally, these suggestions help in encouraging an inclusive learning environment for all students regardless of abilities and disabilities.

Conclusion and Recommendations

This study aimed to develop an accessible instructional material for learners with visual impairment in teaching basic mathematical concepts such as subtraction and addition. The study revealed that the product, TactiMath Flips, is perceived as an effective and accessible learning material by the Special Education (SPED) teachers and the engineers for teaching addition and subtraction to visually impaired students. It is also revealed that the product is specifically most effective for students with visual impairment. Highlighted as an important aspect in improving the learning experience and promoting tactile engagement for students are the features of the product that comprises the large braille dots, the clear divider, the tangible tiles, and the embossed number shapes. Additionally, the product was deemed to be safe for users to utilize, since there are no sharp edges and there were no harmful volatile materials used. However, there are also challenges noted, specifically in relation to the students' preparedness in using the product, its possibility to distract learners with intellectual disabilities and autism spectrum disorder, and the inevitable need for teacher supervision during the utilization of the product.To improve the product's accessibility and physical attributes the researchers recommend that an audio feature will be added into the product, the use of sandpaper in the embossed number shapes and enhancing the quality of the braille dots' size and spacing to better assist learners with visual impairments. Since the scope of the study is limited to developing the "TactiMath Flips", researchers recommend that its impact on the academic performance on the learners with disabilities in inclusive classrooms set-up will also be evaluated.

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Appendix A

Research Instrument Questionnaire for Teachers

1. How does the product enhance the student's learning experience?
2. What challenges have you encountered while using the product for teaching addition and subtraction?
3. How do these challenges affect the teaching or learning process of the students?
4. How easy or difficult is it for you to use the product to teach addition and subtraction?

Research Instrument Questionnaire for Teachers and Experts

5. Do you feel the product is accessible and user-friendly for you? Why?
6. What features of the product do you find most helpful for learning addition and subtraction to students with visual impairment?
7. Do you find any feature of the product harmful to the students?
8. Do you have any suggestions for how the product could be improved to better assist you in teaching addition and subtraction for visually impaired students?