Vol. 12, No. 2, pp. 912-924, 2022 DOI: 10.23960/jpp.v12.i2.202240

Jurnal Pendidikan Progresif

e-ISSN: 2550-1313 | p-ISSN: 2087-9849
http://jurnal.fkip.unila.ac.id/index.php/jpp/

How to Build Mathematical Abilities in Deaf Students? A Grounded Theory

Samuel Igo Leton*
Department of Mathematics Education, Universitas Katolik Widya Mandira, Indonesia

*Corresponding email: letonsamuel@unwira.ac.id

Received: 24 April 2022 *Accepted: 19 June 2022* *Published: 21 June 2022*

Abstract: How to Build Mathematical Abilities in Deaf Students? A Grounded Theory. Objective: This study aims to produce a conceptual model as a strategy for building mathematical abilities in deaf students. **Methods:** This is qualitative research with a grounded theory design involving 45 deaf students from four middle schools in Indonesia. **Findings:** The results of the data analysis at the open coding stage obtained five categories of visual, feeling, understanding, learning experience, and habits in learning mathematics. At the axial coding stage, mathematical understanding was used as the core category. While at the selective coding stage, a conceptual model was built where each category contributes to building mathematical abilities. **Conclusion:** That efforts are crucial to develop the mathematical abilities of deaf students comprehensively. This can be done by visualizing the problems, connecting the problems with the student environment, providing learning experiences with various questions, giving motivation, and increasing self-confidence using praise and more attention from parents or teachers.

Keywords: deaf student, grounded theory, mathematical abilities.

Abstrak: Bagaimana Membangun Kemampuan Matematis pada Siswa Tuna Rungu? Sebuah Teori Dasar. Tujuan: *Penelitian ini untuk menghasilkan model konseptual sebagai strategi untuk membangun kemampuan matematik pada siswa tunarungu.* ***Metode:*** *Penelitian kualitatif dengan desain grounded theory yang melibatkan 45 siswa tunarungu dari empat sekolah menengah pertama di Indonesia.* ***Temuan:*** *Hasil analisis data pada tahap open coding diperoleh lima kategori yaitu visual, feeling, pemahaman, pengalaman belajar, dan kebiasaan dalam pembelajaran matematika. Pada tahap pengkodean aksial, pemahaman matematis digunakan sebagai kategori inti. Sedangkan pada tahap selective coding, dibangun model konseptual dimana setiap kategori berkontribusi dalam membangun kemampuan matematis.* ***Kesimpulan:*** *Upaya pengembangan kemampuan matematis siswa tunarungu sangat penting dilakukan secara komprehensif. Hal ini dapat dilakukan dengan memvisualisasikan masalah, menghubungkan masalah dengan lingkungan siswa, memberikan pengalaman belajar dengan berbagai pertanyaan, memberikan motivasi, dan meningkatkan kepercayaan diri dengan pujian dan perhatian lebih dari orang tua atau guru.*

Kata kunci: *siswa tuna rungu, teori dasar, kemampuan matematis.*

To cite this article:

Leton, S., I. (2022). How to Build Mathematical Abilities in Deaf Students? A Grounded Theory. *Jurnal Pendidikan Progresif*, *12*(2), 912-924. doi: 10.23960/jpp.v12.i2.202240.

INTRODUCTION

Generally, learning math is directed to forming concepts and ideas to solve mathematical and other scientific problems. This is also done to develop mathematical abilities, including logical, critical, and practical thinking skills, as well as mathematical connection, problem-solving, and communication skills, and the ability to nurture positive and creative minds. Mathematics is indeed one of the essential abilities. Those with good mathematical skills can form a logical and systematic way of thinking, giving them a better chance to compete in the economic and technological fields. Therefore, both non-disabled children and those with specific needs must equip themselves with Mathematical skills.

Deaf children can be described as those who have difficulty hearing or unable to hear any sound. However, in many cases, there are still remnants of hearing that can be optimized by them. The limitations suffered by deaf children due to lack of information acquisition and language understanding affect their thinking process in building mathematical abilities. Although their level of intelligence is generally intact, their development of language-related intelligence is compromised and caused them to have lower intelligence than other children. In other words, this issue is rooted in the non-maximization of their intelligence. For the non-verbalized courses, generally speaking, deaf children have intelligence development as fast as other children; however, this is not the case with verbalized lessons. This is influenced by their difficulties in understanding spoken language. Deaf children have low ability concerning the acquisition of information and language. They also lack vocabulary and have difficulty understanding language expressions containing figurative meanings and abstract words. Their low abstraction power is related to the language and speech disorders caused by hearing impairment.They have difficulty processing abstract concepts, which makes it more challenging to solve mathematical problems related to everyday life. Therefore, they are slower in processing information than other children (Akram et al., 2013) and have more challenges working on tasks with higher linguistic demands (Barbosa, 2013). As a result, they need more time learning how to link mathematical concepts and use them in problem-solving.

Deaf children may rapidly develop their visual and kinaesthetic intelligence, and they can follow the learning process using their visual and lip-reading abilities. For them, visual and lip-reading play an important role in comprehending a problem. Deaf children have a higher visual ability (Marschark et al., 2017), which is their strength in learning to improve their language proficiency and communication (Marlatt, 2014). Moreover, children with hearing loss exhibit more mathematical abilities in space and measurements that use visuospatial skills (Vosganoff et al., 2011). They also use the same types of general strategies used by other children, such as modelling, calculation, and fact-based strategies. They show a great use of strategies for all types of problems (Pagliaro & Ansell, 2012), also tend to use images and counting out loud as a strategy in solving mathematical problems (Leton et al., 2019).

It is assumed that hearing loss in deaf children is not a direct cause of learning mathematics. They need a learning strategy or model that focuses on using their strengths as a bridge to help their thinking process in building mathematical abilities. Therefore, this study aims to produce a conceptual model to build mathematical abilities in deaf students. By producing a conceptual model, it is expected to contribute to the development of mathematical learning theory, produce teaching materials or special mathematics textbooks for deaf students to achieve the goals of mathematics learning.

METHODS

Participant

This research involved 45 deaf students out of 155 students from four schools namely SLB Karya Murni Ruteng, SMPLB Negeri Semarang, SLB-B Don Bosco Wonosobo and SLB-B Denaupakara Wonosono in Indonesia. The 8th-grade students involved in this research have consented to their participation through their schools and guardians. The participants' contributions have been incentivized as well.

Table 1. Number of participants from their respective schools

	Male	Female	Total
SLB Karya Murni	4	7	11
SMPLBN Semarang	5	4	9
SLB-B Don Bosco	12	0	12
SLB-B Denaupakara	0	13	13
n	21	24	45

Data collection

The study used a problem-solving skill test, questionnaire, interview, and observations and field report to collect the data as discussed below.

Problem solving skill test

The test preparation began by examining the mathematics material taught in the school curriculum for grade eight. These problems range from geometry, algebra to social arithmetic to measure student mathematic proficiency. Instrument validity testing was conducted. This included content validity and construct validity. Content validity evaluates the test material's compatibility to reveal the participant's ability to connect their mathematical and problem-solving aptitude. Construct validity evaluates the structure of the problem used, ensuring the problems are easily understood and preventing ambiguity. The problem-solving ability test was made by the researcher which consisted of 5 types of problems to measure mathematical connection skills where problem 1 was to measure aspects between mathematical topics, problem 2 was to measure mathematics with other disciplines and problem 3 was to measure mathematics with everyday life. While problem 4 and problem 5 are used to measure mathematical problem solving abilities related to social arithmetic and fractions.

Furthermore, a pilot study was conducted involving two deaf students. This was done to ensure whether the test met its readability requirement or not. The results indicated that the instrument was valid to be used where 93.5% validator supporting material's compatibility, questions' construction, as well as the readability of the test. The pilot study indicates that the instrument was easily understood and not prone to misinterpretations. The test is shown in Fig. 1.

Questionnaire

This questionnaire developed by the researcher was used to identify the participants' habits while learning mathematics (S.I. Leton, 2018). To identify their habits in learning mathematics, the researchers made 3 (three) indicators, namely; 1) consistent behavior, 2) discipline behavior, and 3) commitment behavior when learning mathematics. Indicators of consistent behavior consist of personal habits, principles, confidence, certainty, and

Figure 1. Mathematical problems given to the participants

willingness to learn that are directed and focused integrated into 12 questions. Indicators of disciplined behavior in learning mathematics consist of following courses according to schedule, discipline in doing assignments, discipline in using learning tools and facilities, and being on time. These indicators were developed into 11 questions. The behavioral indicators of commitment in learning mathematics consist of self-confidence, determination, learning while practicing with equations, evaluation of progress, and improvement efforts. The indicators were developed into ten questions. Each question has four possible answers: always, often, sometimes, and never.

Interview

This research used a semi-structured interview since it is considered better and more flexible to generate in-depth information than a structured interview (Arikunto, 1993). Interview guidelines were created and consulted among peers and mathematic teachers who taught the subjects at the researched schools. Due to communication barrier, teachers were asked to act as the interviewers for this research. After the interview, the transcript was written using the following code. MAiNp/SSi : Problem Aspect number; i (i = 1, 2, ...5); N: Dialog arrangement between P and Sn; P: Interviewer; Sn : Participant number-n (n = 1,; … : Pause)

Observation and field report

Observation and field report consisted of information heard, seen, experienced, and thought of during the data collection and reflection, as well as the compatibility of tests, surveys, observations, and interview data.

RESULT AND DISCUSSIONS

The Results should include the rationale or design of the experiments as well as the results of the experiments. Results can be presented in figures, tables, and text. The Results should include the rationale or design of the experiments as well as the results of the experiments. Results can be presented in figures, tables, and text. The analysis process began by examining and analysing the participants' mathematical abilities in working on some problem(s). Then, in-depth interviews were conducted to explore how they solve the given problems, influencing factors, and other relevant matters. The results are presented in this section.

Open coding

Open coding was done by giving a code to each answer related to the idea(s) in solving math problems obtained from the participant worksheets and the interviews. This produced five categories that become factors in building mathematical abilities — visual, feeling, mathematical understanding, learning experience, and habits in learning mathematics. The five categories can be explained as follows:

Visual

This visual category arose from coding with keywords 'using images' and 'concrete objects.' First, most of the participants drew diagrams and shapes to help them understand the problems at

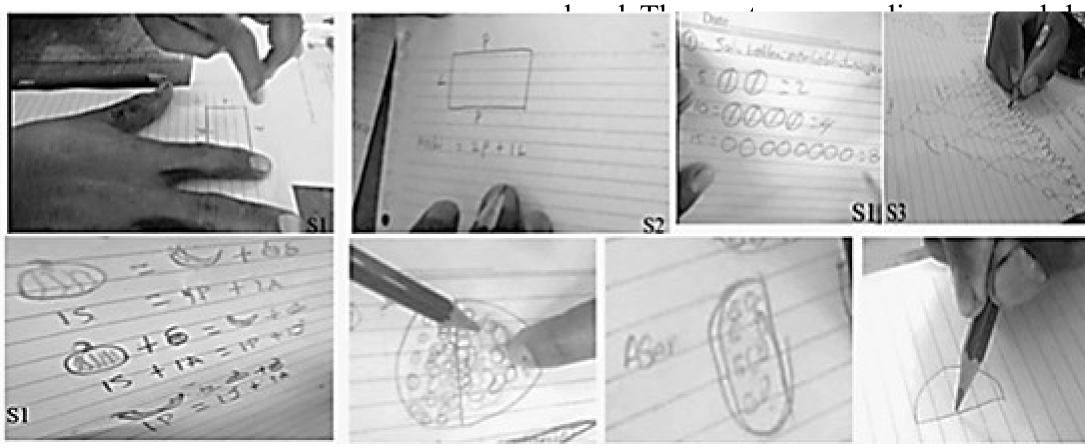

Figure 2. Models of images made by students

By Illustrating problems using drawing, students build an understanding of the problem at hand, identify the known elements, and re-express them in a more straightforward language. This demonstrates their level of understanding.

Second, concrete objects are the most accessible tools because no preparations are needed, and the teacher can immediately show the objects to the students during a lesson. As tangible matters, concrete objects provide direct experience to the students to help them understand math problems. Concrete objects are necessary to use in the learning process because they aid problem-solving. Paint cans, markers, matches, balms, toy cars, chalks, rubber erasers, and boxes are the most commonly used concrete objects that are easy to find and low-cost. Using concrete objects facilitates an authentic experience that stimulates independent learning and adds new experiences to deaf students. Fig. 3 shows participants solving math problems with the aid of concrete objects.

Figure 3. Participants using concrete objects to solve math problems

In addition to using visual and concrete objects, the participants often use body language to communicate with their peers. This can be in the form of sign language, gesture, and facial expression. Sign language consists of non-standardized and standardized sign language (ASL). The non-standardized sign language primarily consists of gestures with fingers and differs across communities. Based on the interviews with the teachers, it was clear that non-standardized sign language was never taught at school. It usually emerges and developed based on the agreement among the members in a particular deaf community and becomes a habit maintained from one generation to another in their communities. On the other hand, ASL is broadly received and is regularly used in activities related to deaf students. It is often interpreted as a unifying language for deaf students. This type of sign language has a literal relationship between the position of the hand and the word described. Each ASL gesture does not have a double meaning, and most can be distinguished and not similar to others. Besides sign language, lip-reading is often used to understand speech. Deaf students will direct their eyes to the opposite speaker's mouth as they observe the lip movements; therefore, it is suggested that others should speak slowly with clear intonation.

Feeling

This category emerged from coding with keywords 'assured', 'happy', 'confident', and 'compliment.' The deafness experienced by the participants causes alienation from other people and their surroundings. Alienation can negatively influence deaf students, making them develop conditions, such as a higher sense of egocentrism than other students, fear of the wider environment, dependence on others, udiverted hyper-focus, plain and innocent nature, also more irritable and easily offended. These issues are discussed further below.

Deaf students may develop a higher sense of egocentrism than other students because they have a small world and limited interaction in a narrow environment. As they have hearing loss, they can only observe the world around them with their eyes. They have high curiosity yet limited to examine their surroundings only by sight. This thirst affects them to be more egocentric than other students. Deaf students may also fear a more expansive environment, often rooted in the lack of adaption skills to new surroundings. This is mainly associated with their low communication skills. Deaf students may find any new environment unclear because they cannot fit nor navigate the new situation easily.

Another negative trait is dependence on others, especially those they already know well. This shows that they may have nowhere else to turn and, thus, constantly seek help. Deaf students may also have undiverted hyper-focus due to their minimal language skills that affect how they perceive their surroundings. Their minds naturally lean towards and are fixated on more tangible, concrete things. It is challenging to shift their attention to other things that they have not yet understood or experienced as they have difficulties fully using their imagination. Having a trait of innocence, deaf students are more honest and straightforward in expressing their feelings compared to other children (Hao & Wu, 2019). Deaf children also usually exhibit raw emotions without many nuances. However, a majority of them might still find it hard to express their feelings. When they are unable to express their emotions properly, deaf students tend to feel more irritable and easily offended. The higher the language proficiency they have, the easier it is for them to understand the words of others. On the contrary, in many cases, unable to understand others and be understood lead them to display irritation and anger.

Mathematical understanding

Mathematical understanding refers to essential knowledge and skills, including understanding mathematical concepts and procedures to solve problems both in mathematics and real life. This study discovered that the participants' initial knowledge is deficient. They lack in understanding concepts and difficult to remember them long term. Based on the classroom observation, it was apparent that the participants required considerable time to understand a mathematical idea. This due to their limitations and influenced by less-skilled teachers who did not maximize deaf students' strengths. In addition, the participants also have a fairly low ability to provide arguments for defending their answers or the procedures they used to solve the given problems.

Learning experience

Learning experience is another category that emerged from the analysis. This relates to the strategies or methods used by each participant in solving different problems. Based on the participant worksheet, it is evident that it was difficult for them to solve problems if they did not have experience solving similar problems before.

Mathematics learning habits

This category examines the participants' habits, consistency, discipline, and commitment to learning mathematics. Students with hearing impairment have strong attitudes, not easily distracted, and highly focused when it comes to learning mathematics. A consistent attitude possessed by them influences their behaviour. They tend to have self-discipline as well. They follow the study schedule and lessons, work on their assignments, use learning facilities responsibly, and be on time for school. Furthermore, the participants exhibited a strong commitment to learning mathematics.

Commitment in this context refers to an attitude of willingness to hold fast to the vision, mission, and willingness to mobilize all efforts in carrying out the duties and responsibilities of the task. The participants' commitment to learning mathematics was shown in their confidence, a high intention to learn, a regular evaluation of the learning outcomes, and efforts in improving their weakness in regard to mathematical skills.

Axial coding

The axial coding process starts by selecting one category from the open coding process as the core category and linking it with the other categories. We built the axial coding model, as shown in Fig. 4. Several strategies are recommended to build mathematical abilities, including building the participants' confidence, providing encouragement, peer tutoring, visual aids, context, and intervention programs.

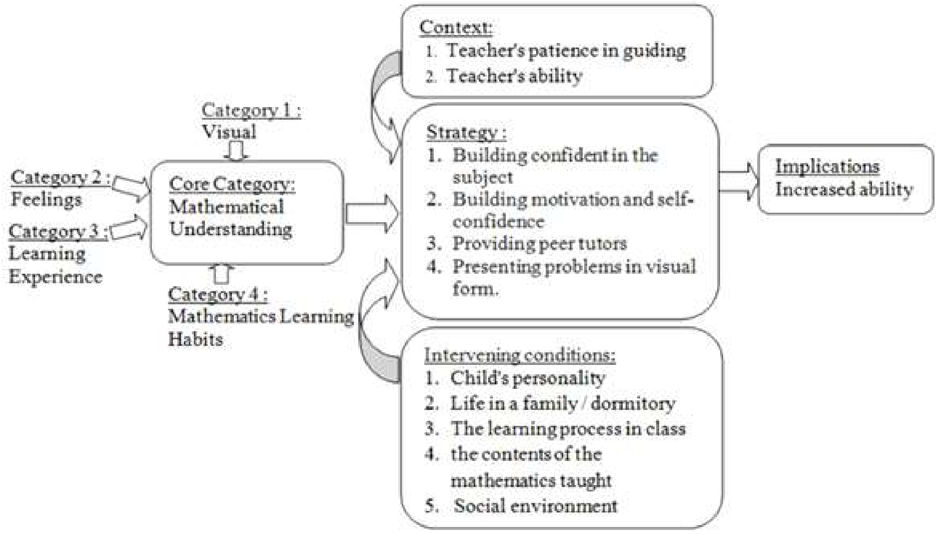

Figure 4. Axial coding model

Building student confidence

Deafness has been one of the contributing factors of lower self-esteem in students with hearing impairment. This is because society still tends to demean and underestimate those who are recognized as vulnerable and weak. Deaf students are often negatively discriminated against for their disability. However, these students also possessed abilities that are far from inferior compared to others. They are skilled at completing a job that becomes their skill, such as hairdressing, make-up artist, sewing garments, making bags, suits, furniture, etc. Therefore, it is crucial to maintain their motivation as much as possible and to increase their self-confidence. Constant genuine appreciation with words of encouragement such as, 'you can', 'you are great', and 'give a thumbs up' are necessary. In addition, creating a safe place to experience failures and how to overcome them is also vital. This will help them to be humble but optimistic about their life.

Building student motivation

Having self-confidence is critical for deaf students in handling a task and work. Their confidence will strengthen the motivation to achieve success because the more someone trusts their own abilities, the stronger the enthusiasm for completing their work. Deaf students need support, guidance, and assistance from people around them, especially their parents. Parents play an important role in the life of deaf students because they understand the circumstances surrounding their children. Therefore, we firmly believe that parents need to pay more attention to their deaf children and follow their development on a daily basis.

Peer tutoring

The study found that peer tutors can reduce discomfort in learning mathematics. This is because the language used by peer tutors is more accessible for deaf students to understand. Moreover, since the peer tutors are their classmates, learning becomes more enjoyable and less stressful. Learning among friends makes them feel less embarrassed when making mistakes, and it minimizes feeling inferior. We recommend peer tutoring as a learning strategy, particularly during lesson review and in-class practice, to help those who struggle in solving specific problems.

Visual aids

The data from classroom observations suggested that when math problems are shown in the form of images, it is easier for deaf students to understand them. Therefore, considering the best trait of deaf students, we recommend that mathematic problems and information or learning material be displayed in the form of interesting images familiar to the students.

Context

The study found two factors that influenced the strategy used to teach mathematics to deaf students: the teacher's patience and their level of ability to teach. Teachers at inclusive schools are one of the main components that directly affect student success. As professional educators, the teachers are responsible for teaching, guiding, directing, training, assessing, and evaluating the students. However, in reality, we found that teachers are expected to do beyond their capacity. Besides their already high teaching workloads to teach according to the character and potential of each student, they are also required to be able to act like paramedics, therapists, social workers, counselors, and administrators. Therefore, it is crucial for inclusive school teachers to have high patience, good physical health, and excellent work mentalities.

Regarding the teaching qualifications, we found that many teachers at the inclusive schools are general education teachers. This raises the concern regarding the suitability of these teachers to work with deaf students as there are significant differences in teaching styles between teachers with college-level mathematics qualifications and those without a similar background (Van der Sandt, 2018). Therefore, we recommend that teachers be provided with specific training to improve their learning media skills, curriculum, learning strategies, and other skills to meet student needs.

Intervening condition

Deaf students experience obstacles in language acquisition or speech due to damage or impairment of some or all of the auditory organs. This condition restricts their development, especially in regard to communication skills; thus, special guides and treatment are necessary to help deaf students grow to their best like other students. Their relationship with parents, especially the mothers, and friends at school and home/dormitory determines their personality development (Zevenbergen et al., 2001). However, their condition in which they are unable to receive auditory stimuli, lack of linguistic knowledge, emotional instability, limited intelligence, and poor treatment from society restrain their personality development.

Selective coding

The selective coding process attempts to build interconnected theories among categories in the axial coding model. The general design of the conceptual model of building mathematical abilities in deaf students is presented in Fig. 5.

Based on the conceptual model in Fig. 5, it appears that each category contributes to the efforts of building mathematical skills. The first category is visual, which consists of pictures and concrete objects. When building an understanding of the problem, this study found that there was a tendency for deaf students to represent problems visually. This suggests that the participants' level of cognitive development is at the stage of concrete operations. Visual aids are helpful to bridge between concrete and abstract elements. Deaf students can concentrate and quickly understand the events they have experienced as concrete and not simply verbalized. They need learning methods that can display concrete following what they have experienced. The mathematical learning approach that suits their

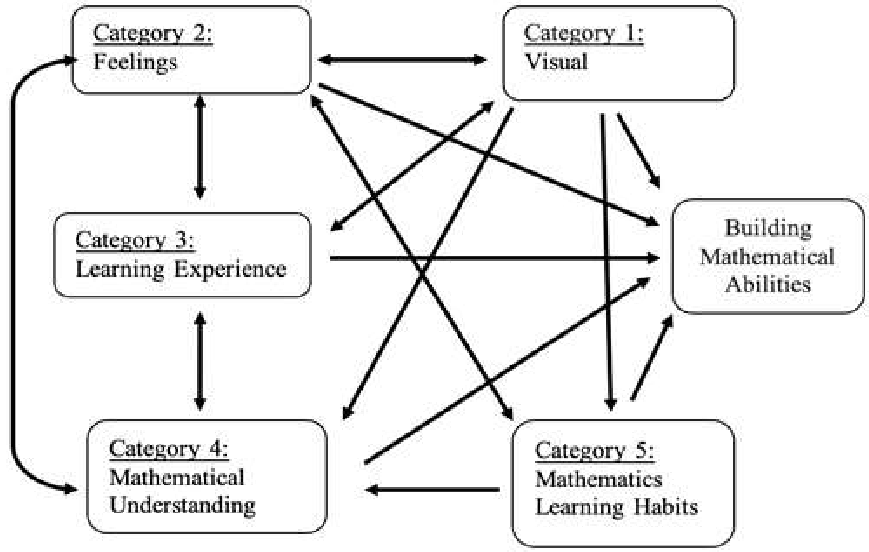

Figure 5. Conceptual models in building mathematical abilities

needs is fact-based learning (Borgna et al., 2018). They also need to be taught using rich concrete language, and teachers need to prevent them from fantasizing about the unknown. Visual acuity is their strength to improve language development and communication (Marlatt, 2014).

Based on the interviews, the participants generally stated that making pictures help them to understand verbalized explanations. This is because a representation of the problem in the form of images represents the whole or part of the problem (Ekawati et al., 2015). The ability to represent images or graphics is the ability to translate mathematical problems into images or graphics, which can be considered the best mathematical ability of children who experience auditory impairment that affects their visuals (Vosganoff et al., 2011). Thus, visual aids are imperative for deaf children in building mathematical abilities. In addition, visual aids can provide a tangible learning experience for deaf students (Lang & Steely, 2003). For them, visual literacy skills are essential in learning mathematics, which enables them to learn to process visual aids that support their reading comprehension (Nikolaraizi et al., 2013). The realistic practice of learning and work training can shape their thinking processes (Barros et al., 2014) and are expected to improve mathematical abilities and their habits of learning mathematics.

The second category is a characteristic referring to conviction, happiness, confidence, and praise. Auditory impairment has caused deaf students to become estranged from other people in their surrounding environment. Therefore, these characteristics have to be considered in the mathematical learning process. This alienation raises several negative influences, such as egocentrism, fear of the expansive environment, dependence on others, undiverted hyper-focus, and has a plain and innocent nature. These attitudes impact the habit of deaf students in which they tend to avoid learning or discussing with their peers when encountering challenging learning materials, leading to low mathematical abilities. To overcome this, they need to get treatment following their characteristics. In addition, from observations, the study found that the participants would feel happy and valued if praised for their answers. Praises in the form of giving a thumbs up or by saying 'great', 'right', and 'ok' will increase their confidence and will arouse their motivation to learn mathematics.

The third category is learning experience. The learning experience is related to what is done to solve mathematical problems such as making patterns, prediction, writing in mathematical models, planning, and carrying out plans that contribute to building mathematical abilities. The basic mathematical knowledge they have will affect the process of solving the problem. They found it more challenging to solve new problems, given they do not have experience in solving them before. Experience in solving various problems will improve their knowledge and skills in solving these problems, and their estimation abilities must be improved, including tasks that require symbolic and non-symbolic estimation and estimation strategies (Bull et al., 2011). In addition, the experience of learning using images, concrete objects, and other interesting media will ease the process of building an understanding of the problem (Stylianides & Stylianides, 2007). They can make connections, compare, develop and deepen their understanding of mathematical concepts using various representations such as physical objects, pictures, diagrams, and symbols to communicate their thoughts. They can elaborate by linking new information with known information (Leton et al., 2019).

The use of diverse representations will provide a varied learning experience in building other mathematical abilities. Learning experiences are also closely related to their beliefs and motivations. A good learning experience background will generate motivation, boosting their confidence when dealing with new problems (Pagliaro, 2012). Thus, varied learning experiences will increase knowledge, mathematical ideas and build confidence in solving math problems.

The fourth category is mathematical understanding. It refers to essential knowledge and skills, including understanding mathematical concepts and procedures to solve problems both in mathematics and real life. These basic skills are built from their classroom learning experiences in solving problems. Experience in solving various problems will improve their mathematical abilities and problem-solving skill. The experience of learning to illustrate problems using images, concrete objects, and other media will build their mathematical abilities (Nunes, 2002). This includes representational and argumentative abilities, mathematical connection skills, and mathematical problem-solving abilities.

The fifth category is characteristic (habits) in learning mathematics, consisting of consistent attitude, discipline, and a commitment to learning. Good habits indicate that they enjoy learning mathematics. Their feelings and learning experiences influence their habits when learning mathematics. A good learning experience in solving different problems using images or concrete objects and good habits in learning mathematics will improve their mathematical abilities.

CONCLUSIONS

Based on the empirical data and the analysis, which included open coding, axial coding, and selective coding, we conclude that several strategies can be used to comprehensively develop the mathematical abilities of auditorily impaired students. This includes visually presenting the mathematic problems, making connections between the lessons and students' environment, providing rich learning experiences, ample encouragement and motivation, and increasing self-confidence by praise. Moreover, parents and teachers should provide more attention to the students both at school and in their home/

dormitory. This research is limited to connection and problem solving abilities, therefore further research is needed to obtain an overview of other mathematical abilities. Aditionally, this study also limited to the material of rectangular area, linear equations of two variables, social arithmetic and fractions, therefore further researchers may necessaryly explore the connection abilities and problem solving on a broader topic.

REFERENCES

Akram, B., Mehboob, R., Ajaz, A., & Bashir, R. (2013). Scientific concepts of hearing and deaf students of grade VIII. Journal of Elementary Education, 23(1), 1-12.

Barbosa, H. H. (2013). Habilidades matemáticas iniciais em crianças surdas e ouvintes. Cadernos CEDES, 33(91), 333–347.

Barros, R., Nunes, T., Evans, D., & Burman, D. (2014). Improving deaf children's working memory through training. *International Journal of Speech & Language Pathology and Audiology*, *2*(2), 51–66.

Borgna, G., Walton, D., Convertino, C., Marschark, M., & Trussell, J. (2018). Numerical and real-world estimation abilities of deaf and hearing college students. *Deafness and Education International*, *20*(2), 59–79.

Bull, R., Marschark, M., Sapere, P., Davidson, W. A., Murphy, D., & Nordmann, E. (2011). Numerical estimation in deaf and hearing adults. *Learning and Individual Differences*, *21*(4), 453–457.

Ekawati, R., Lin, F. L., & Yang, K. L. (2015). Developing an instrument for measuring teachers' mathematics content knowledge on ratio and proportion: A case of Indonesian primary. *International Journal of Science and Mathematics Education*.

Hao, J., & Wu, C. (2019). Deaf children's moral behavior, moral reasoning and emotion attribution. *Journal of Deaf Studies and Deaf Education*, *24*(2), 95–103.

Lang, H. G., & Steely, D. (2003). Web-based Science Instruction for Deaf Students: What Research Says to the Teacher. *Instructional Science*, *31*(4–5), 277–298.

Leton, S., Wahyudin, W., & Darhim, D. (2019). *The ability of deaf student in solving mathematics problem*. International Conference on Science and Technology for an Internet of Things, 2-8, 20 October 2018, Yogyakarta, Indonesia.

Leton, S.I. (2018). Kemampuan Koneksi dan Pemecahan Masalah Matematis Serta Kegemaran Belajar Matematika Siswa Tunarungu Kelas VIII. Disertasi. Universitas Pendidikan Indonesi. 1502243.[Eighth Grade Deaf Students' Ability On Mathematical Connection And Problem-Solving And Passion For Math Learning]. Dissertation

Leton, Samuel Igo, Lakapu, M., & Dosinaeng, W. B. N. (2019). Mathematical problem-solving abilities of deaf student in solving non-routine problems. *Math Didactic: Jurnal Pendidikan Matematika*.5(2), 157-167

Marlatt, E. (2014). The importance of visual stimulus as a component of audition stimulus in the aural/oral (re)habilitation of children/clients with hearing loss. *American Annals of the Deaf*, *159*(4), 317–318.

Marschark, M., Paivio, A., Spencer, L. J., Durkin, A., Borgna, G., Convertino, C., & Machmer, E. (2017). Don't assume deaf students are visual lLearners. *Journal of Developmental and Physical Disabilities*.

Nikolaraizi, M., Vekiri, I., & Easterbrooks, S. R. (2013). Investigating deaf students' use of visual multimedia resources in reading comprehension. *American Annals of the Deaf*, *157*(5), 458–473.

Nunes, T. (2002). An Intervention Program for Promoting Deaf Pupils' Achievement in Mathematics. *Journal of Deaf Studies and Deaf Education*, *7*(2), 120–133.

Pagliaro, C. M. (2012). Mathematics Reform in the Education of Deaf and Hard of Hearing Students. *American Annals of the Deaf*, *143*(1), 22–28.

Pagliaro, C. M., & Ansell, E. (2012). Deaf and hard of hearing students' problem-solving strategies with signed arithmetic story problems. *American Annals of the Deaf*, *156*(5), 438–458.

Stylianides, A. J., & Stylianides, G. J. (2007). Learning mathematics with understanding: A critical consideration of the learning principle in the principles and standards for school mathematics. *The Montana Mathematics Enthusiast*, *4*(1), 103–114.

Suharsimi Arikunto. (1993). Prosedur Penelitian: Suatu Pendekatan Penelitian. Rineka Cipta. [Research Procedure: A Research Approach]

Van der Sandt, S. (2018). A case study: Teachers' confidence in theirown and their students' abilities in deaf/hard of hearing high school mathematics classrooms. *Issues in the Undergraduate Mathematics Preparation of School Teachers*, *5*(August), 1–15. https://eric.ed.gov/?id=EJ1189601

Vosganoff, D., Paatsch, L. E., & Toe, D. M. (2011). The mathematical and science skills of students who are deaf or hard of hearing educated in inclusive settings. *Deafness and Education International*, *13*(2), 70–88.

Zevenbergen, R., Hyde, M., & Power, D. (2001). Language, Arithmetic Word Problems, and Deaf Students: Linguistic Strategies used to Solve Tasks. *Mathematics Education Research Journal*, *13*(3), 204–218.