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Navigating the Digital Divide: A Multiple Case Study of the ALS Learners in Adopting Technology for Mathematics Education

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ABSTRACT

Grounded in the Technology Acceptance Model and Digital Divide Theory, this qualitative multiple-case study examined the perceptions, challenges, and coping strategies of Alternative Learning System (ALS) learners in adopting technology for mathematics education in Davao de Oro, Philippines. Addressing the limited research on non-traditional learners in developing contexts, each participant was treated as an individual case to generate in-depth insights. Three ALS learners were purposively selected through maximum variation sampling. Data were collected via semi-structured interviews and triangulated with ALS teachers and a family member. Trustworthiness was ensured through member checking, peer debriefing, and audit trail procedures. The data were analyzed using thematic analysis. Findings indicated that learners perceived technology as useful for accessing and verifying solutions, reflecting key constructs of the Technology Acceptance Model. However, consistent with Digital Divide Theory, barriers such as limited internet access, device constraints, and insufficient digital skills shaped their experiences. Learners responded through adaptive strategies, including reliance on digital tools, human support, and blended learning approaches. The study highlighted that technology adoption in ALS mathematics education depends on the interaction of perceived usefulness, access, and digital competence, underscoring the need for context-responsive interventions. While not generalizable, the findings offered transferable insights for alternative education settings.

Keywords: *Mathematics, alternative education, technology integration, learner perceptions, coping strategies, Philippines*

INTRODUCTION

The digital divide refers not only to unequal access to devices and internet connectivity but also to disparities in digital literacy, technological competence, and the ability to effectively use technology for meaningful learning experiences (Van Dijk, 2020). In Mathematics education, digital tools such as interactive applications, online learning platforms, and multimedia resources have been recognized for improving conceptual understanding, mathematical reasoning, and problem-solving skills among learners (Bray & Tangney, 2017; Li & Ma, 2010). Also, Technology-enhanced learning environments promote learner engagement, accessibility to educational resources, collaboration, and the development of 21st-

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century skills (OECD, 2023; UNESCO, 2023). Meanwhile, it is noted that in the Alternative Learning System (ALS), students face challenges that are compounded by limited internet access, unavailability of digital devices, inadequate digital skills, and a lack of sufficient guidance in navigating digital platforms effectively (Carney et al., 2022). These barriers negatively affect learner participation, continuity of learning, and educational quality, particularly among vulnerable and marginalized sectors (World Bank, 2020).

As such, despite the growing importance of technology in education, disparities in access and utilization remain evident among different groups of learners. Mainstream learners in formal educational settings generally benefit more from digital learning opportunities because of better access to technological infrastructure and instructional support (Loh et al., 2025). Conversely, learners in the Alternative Learning System (ALS) face significant challenges in utilizing technology, particularly in Mathematics education, due to economic limitations and unequal access to digital resources (Ilumin, 2021). These challenges often compound, as the challenges faced by the learners include limited access to the internet, the unavailability of devices, low digital skills, and a lack of adequate guidance to utilize the digital platform effectively (Carney et al., 2022). Ultimately, the issues regarding these problems directly impact the vulnerable learners, making the educational quality worse (World Bank, 2020).

At the global level, challenges related to technology integration in non-formal education are similarly experienced across different countries. According to the Organization for Economic Co-operation and Development (OECD, 2023), educational inequalities continue to widen because marginalized learners often have less access to technological resources and digital learning opportunities. In Thailand, Non-Formal Education (NFE) programs experienced problems related to inadequate infrastructure, limited availability of computers, and insufficient localized digital learning materials for learners (Dipendra, 2023). Likewise, Alternative Learning Centers (ALCs) and Accelerated Education Programs in Malaysia encountered challenges involving weak internet connectivity, limited devices, and unsuitable learning environments that hindered effective digital learning participation (Loganathan et al., 2021). In Indonesia, the Equivalency Education Program (Kejar Paket A/B/C) also struggled with limited technological infrastructure, persistent digital divide issues, and low integration of information and communication technology (ICT) in instruction (Kusuma & Sutarto, 2025). These international experiences mirror the realities faced by out-of-school youth and adult learners in the Philippines, highlighting that the digital divide remains a global educational concern.

In the Philippine context, studies on the integration of technology in the ALS program have revealed various infrastructural, instructional, and technological challenges. The complexity of integrating technology into ALS programs remains a persistent concern. As reported by Denajeba and Ducot (2025), the unavailability of digital devices is one of the leading problems encountered by ALS learners. Similarly, Espinosa et al. (2023) noted that unstable internet connectivity significantly hinders the effective utilization of technology in the learning process. The inconsistency of access to digital devices and internet services creates difficulties for both learners and facilitators in building a strong foundation for digital learning and technological navigation (Almojano, 2025). As highlighted by the Department of Education (2020), learner preparedness and readiness significantly influence the successful utilization of educational technology.

Furthermore, the integration of technology in ALS is hindered not only by limited access to infrastructure but also by insufficient contextualized instructional materials and a lack of localized digital content suited to adult learners and out-of-school youth (Department of Education, 2022; UNESCO Institute for Lifelong Learning, 2022). As emphasized by Caloscos (2025), generic instructional approaches often fail to resonate with the diverse learning backgrounds and experiences of ALS learners, thereby creating barriers to digital literacy development. Consequently, teachers are frequently compelled to improvise instructional materials and strategies, making technology integration more difficult and highlighting the need for context-specific instructional design to bridge the digital divide within ALS programs.

At the local level, technology integration in ALS programs presents a complex reality in which digital tools function as both learning opportunities and barriers. According to Abregoso and Dioso (2024), technology can serve as both a tool and a hurdle for adult learners who often struggle to navigate unfamiliar digital platforms without adequate training and support. In the absence of proper guidance and resources, learners encounter difficulties that extend beyond mere access to technology. This situation is particularly evident in Mindanao, where infrastructural limitations and insufficient technological support continue to affect ALS implementation. In Davao City, ALS learners reportedly demonstrated limited engagement in online learning because of unstable internet connectivity and a lack of available devices, thereby restricting participation in digital learning environments (Deiparine, 2025). Similarly, in Davao de Oro, infrastructural gaps, limited instructional support, and inadequate technological resources hindered the effective integration of technology in ALS programs (Salupan, 2025). These local conditions suggest that technological inequities continue to shape the educational experiences of ALS learners, particularly in Mathematics education, where conceptual understanding and learner engagement are essential.

Purpose of the Study

This qualitative multiple case study aimed to explore the lived experiences of learners in the ALS as they navigated the digital divide in adopting technology for Mathematics education. Specifically, the study examined how ALS learners perceived the accessibility, usability, and educational value of digital tools and how these perceptions influenced their engagement and willingness to integrate technology into their Mathematics learning practices. By employing a multiple case study approach, the research sought to identify both convergent and divergent experiences across varied learner contexts, while also examining the contextual factors that facilitated or constrained technology adoption, such as access to digital resources, connectivity, digital literacy, and instructional support. Moreover, the study was intended to contribute empirical insights to the growing body of literature on technology integration in non-formal education and marginalized learning environments.

Adding on, by foregrounding the experiences of ALS learners, the research aimed to inform the development of inclusive, context-responsive, and evidence-based digital interventions for Mathematics education. In doing so, the study aligned with the goals of United Nations Sustainable Development Goal 4, in promoting an inclusive and equitable quality education and lifelong learning opportunities for all, while situating ALS within broader global efforts toward digital inclusion and educational equity.

Research Questions

1. What are the perceptions of the ALS learners on the adoption of technology in Mathematics education?
2. What challenges do the learners face in terms of access, skills, and resources when adopting technology in Mathematics education?
3. What are the coping strategies of ALS learners using technology in Mathematics education despite the barriers of the digital divide?
4. What explains the similarities and differences of each case?

Theoretical Lens

This qualitative research study was seen through the lens of the Technology Acceptance Model (TAM) by Davis (1989), and supported by the Digital Divide Theory by van Dijk (2006). The Technology Acceptance Model provided the primary theoretical lens for understanding how learners in the Alternative Learning System perceive and adopt digital technologies for Mathematics education. Specifically, TAM explains technology adoption through two central constructs: Perceived Usefulness (PU), which refers to the extent to which learners believe that technology can enhance their Mathematics learning performance, and Perceived Ease of Use (PEOU), which pertains to the degree to which learners perceive digital tools as accessible, understandable, and easy to utilize. Within the context of ALS, TAM enabled me to examine how the perceptions of usefulness and usability of the learners shaped their willingness, motivation, and behavioral intention to integrate digital technologies into their Mathematics learning experiences.

Complementing TAM, the Digital Divide Theory provided a broader socio-educational perspective by explaining how disparities in access to devices, internet connectivity, digital literacy, and technological resources influence learners' opportunities to engage with digital learning environments. The theory emphasized that technology adoption is not solely determined by individual acceptance, but also by structural and contextual inequalities that are prevalent in underserved and marginalized communities, including ALS settings. As such, together, these theories offered a comprehensive framework for exploring the perceptions, challenges, adaptive strategies, and lived experiences of ALS learners as they navigated technological barriers in Mathematics education.

Moreover, the integration of these theoretical perspectives strengthened the multiple case analysis of the study by enabling me to examine both individual technology acceptance and the broader contextual realities shaping digital inclusion in non-formal education. Using the two theories as lenses in this study was apt for exploring the perceptions, challenges, and coping strategies of the learners in adopting technology in Mathematics education.

METHODS

Research Design

A qualitative research design was used in this study, specifically a multiple case study. A qualitative research design is a process of inquiring into the social or human problem they are experiencing in a natural setting, in which the researcher builds a complex picture in a holistic analysis, analyzes the responses, and reports a view in a detailed way (Cresswell & Cresswell, 2018). Qualitative research describes in a comprehensive and detailed manner non-numeric data, focusing on answering how and why of the problem (Yin, 2016). Moreover, qualitative research emphasizes the practical methods and non-numerical focus of data as well as contextualizes the insights of human and social phenomena (Billups, 2021).

In particular, a multiple-case study focuses on understanding several cases in order to examine their differences and similarities (Hunziker & Blankenagel, 2021). Additionally, it refers to a research design that collects data from two or more participants who experienced the same phenomena (Yin, 2016). Using a multiple-case qualitative research design, the different perspectives and dimensions of the phenomenon were analyzed to generate well-supported findings (Creswell & Poth, 2018).

Consequently, the multiple-case qualitative research design aligns with the goal of the study by exploring the experiences of the participants from different perspectives. This approach enabled the researcher to examine the varied perceptions and experiences of learners of different ages regarding the integration of technology in Mathematics education. Through the identification of themes from the collected data, the study sought to develop a deeper understanding of the phenomenon and generate insights for further investigation (Chang & Wang, 2021). Furthermore, comparing multiple cases provided a broader and more comprehensive understanding of how learners utilize technology in learning Mathematics (Creswell & Poth, 2018).

Participants of the Case Units

This study employed maximum variation sampling to capture diverse experiences across age groups and ensure heterogeneity in perspectives regarding technology adoption (Patton, 2015). This sampling approach was appropriate for a multiple-case study design because it enhanced the transferability of findings and provided a more comprehensive understanding of the digital divide in ALS Mathematics education through cross-case comparisons that revealed common patterns and variations (Adams et al., 2022). The participants of this study consisted of three ALS learners who were officially enrolled and actively attending classes during the School Year 2025–2026 in Davao de Oro and were taking Learning Strand 3: Mathematical and Problem-Solving Skills.

Meanwhile, recruitment of participants was conducted with the assistance of ALS implementers and teachers in Davao de Oro. Inclusion criteria required participants to be officially enrolled in the ALS - Accreditation and Equivalency (A and E) Program for Junior High School during the School Year 2025–2026, currently taking Learning Strand 3 (LS3), actively participating in ALS classes, willing to share their experiences, and available for face-to-face interviews. Participants were also required to have experience using technology in learning Mathematics.

In particular, the exclusion criteria included individuals who were not officially enrolled in the ALS - A and E Program during the specified school year, learners without experience using technology for LS3, individuals with severe cognitive or physical impairments that could hinder participation in interviews, and those unwilling or unable to provide informed consent. For participants below 18 years old, parental consent and participant assent were secured prior to participation.

Moreover, the participants were considered vulnerable due to their status as out-of-school learners, their socioeconomic challenges, limited prior formal education, and potential exclusion from digital opportunities. Recognizing these vulnerabilities, the study prioritized ethical considerations to ensure that participation was voluntary, respectful, and non-exploitative. The research aimed to provide learners with an opportunity to share their lived experiences while contributing to the development of more responsive educational interventions and support systems. Throughout the research process, the researcher ensured the protection of participants through informed consent procedures, confidentiality measures, voluntary participation, and continuous adherence to ethical standards.

Consequently, the chosen participants were divided into three groups based on age, and the most suitable participants in each group were carefully selected for inclusion, as follows:

Case Unit 1. ALS Learner A was a learner who was a sixteen-year-old male, single, and unemployed. He was able to reach Grade 9 in formal education, but discontinued his studies due to personal circumstances. He is currently enrolled in the ALS program with the intention of continuing his education and eventually entering Senior High School.

Case Unit 2. ALS Learner B is a twenty-six-year-old female who previously reached the elementary level but discontinued her schooling. She is currently engaged in informal work and has family responsibilities. She enrolled in the ALS program as a means to continue her education and improve her opportunities for future employment and career advancement.

Case Unit 3. ALS Learner C is an adult learner who is fifty years old with significant family responsibilities. The participant is currently engaged in work, particularly in labor-intensive or service-related activities. Due to these responsibilities, participation in formal schooling has been limited. The learner enrolled in the ALS program to continue education and enhance opportunities for career advancement.

Data Analysis

The researcher analyzed the data collected from the in-depth semi-structured interviews with the participants and informants, including audio recordings, field notes, recorded observations, and other textual data, to gain a comprehensive understanding of the phenomenon under investigation. The analysis involved several interconnected processes, including transcription, coding, categorization, thematic analysis, and cross-case analysis. These analytical procedures enabled the researcher to systematically organize, interpret, and compare the experiences of the participants regarding the adoption and utilization of technology in Mathematics education within the Alternative Learning System (ALS). Since this study employed a multiple-case study design, each case unit was analyzed individually before conducting comparisons across cases to identify recurring patterns, similarities, and unique variations. Meanwhile, the transcription involved converting all recorded interview data into written form for detailed examination and

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analysis. I carefully transcribed the audio recordings verbatim to preserve the authenticity and meaning of the participants' responses. To ensure transcription accuracy and data integrity, I repeatedly listened to the recordings while reviewing and verifying the transcripts against the original audio files. This process minimized transcription errors and ensured that the participants' intended meanings were faithfully represented. Consistent with Miles et al. (2020), transcription involved organizing the raw interview data, reviewing the textual information, and developing an initial understanding of the emerging ideas and experiences reflected in the narratives.

Consequently, the coding process involved systematically organizing and reducing the data into meaningful units to facilitate interpretation and analysis. Coding and categorization were guided by the procedures suggested by Patton (2015), which emphasized systematic data reduction, pattern recognition, and interpretation. During data reduction, irrelevant, repetitive, or unrelated statements were carefully filtered while preserving significant responses relevant to the research questions. Then, I conducted focused coding by identifying keywords, phrases, and significant statements that reflected the experiences, perceptions, challenges, and coping strategies of the participants regarding technology adoption in Mathematics learning. The coding process included both inductive and deductive approaches, wherein predetermined concepts from the Technology Acceptance Model (TAM) and Digital Divide Theory guided the analysis while allowing new categories and insights to emerge directly from the accounts of the participants. After coding, related codes were grouped into categories to identify broader patterns and conceptual relationships within the data. Thematic analysis was employed to identify, analyze, and interpret patterns of meaning across the collected data. The study followed the six-phase framework of Braun and Clarke (2006), which included familiarization with the data, generation of initial codes, searching for themes, reviewing themes, defining and naming themes, and producing the final report. The Technology Acceptance Model (TAM) and Digital Divide Theory served as theoretical lenses that informed the interpretation of the themes, particularly regarding perceived usefulness, perceived ease of use, access to technology, digital skills, and patterns of technology utilization. However, the analysis remained open to new and unanticipated insights emerging from the participants lived experiences. This approach ensured theoretical sensitivity while maintaining openness to context-specific meanings grounded in the actual experiences of ALS learners.

Moreover, to support the organization and management of qualitative data, I utilized Taguette, an open-source qualitative data analysis software (Rampin & Rampin, 2021). The software facilitated efficient coding, categorization, retrieval of excerpts, and organization of themes across the different case units. The use of qualitative data analysis software enhanced the auditability and systematic management of the data by allowing the researcher to maintain organized records of codes, categories, thematic development, and analytical decisions throughout the study.

Furthermore, cross-case analysis was conducted to examine patterns of convergence and divergence across the three case units. This analytical procedure enabled me to compare the experiences, perceptions, behaviors, and coping mechanisms of the participants regarding technology adoption in Mathematics education. Through cross-case analysis, the researcher identified recurring themes, shared experiences, and distinct contextual differences influenced by factors such as age, responsibilities, educational background, and access to digital resources. Cross-case comparison strengthened the analytical depth of the study by allowing me to move beyond isolated case descriptions and develop broader interpretations regarding the phenomenon across different learner contexts. It also helped establish the boundaries and uniqueness of each case while generating a more comprehensive understanding of how ALS learners experience and navigate technology integration in Mathematics learning.

Moreover, to further strengthen the trustworthiness of the analysis, I maintained reflexivity throughout the analytical process by continuously examining personal assumptions, biases, and interpretations that could influence the findings. In addition, member checking and triangulation with informants' perspectives were incorporated during analysis to validate the consistency and credibility of the

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emerging themes. These strategies enhanced the credibility, dependability, confirmability, and overall rigor of the qualitative findings.

RESULTS AND DISCUSSIONS

The presentation of the cross-case analysis synthesizes the experiences of Alternative Learning System (ALS) learners in adopting technology for Mathematics education. The analysis highlights the similarities and differences across Cases A, B, and C in terms of their perceptions, challenges, and coping strategies. By examining recurring patterns and distinct experiences, the study provides a deeper understanding of how learners navigate the digital divide within varied personal, educational, and socioeconomic contexts. The cross-case analysis further allows the identification of convergent and divergent themes across participants, thereby strengthening the credibility and analytical depth of the findings. Through comparing the lived experiences of learners from different age groups and educational backgrounds, the study demonstrates how technological adoption in Mathematics education is shaped not only by access to devices but also by motivation, prior educational experiences, family support, and digital literacy.

In particular, the profile of the participants is reflected in Table 1. Aside from the demographic details presented in the table, each participant embodied a unique life circumstance that influenced their experiences in adopting technology for Mathematics learning and their educational journey before enrolling in the ALS Accreditation and Equivalency (A&E) Program. Their narratives revealed how personal struggles, interrupted schooling, and socioeconomic realities became motivating factors in pursuing education through ALS. The experiences participants also revealed the inclusive nature of the ALS program, accommodating learners from diverse age groups and life situations who seek educational opportunities despite prior educational discontinuity. Their experiences served as motivation to continue learning and achieving their educational goals through the ALS program.

Table 1. *Profile of the Participants in In-Depth Interview (IDI)*

Point of Similarities and Differences	ALS Learner age 15 to 19 years old (Case A)	ALS Learner age 20 to 30 years old (Case B)	ALS Learner age 30 years old and above (Case C)
Age	16	26	55
Gender	Male	Female	Female
Highest Educational Attainment in Formal Education	Junior High School (Grade 9)	Elementary (Grade 4)	Elementary (Grade 6)
Occupation	None	None	Farmer and Miner
Program Enrolled	A&E	A&E	A&E
Type of Device Used	Cellphone and Calculator	Cellphone	Cellphone
Participant Code	PN1	PN2	PN3

Firstly, Case A, a learner who is sixteen years old, was able to attend up to grade nine level and repeated the same year twice. He is currently focusing on ALS programs as he has no occupation. He is currently enrolled in the Accreditation and Equivalency (A&E) program, in which he applied and used technology using his cellphone and calculator to answer Learning Strand 3 (LS3) modules.

Secondly, Case B, a learner who is 26 years old, was able to attend formal education up to Grade 3 because of a personal reason. She is currently unemployed and attending the ALS program. She is currently enrolled in the Accreditation and Equivalency (A&E) program, in which he applied and used technology using her cellphone to answer LS3 modules.

Lastly, Case C, a learner who is 55 years old, was able to attend formal education up to grades six because she prioritized her family before she continued her journey through the ALS program. She is a farmer and at the same time a miner, and was enrolled in the ALS program. She is currently enrolled in the Accreditation and Equivalency (A&E) program, in which she answered her modules with the help of her family in utilizing technology.

Both perceptions and coping strategies help learners face challenges in adopting technology for learning Mathematics, from start to finish, completing their module in LS3. These experiences assist in solving mathematical problems with technology and serve as a stepping stone for self-improvement.

The Perceptions of the ALS Learners on the Adoption of Technology in Mathematics Education

The perceptions of the ALS learners on the adoption of technology in Mathematics education reveal profound themes, namely, the motivation and aspirations in ALS, technology as a tool for easy and fast access to answer, technology as a tool for verification of answers, preference for technology over traditional modules, technology as a support to manual solving, and technology as a supplementary learning tool. Access to an adequate learning environment should be available to everyone, no matter their life experiences, regardless of whether it is formal education or in a parallel education like the ALS program.

Table 2. *The Perceptions of the ALS Learners on the Adoption of Technology in Mathematics Education*

Essential Themes	Core Ideas
Learners' Motivation and Aspirations in ALS	• Preference for flexible and easier learning through ALS (module-based) • Desire to complete education and obtain credentials for future opportunities • Personal drive for self-improvement influenced by life experiences and social factors
Technology as a Tool for Easy and Fast Access to Answer	• Enables quick searching of solutions • Provides immediate answers to math problems • Makes task completion more efficient
Technology as a Tool for Verification of Answers	• Helps check the correctness of solutions • Reduces fear of making mistakes • Supports confidence in final answers
Preference for Technology over Traditional Modules	• Gadgets are more convenient than printed modules. • Easier to find answers using technology • Learners rely less on modules alone.
Technology as a Support to Manual Solving	• Used alongside scratch paper and step-by-step solving • Does not replace manual computation • Complements traditional problem-solving methods
Technology as a Supplementary Learning Tool	• Supports understanding of difficult concepts • Enhances learning beyond module content • Provides additional explanations and examples

Learners' motivation and aspirations in ALS

The participants in the present study demonstrated a strong motivation to continue their education through ALS despite encountering personal, social, and economic challenges. Their narratives indicate that the adoption of technology in Mathematics was linked to a broader desire to complete their education and enhance their quality of life. This observation aligns with the findings of Idulsa and Luzano (2024), who reported that ALS learners frequently exhibit high motivation to complete their studies and improve their living conditions.

Meanwhile, in the cases examined, motivation manifested in diverse ways: Case A was attracted to ALS due to its accessibility and flexibility; Case B was influenced by social pressure and the aspiration to attain credentials; and Case C was motivated by a longstanding desire to complete schooling after prioritizing family responsibilities. These varied experiences reflect both intrinsic and extrinsic forms of motivation, which Deci and Ryan (2017) identified as critical factors influencing persistence and achievement. Furthermore, the results are consistent with the study by Aniasco (2024), who emphasized that social support reinforces the motivation and perseverance of the learners. Accordingly, this theme is pertinent because it illustrates that the utilization of technology by learners in Mathematics was founded upon their broader aspirations for self-improvement, dignity, and future opportunity.

Technology as a tool for easy and fast access to answers

The findings indicated that participants value technology due to its capacity to facilitate rapid answer searches and more efficient completion of Mathematics tasks. This perception is particularly significant within the ALS context, where learners might lack immediate access to teacher guidance and frequently require practical solutions for managing academic responsibilities. The three cases consistently described utilizing mobile phones, search engines, and online resources to acquire answers more swiftly and effortlessly. This observation corroborates the findings of Haleem et al. (2022), who identified that digital tools enable prompt information retrieval. In addition, Drijvers and Sinclair (2023) observed that technology enhances productivity and engagement by providing instant access to information.

Additionally, it supports Sala et al. (2026), who contend that technology is especially advantageous in flexible and alternative learning environments due to its capacity to offer immediate access to essential support. The experiences of the learners further align with the Global Education Monitoring Report Team (2023), which emphasizes that technology places information within immediate reach. This theme is particularly relevant because it demonstrates that learners favor technology not merely for its modernity, but because it delivers immediate and practical assistance in resolving mathematical tasks.

Technology as a tool for the verification of answers

The participants also regarded technology as vital for verifying the accuracy of their responses. Instead of solely depending on initial written answers, they employed digital tools to compare results and minimize errors, thereby enhancing their confidence in solving mathematical problems. This practice was observed across the cases, particularly among learners who cross-checked their manual solutions with online answers or application-generated responses. This observation corroborates Kuklick (2025), who noted that technology enables self-directed learners to validate the quality of their work independently. Similarly, Outhwaite et al. (2023) found that immediate feedback facilitates the identification and correction of errors more efficiently.

Accordingly, it aligns with Feng et al. (2024), who reported that technological verification improves mathematical accuracy and reduces errors in problem-solving. The utilization of the learners on the digital verification implies that technology functioned as a form of feedback that partly replaced the immediate validation traditionally provided by an educator. This theme is significant as it underscores how technology enhances learner confidence and supports more precise and reflective Mathematics learning.

Preference for technology over traditional modules

The responses of the participants also demonstrated a clear predilection for technology over printed modules in the context of Mathematics education. Although printed modules continued to constitute part of their learning resources, technology was frequently regarded as more convenient, engaging, and responsive to their needs. This trend was evident in the cases where learners characterized gadgets as easier to use for searching answers, viewing examples, and comprehending mathematical tasks than relying solely on modules. This observation aligns with the findings of Detyna et al. (2025), who discovered that learners tend to be more engaged in environments rich in technology. Furthermore, El-Sabagh (2021) argued that digital tools offer greater flexibility compared to static printed materials, as they can accommodate diverse learning styles.

The preference of the participants further corroborates the work of Cabalbag (2025), who reported high learner engagement when technology was integrated into instructional practices. Similarly, Poçan et al. (2023) identified a tendency among learners to depend more heavily on digital devices even when modules are accessible. In the ALS setting, where learners frequently study independently, the accessibility and responsiveness of technology seem to enhance its attractiveness relative to traditional modules. This theme is pertinent as it illustrates that learners perceive technology as a more supportive and efficient medium for Mathematics learning.

Technology as a support for manual solving

The findings further indicate that the participants did not regard technology as a substitute for manual problem-solving; rather, they viewed it as a supplementary aid. They persistently employed scratch paper, adhered to step-by-step procedures, and engaged in handwritten calculations before utilizing technology to assist, guide, or verify their work. This pattern suggests that manual problem-solving remained a fundamental component of their Mathematics education, with technology serving as a reinforcement rather than a replacement. This observation aligns with Crisan (2023), who contended that technology ought to support mathematical learning without supplanting manual problem-solving. Similarly, St. Omer (2025) et al. highlighted that learners achieve improved procedural and conceptual understanding when they remain actively involved in the process themselves.

Additionally, the findings correspond with Kirsten (2026), who noted that learners benefit from initially solving problems by hand and subsequently employing technology to confirm accuracy. In this study, the utilization of the participants of both manual and digital methods exemplifies a balanced approach to learning Mathematics. This theme is particularly relevant as it demonstrates that technology is most effective when integrated with, rather than substituting for, foundational mathematical practices.

Technology as a supplementary learning tool

The participants also perceived technology as a valuable source of additional support when modules did not provide sufficient explanation. They relied on digital tools for examples, tutorials, or further clarification, particularly when concepts were challenging or ambiguous. This was evident in the cases where learners utilized online materials and applications to enhance their understanding of Mathematics beyond the content presented in the module. This finding is corroborated by Servano (2025), who observed that technology supplements learning by offering additional explanations and examples, especially in non-formal educational settings. It also aligns with the research of Msomi and Mthethwa (2024), who determined that digital tools improve comprehension when primary instructional resources are limited. Furthermore, Trivedi et al. (2024) highlighted that online materials bolster independent learning and conceptual understanding. In this context, technology broadened the access of the learners to Mathematics support beyond the confines of the module content. This theme is significant as it demonstrates that technology has enhanced the educational experience for ALS learners by addressing instructional deficiencies and rendering Mathematics more accessible.

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The Challenges the ALS Learners Face in Terms of Access, Skills, and Resources When Adopting Technology in Mathematics Education

Although the participants saw technology as helpful in Mathematics learning, their experiences also revealed that technology use was constrained by the challenges related to access, skills, and available resources. These challenges affected not only whether technology could be used, but also how consistently and effectively it supported learning. Across the cases, the findings show that the learners had to deal with unstable connectivity, weak devices, limited digital skills, dependence on manual alternatives, situational interruptions, and difficulty translating general technology use into academic use.

Table 3. *The Challenges the ALS Learners Face in Terms of Access, Skills, and Resources when Adopting Technology in Mathematics Education*

Essential Themes	Core Ideas on Challenges	Categorization (Access/Skills/ Resources)
Limited Internet Access	• Internet access depends on the availability of the load. • The signal is unstable or intermittent. • Online searching is sometimes interrupted.	Access
Device Limitations	• A low battery prevents continuous gadget use. • Learning is disrupted when devices shut down. • Limits the ability to search for answers	Access
Skills-Related Challenges in Using Technology	• Difficulty understanding English content when searching for answers • Challenges in typing or inputting mathematical symbols (e.g., equal sign) • Lack of familiarity with advanced tools (e.g., scientific calculator, tablet) • Fear or hesitation in using unfamiliar digital devices • Initial difficulty in operating gadgets (e.g., pressing incorrect buttons)	Skills
Reliance on Manual Methods Due to Technological Limitations	• Reliance on pen-and-paper and manual step-by-step solving when the internet, load, or devices are unavailable • Use of own thinking and basic computation strategies due to limited skills in using digital tools (e.g., scientific calculator) • Manual methods require more time and effort, often causing confusion and slower problem-solving without digital support.	Resources and Skills
Situational Access Limitations Despite Available Resources	• Learners report a lack of load despite available resources. • Inconsistent access to the internet and gadgets • Differences between participant and informant perspectives	Resources
Mismatch Between Technological Skills and Academic Use	• Learners are skilled in using gadgets. • Technology is not always used for academic purposes. • Distractions and lack of discipline affect learning use.	Skills

Limited internet access (load and signal issues)

The utilization of the participants of technology in Mathematics was frequently interrupted by unstable internet connectivity, weak signals, and the recurring necessity to purchase mobile data. These challenges hindered their capacity to search for answers, access resources, and maintain engagement in online learning tasks. Across Cases A, B, and C, inadequate connectivity limited consistent access to digital support for Mathematics. This observation corroborates the findings of Castañeda and Selwyn (2018), who posited that limited connectivity constrains meaningful participation in digital education. Furthermore, Dolindo (2025) underscored that connectivity issues frequently impede access to learning platforms. This also aligns with Hjort and Tian (2025), who identified internet access as a significant challenge in developing contexts. In addition, Mathrani et al. (2022) discussed how deficient infrastructure and limited affordability contribute to digital inequality. The findings are similarly consistent with Akmad and Abatayo (2024), who reported that unreliable internet deters learners and disrupts academic continuity. In the context of ALS learners, internet limitations directly impacted their ability to leverage technology in Mathematics.

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This theme is pertinent as it underscores the ongoing influence of the digital divide on learning opportunities within non-formal educational settings.

Device limitations (battery constraints).

The participants also encountered difficulties in utilizing technology due to the inconsistency and unreliability of their devices. Issues such as low battery levels, lack of access to electricity, and the sharing of devices diminished the capacity of the participants to employ mobile phones for Mathematics learning whenever required. These challenges were particularly evident in instances where participants reported interruptions caused by dead batteries, charging difficulties, and limited access to operational devices. This observation concurs with Muraina et al. (2025), who identified battery and power issues as significant obstacles to sustained digital learning. Similarly, Golden et al. (2023) observed that the absence of dependable devices can adversely affect both learner motivation and task completion. Furthermore, the findings support the work of Manguilimotan et al. (2025), who discussed device constraints as a primary factor limiting participation in learning activities. In the same vein, Van der Vlies (2020) characterized such limitations as a form of technological inequity. For the participants involved in this study, device-related problems not only delayed access to educational tasks but also restricted their opportunities to comprehend mathematical content through technological means. This theme is significant because it illustrates that the mere presence of technology does not ensure meaningful engagement, particularly when devices are unstable or inadequate.

Skills-related challenges in using technology (e.g., language, symbols, unfamiliar tools**)**

The experiences of the participants also revealed that employing technology for Mathematics necessitated skills that they did not always possess. Difficulties in typing symbols, comprehending English instructions, and utilizing unfamiliar tools rendered digital learning more complex, despite the availability of devices. These obstacles were evident in the study, as learners described issues with mathematical input, interpretation of online content, and navigation of unfamiliar applications. This finding aligns with Njiku (2024), who observed that language and symbol use create barriers in digital Mathematics tasks. Similarly, Mangarin and Climaco (2024) contended that learners require adequate digital skills to derive benefit from educational technology. Furthermore, it corroborates Alanoglu (2025), who underscored the significance of digital literacy for self-directed online learning. In addition, Denajeba and Ducot (2025) identified language and skill barriers as persistent challenges in technology-based education. The experiences of the participants suggest that familiarity with gadgets in everyday life does not automatically translate into confidence in academic Mathematics tasks. This theme is pertinent as it demonstrates that the adoption of technology in ALS Mathematics education depends not only on access but also on the capacity of the learners to utilize digital tools effectively.

Reliance on manual methods due to technological limitations

The findings further indicated that, in instances where technology was unavailable or unreliable, participants reverted to manual problem-solving techniques. They utilized scratch paper, handwritten solutions, and step-by-step calculations as alternative methods to continue their Mathematics education. This response was not solely a matter of preference but often a necessary adaptation to technological limitations, such as inadequate internet connectivity, lack of device power, or device failure. These observations corroborate the assertions of Drijvers and Sinclair (2023), who emphasized that technology should ideally serve to support Mathematics learning rather than supplant it. In addition, Gqoli et al. (2024) documented that learners with limited access frequently depend heavily on pen-and-paper methods. Furthermore, this aligns with the findings of Villanueva et al. (2023), who reaffirmed the ongoing significance of manual problem-solving in low-resource environments. Conversely, Viberg et al. (2023) cautioned that an exclusive reliance on manual methods may diminish access to supplementary resources that enhance efficiency and comprehension. In the current study, manual problem-solving facilitated continuity of learning but also highlighted the technological barriers that impeded more comprehensive digital support. This theme is pertinent as it elucidates how learners maintained their educational engagement through traditional approaches while managing limited technological resources.

Situational access limitations despite available resources

Even when technology or connectivity was available, the participants were not always able to use it consistently due to situational demands. Family responsibilities, shared device use, time constraints, and household conditions frequently hindered their ability to utilize technology for mathematical purposes. The findings demonstrate that resource availability does not automatically guarantee regular academic access, as daily realities influence when and how learners are able to study. This theme aligns with the contentions of Castañeda and Selwyn (2018), who posited that social and situational factors heavily influence digital participation. In support of this, Ducot (2025) observed that caregiving responsibilities, employment, and economic pressures often significantly limit educational engagement. The findings also corroborate the work of Bringula et al. (2021), who emphasized the specific impact of time and household conditions on the digital participation of the learners. Furthermore, Ruef and Shepard (2022) asserted that merely possessing technological resources does not necessarily ensure consistent or effective academic utilization. In the context of ALS, the experiences of participants indicate that access must be understood in relation to lived conditions, rather than solely in terms of devices or connectivity. This theme underscores the complexity of achieving equitable technology use in Mathematics education.

Mismatch between technological skills and academic use

The participants also demonstrated that being comfortable with technology in daily life did not mean they could use it effectively for Mathematics learning. Although they were familiar with phones and common applications, they still struggled when technology was used for academic purposes, especially for mathematical problem-solving and educational platforms. This pattern was evident in the study, where learners were more at ease with everyday digital tasks than with school-related uses of technology. This finding is consistent with Paul and Crowe (2023), who noted that general digital familiarity does not guarantee academic application. Additionally, Angel-Urdinola et al. (2025) emphasized that digital learning requires more specific competencies. It also aligns with Joshi et al. (2025), who found that learners often manage entertainment and communication applications more easily than educational tools. It was also supported by Liu et al. (2025), who observed that technology can feel familiar in leisure contexts but difficult in academic ones. Mhaske et al. (2025) further argued that frequent use of devices does not automatically translate into meaningful learning use. This theme is relevant because it shows the need for support that helps ALS learners transform everyday digital habits into effective mathematical learning practices.

The Coping Strategies of ALS Learners Using Technology in Mathematics Education, Despite the Barriers of the Digital Divide

Notwithstanding the challenges related to the adoption of technology, ALS learners utilized various adaptive strategies to optimize its advantages in Mathematics education. These strategies underscore their resourcefulness and capacity to navigate both digital tools and human support systems.

Table 4. *The Coping Strategies of ALS Learners Using Technology in Mathematics Education, Despite the Barriers of the Digital Divide*

Essential Themes	Core Ideas on Coping	Barriers Addressed
Use of Online Platforms and Digital Tools as Learning Support	• Use of online platforms (e.g., Brainly, ChatGPT) • Searching for answers and solutions online	Difficulty in understanding concepts and a lack of immediate assistance in solving problems.

	• Independent use of digital tools for learning	
Human Support as a Primary Learning Resource	• Seeking help from family members • Guidance from teachers (step-by-step) • Limited peer support through sharing and advice	Limited digital skills and difficulty in understanding lessons.
Adaptive Learning Strategies under Technological Constraints	• Use of manual solving (pen and paper) • Adjusting learning strategies without the internet • Continuing tasks despite a lack of resources and time constraints	Limited internet access, device and time constraints, and a lack of resources.
Blended Learning Approach	• Using technology for initial answers • Verifying answers through human guidance • Combining digital tools with instruction	Uncertainty in answers and the mismatch between technological skills and academic use.

Technology-supported and self-directed learning strategies

The participants exhibited self-direction through the utilization of digital tools to seek answers, explore resources, and manage mathematical tasks with minimal supervision. In the ALS environment, where independent learning is prevalent, this pattern indicates that learners proactively took the initiative to direct their own learning processes via technology. Their dependence on mobile devices for searching, reviewing, and identifying alternative explanations was observed across the cases. This observation aligns with Makonye and Sulisworo (2025), who demonstrated that digital tools facilitate self-directed learning by providing learners with control over pace, resource access, and learning strategies. It also concurs with Hero and Gloria (2025), who underscored the significance of self-direction in adaptable learning contexts. Additionally, Akhmetzhanova et al. (2025) reported that digital technology fosters behaviors conducive to independent learning. Furthermore, these findings corroborate Sisouvong and Pasanchay (2024), who noted that mobile technology encourages learner autonomy by making resources readily accessible. This theme is pertinent as it illustrates that technology empowers ALS learners to become more active and independent in tackling mathematical tasks.

Human support as a primary learning resource

Although the participants employed technology, they continued to rely substantially on educators, family members, and peers for guidance, clarification, and encouragement. Human support remained indispensable when digital tools proved insufficient to elucidate concepts, verify responses, or alleviate confusion. Across the cases, learners turned to individuals in their vicinity when faced with challenges in Mathematics or in the utilization of technology itself. This observation substantiates Galamiton (2025), who accentuated that social support enhances comprehension, confidence, and academic achievement. It also concurs with Moore-Russo et al. (2025), who noted that learners frequently seek human explanation when confronted with complex mathematical tasks. Furthermore, Hoffman et al. (2025) contended that human guidance remains an essential complement to digital learning tools. In the ALS context, the experiences of the participants suggest that technology did not supplant interpersonal learning support, but rather functioned in conjunction with it. This theme is significant as it demonstrates that Mathematics learning possesses a relational nature, with human support serving as a critical source of understanding and confidence.

Adaptive learning strategies under technological constraints

The participants also demonstrated adaptability by modifying their strategies when technology failed or became difficult to operate. They transitioned to manual problem-solving, employed offline methods, waited for more favorable opportunities to study, or sought alternative sources of assistance to maintain progress on Mathematics tasks. These responses indicate that the learners practically adjusted to

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their circumstances rather than abandoning the task altogether. This observation aligns with the findings of du Plooy et al. (2024), who noted that learners in constrained environments often alter their approaches and utilize available resources to continue advancing. In a similar vein, Rincon-Flores et al. (2024) observed that such learners demonstrate resilience by adapting their methods to overcome technological barriers. The findings also corroborate the work of Tan and Cabaguing (2025), who identified flexibility as a crucial element in successful learning within non-formal and resource-limited settings. The persistence exhibited by the participants demonstrates that barriers did not entirely impede learning; rather, they necessitated ongoing adjustments. This theme is pertinent as it underscores the resilience of ALS learners and their capacity to sustain mathematical learning despite recurrent technological challenges.

Blended learning approach (technology with guided support).

The experiences of the participants also showed that the most effective support for Mathematics learning came from combining technology with human guidance. They used digital tools to search for information, watch explanations, and verify answers, but they also consulted teachers or family members when deeper clarification was needed. This blended pattern was evident across the cases, as learners moved between digital resources and interpersonal support depending on the demands of the task. This finding aligns with the work of Anabo et al. (2023), who described blended learning as the strategic integration of digital tools and guided instruction. In support of this, Park and Doo (2024) found that such integrated approaches significantly improve learner understanding and engagement. Similarly, Zhang (2025) observed that blending digital resources with human guidance fosters a more immersive learning environment. The findings also support Noval and Polig (2026), who noted that learners benefit from combining independent digital exploration with direct interpersonal support. Furthermore, this corresponds with Goldie (2016), whose discussion of connectivism emphasizes that learning occurs most effectively through both digital and human networks. In the ALS setting, this combination allowed learners to maximize the usefulness of technology without depending on it alone. This theme is relevant because it shows that effective Mathematics learning emerged most strongly when digital access and human guidance were used together.

Similarities and Differences of ALS Learners On the Adoption of Technology in Mathematics Education

The perceptions of the ALS learners on the adoption of technology in mathematics education

The theme of motivation and aspirations in ALS was evident across Cases A, B, and C, as all three learners expressed a desire to continue their education despite an interruption in formal schooling. This similarity might be explained by the fact that ALS is commonly viewed as an opportunity for learners to return to education and improve their future. The commonality of motivation across the three cases supports the findings of Idulsa and Luzano (2024), who emphasized that ALS learners are often highly goal-oriented and motivated to complete their education. In addition, this aligns with the work of Baluya (2025), who explained that ALS creates critical opportunities for social mobility and self-improvement. Furthermore, Tan and Cabaguing (2025) noted that the program provides a renewed educational direction for those who have experienced interruptions in their formal schooling. Thus, the three cases were similar in seeing ALS as a meaningful pathway toward a better life. However, the cases differed in the reasons behind that motivation. Case A was motivated mainly by the convenience and flexibility of the ALS program, especially its modular structure. This aligns with Del Rosario (2025), who found that flexible and modular systems attract learners who cannot continue in traditional schooling. Case B was motivated more by social pressure, stigma, and the desire to gain credentials, which is consistent with Tan and Cabaguing (2025), who noted that learners with interrupted education may see schooling as a means of improving self-image and social standing. In contrast, Case C was motivated by personal fulfillment, delayed education, and life goals after prioritizing family responsibilities, which supports Baluya (2025), who explained that adult learners often

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return to education for self-actualization and meaningful life change. Therefore, while all three learners were similarly motivated to continue their education, the source of that motivation differed according to their lived experiences.

Table 5. *Similarities and Differences of ALS Learners on the Adoption of Technology in Mathematics Education*

Themes on Perceptions, Challenges, and Coping Strategies of ALS Learners on Using Technology	Case Unit		Remarks
	Similar	Different	
Perceptions			
Learners' Motivation and Aspirations in ALS	A, B, C		All learners expressed a desire to continue education through the ALS program and viewed it as an opportunity to improve their lives and future.
		A	Motivated by the convenience and flexibility of modular learning
		B	Motivated by social pressure, stigma, and the desire to gain credentials
		C	Motivated by personal fulfillment, delayed education, and life goals
Technology as a Tool for Easy and Fast Access to Answer	A, B, C		All three cases perceived technology as helpful in making mathematical tasks easier and faster. Case A said gadgets made it easier to get answers quickly; Case B said answers could be found through Google; Case C said digital tools made the solving process easier.
		A	Case A particularly emphasized technology as a way to quickly obtain answers and search for solutions while also checking if his answers were correct.
		B	Case B emphasized technology as reducing stress and making thinking lighter, showing a more dependence-based perception of usefulness.
		C	Case C emphasized that technology became helpful after she intentionally adapted to it, showing a more effort-based and developmental perception.
Technology as a Tool for Verification of Answers	A, B		Cases A and C both used technologies not only to get answers but also to compare or check whether their own answers were correct.
		B	Case B mainly used technology to find answers and explanations, but her responses did not clearly show answer verification in the same way as Cases A and C.
Preference for Technology over Traditional Modules	A, B, C		All cases (A, B, C) preferred gadgets over relying only on modules because technology made answers easier to find and understand.
		A	Case A prefers technology due to its efficiency and convenience, using it to simplify the process of finding answers.
		B	Case B demonstrates a stronger dependence on technology, as it becomes essential for understanding lessons that cannot be easily grasped through modules alone.
		C	Case C uses technology as a complementary tool, valuing its ability to guide while still engaging in independent and manual problem-solving.
Technology as a Support to Manual Solving	A, C		Cases A and C still relied on manual solving. Technology-supported learning, but manual computation remained important when solving or when technology was unavailable.

		B	In Case B, this pattern is not evident and tends to depend more on searching for answers through digital tools.
Technology as a Supplementary Learning Tool	A, B, C		Across all three cases, technology functioned as an additional tool alongside modules, teacher instruction, and manual solving.
Challenges			
Limited Internet Access (Load and Signal Issues)	A, B, C		All three cases faced internet issues like unstable signals, low load, or weak connectivity. These problems disrupted their ability to use technology in LS3.
		B	Case B's access issues were intensified by shared gadget use, weak signal, and power interruptions.
		C	Case C's access issues were tied more strongly to slow internet in the CLC and the need to go elsewhere for a connection.
Device Limitations (Battery Constraints)	A, B, C		All three cases experienced device-related limitations, but in different forms.
		A	Case A specifically mentioned low battery and lack of load as device-related interruptions.
		B	Case B mentioned a low battery because of no electricity, as well as limited access because her child also used the cellphone.
		C	Case C differed because her main device limitation was financial: she lacked a proper smartphone and saw keypad phones as insufficient for LS3 tasks.
Skills-Related Challenges in Using Technology (e.g., language, symbols, unfamiliar tools)	A, B, C		All learners experienced difficulty in using certain aspects of technology when solving mathematical problems, showed limitations in digital skills that affected their learning process, and required guidance when using unfamiliar tools or features.
		A	Difficulty understanding English content and interpreting online answers
		B	Difficulty typing mathematical symbols and low confidence in using devices
		C	Initial difficulty operating gadgets, but improved through repeated practice.
Reliance on Manual Methods Due to Technological Limitations	A, B, C		All three cases turned to manual solving when technology was limited, unavailable, or difficult to use.
Situational Access Limitations Despite Available Resources	A, B, C		In all cases (A, B, C), the presence of gadgets or potential access to technology did not lead to consistent or effective use. This was because of factors like internet connectivity issues, time limits, or a lack of digital skills.
		A	Case A was unique because the participants reported problems accessing resources, while informants said he generally had enough resources. This showed a difference between situational barriers and available resources.
Mismatch Between Technological Skills and Academic Use	A, B		Cases A and B both showed a gap between using gadgets and using them well for learning. Case A had issues with too much gadget use and poor self-discipline. Case B dealt with distractions from non-academic content.
		C	Case C was different because her main challenges did not involve misusing technology. Instead, she faced issues related to time, work, financial limits, and internet access.
Coping Strategies			

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Use of Online Platforms and Digital Tools as Learning Support	A, B, C		All learners used online platforms and digital tools as their main support in solving math problems. They searched for answers, accessed explanations, and relied on tech resources when they encountered difficulties.
Human Support as a Primary Learning Resource	A, B, C		All cases depended on teachers, family members, and others who could help with lessons and solve math problems. This is especially useful when struggling with technology or understanding concepts.
Adaptive Learning Strategies under Technological Constraints	A, B, C		All learners used flexible strategies to deal with technological limits. Cases A and C switched to manual solving methods. Case B adjusted her learning based on resources such as time, electricity, and access to devices.
Blended Learning Approach: Technology with Guided Support	A, B, C		All learners used technology along with human guidance to improve their understanding and ensure their answers were correct.
		A	Uses technology first, but checks the answers by asking others because of doubts about their accuracy.
		B, C	Cases B and C use applications along with advice from informed family members.

The theme of technology as a tool for easy and fast access to answer was also common across Cases A, B, and C, as all three perceived technologies as helpful in making mathematical tasks easier and faster. This similarity might be justified by the ability of digital tools to provide quick access to information and solutions. This supports the findings of Bright et al. (2024), who noted that technology improves Mathematics learning by giving learners faster access to problem-solving information. Similarly, Turmuzi et al. (2026) emphasized that these tools enable learners to reach mathematical solutions more efficiently. Across all three cases, technology was seen as a practical and immediate source of academic help, especially for completing LS3 tasks more efficiently.

Despite this commonality, the cases differed in how they experienced this convenience. Case A particularly emphasized technology as a quick way to obtain answers, search for solutions, and check whether answers were correct. Case B emphasized technology as reducing stress and making thinking easier, suggesting a more dependence-based perception of usefulness. This aligns with Ducot (2025), who observed that learners with weaker academic backgrounds are more likely to rely on digital tools to fill learning gaps. Case C, meanwhile, viewed technology as helpful only after adapting to it and making an effort to use it, reflecting a more developmental and effort-based perception. This supports Paez (2025), who argued that the benefits of educational technology are shaped by the access conditions and working realities of the learners. Therefore, although all three learners similarly viewed technology as fast and useful, the meaning of that convenience differed across the cases.

The next theme is technology as a tool for the verification of answers. This theme was similar only in Cases A and C, as both learners used technology not only to obtain answers but also to verify whether their own answers were correct. This similarity might be explained by the role of the technology in strengthening confidence and reducing errors during Mathematics problem-solving. This supports Akhmetzhanova et al. (2025), who noted that technology enhances self-checking and self-regulated learning by allowing learners to monitor the correctness of their work. In both Cases A and C, technology served as a feedback tool that helped confirm answers and build confidence before submission.

Case B differed because the learner primarily used technology to find answers and explanations. However, her responses did not show the same explicit pattern of verification as in Cases A and C. This difference might be explained by a stronger need of the learner for immediate academic support rather than reflective checking. This aligns with Ducot (2025), who found that learners who lack confidence in understanding lessons often use digital tools more for direct assistance than for answer validation. Thus, the similarity under this theme was limited to Cases A and C, while Case B differed because technology was used more to obtain help than for deliberate verification.

The preference for technology over traditional modules was evident across Cases A, B, and C, since all three learners perceived gadgets as more helpful than modules alone in learning Mathematics. This similarity might be justified by the accessibility, responsiveness, and convenience of digital tools compared with printed materials. This supports Bright et al. (2024), who found that learners prefer technology because it makes learning more interactive and responsive, and Ilumin (2021), who noted that technology supplements the limitations of printed instructional materials in alternative learning settings. Therefore, the cases were similar because all three learners saw technology as more practical than modules alone.

However, the cases differed in the reason for this preference. Case A preferred technology because it was efficient and convenient for finding answers. Case B showed a stronger dependence on technology because modules alone were difficult to understand, which aligns with Hero (2025), who found that learners who struggle with independent comprehension tend to favor digital devices over printed materials. Case C also preferred technology but treated it more as a complementary guide while still valuing personal effort and manual solving. This difference suggests that while the preference was common, the degree of dependence on technology varied. Thus, all three cases similarly preferred technology over modules, but their level of reliance differed.

Technology as a support to manual solving, in which this theme was similar in Cases A and C, Technology supported learning, but manual solving remained important in the problem-solving process. Both learners still relied on scratch paper, step-by-step solving, and traditional computation even while using technology. This similarity is supported by Göktepe and Göktepe (2025), who argued that technology complements Mathematics learning when it supports procedural work rather than replaces it. It also aligns with Ducot (2025), who found that learners understand concepts better when digital tools are combined with manual and procedural methods. Thus, Cases A and C were similar because both maintained a balance between digital assistance and manual solving.

Case B differed because this pattern was not strongly evident in the responses of the learner. She tended to depend more on searching for answers and explanations through digital tools rather than emphasizing manual computation as part of the process. This may be explained by the greater need for technological support in understanding the lessons of the learners. This aligns with Rodríguez-Cano et al. (2022), who found that learners with weaker comprehension often rely more heavily on digital support. Therefore, the similarity under this theme was clearer in Cases A and C, while Case B differed because manual solving was less central in the use of technology by the learner.

The last theme is technology as a supplementary learning tool. This theme is consistent across Cases A, B, and C, as all three learners used technology as an additional tool alongside modules, teacher support, and manual solving. This similarity might reflect the role of digital tools in providing additional explanations, examples, and guidance when primary materials are insufficient. This finding aligns with the work of Ventura and Quimpo (2023), who described technology as a supplementary teaching resource rather than a replacement for core instruction. In addition, Cahyono et al. (2024) found that digital resources enhance mathematical understanding by providing learners with a variety of added examples. Furthermore, Hillmayr et al. (2020) observed that these tools offer necessary clarification that supports deeper comprehension of complex concepts. Thus, the three cases were similar in viewing technology as something that supplemented what the modules alone could not fully provide.

The cases differed only in how this supplementary role appeared. Case A used technology primarily for efficiency and verification, Case B used it more for understanding difficult lessons, and Case C viewed it as supplementary but used it less often because of time and access limitations. This finding aligns with the research of Hero (2025), who explained that learners differ in how much they utilize supplementary technology based on their specific comprehension needs. In a similar vein, Paez (2025) noted that these variations in usage are also significantly influenced by individual access conditions. Therefore, while the three cases were similar in viewing technology as supplementary, their depth of use differed.

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Challenges the ALS learners face in terms of access, skills, and resources when adopting technology in mathematics education

The theme of limited internet access was similar across Cases A, B, and C, as all three learners experienced unstable signal, insufficient load, or weak connectivity that disrupted their use of technology in Mathematics. This similarity might be explained by the fact that unequal internet access remains one of the strongest barriers to educational technology. This aligns with Paez (2025), who identified unequal digital access as a major challenge for the learners. Similar to Hero (2025), who found that limited internet access reduces opportunities for technology to support learning. Thus, all three cases were similar in that internet access directly determined whether technology could function as a learning aid.

However, the impact of this challenge varied by case. Case B was more severely affected because a weak signal and limited data were compounded by shared device use and power interruptions. Case C was also strongly affected because access problems were tied to location, work, and fewer opportunities to use data freely. Case A, while affected, appeared to experience this barrier less severely than the other two. This supports Yeh and Tsai (2022), who noted that access barriers do not affect all learners equally. Therefore, the cases were similar in facing internet limitations, but differed in the degree to which those limitations disrupted learning.

Device limitations were also similar across Cases A, B, and C, because all three encountered interruptions in learning caused by battery life, electricity issues, or gadget quality. This similarity may be explained by the fact that access to technology depends not only on having a device but also on whether it can function long enough for learning. These findings support the work of Banerjee (2022), who found that device-related problems, such as battery issues and poor device functionality, significantly limit educational use. Similarly, Sophonhiranrak (2021) identified that hardware-related constraints can be just as restrictive to learning as connectivity problems. Thus, all three cases were similar because their use of technology depended on imperfect devices.

The difference lies in the form of the device limitation. Case A reported low battery and interruptions related to load; Case B experienced battery problems linked to lack of electricity and shared use; and Case C faced a broader financial limitation because a more functional smartphone was not always available. This aligns with Rideout and Katz (2016), who found that device restrictions vary according to household and life conditions. Therefore, the cases were similar in experiencing device-related interruptions, but differed in the kind of device limitation they faced.

Skills-related challenges were similar across Cases A, B, and C, because all three learners experienced some form of difficulty in using technology for Mathematics, whether in language, symbol input, or unfamiliar tool use. This similarity might be justified by the notion that access alone is insufficient for effective learning. This corroborates the findings of van de Werfhorst et al. (2022), who contended that learners require specific digital skills to benefit from educational technology fully. Additionally, Alanoglu (2025) determined that lower digital and language skills significantly hinder online learning. Consequently, the cases were comparable in that each learner encountered a barrier between having access to technology and utilizing it effectively for mathematical learning.

The particular difficulties varied across cases. Case A encountered greater challenges in understanding English-language content and interpreting responses. Case B faced more significant difficulties in typing mathematical symbols, reading instructions, and navigating technology-based tasks. Case C demonstrated less familiarity with the educational application of technology due to limited time and exposure. This aligns with the research of Fang and Nie (2025), who discovered that the digital difficulties of the learners differ in nature and severity based on background and opportunity. Therefore, although all three cases involved skills-related barriers, the nature of these barriers was not uniform.

The reliance on manual methods is due to technological limitations. This theme was consistent across Cases A, B, and C, as all three learners turned to manual solving when technology was unavailable or difficult to use. This pattern might reflect the ongoing value of non-digital Mathematics strategies in resource-limited settings. This aligns with Weinhandl et al. (2025), who found that manual methods remain important when learners face technological barriers. Furthermore, Kormos and Wisdom (2023) noted that alternative learners often shift between digital and non-digital approaches depending on access. Thus, the three cases were similar in that manual solving became a common fallback whenever technology could not be used.

The difference lies in the degree of that reliance. Case A used manual and digital methods more interchangeably, Case B relied more on manual strategies when technology was not consistently available, and Case C depended more heavily on manual solving because several constraints limited access to technology. This aligns with Paez (2025), who explained that under-resourced learners tend to rely more heavily on traditional approaches. Therefore, the cases were similar in returning to manual methods, but differed in how strongly they depended on them.

The next theme is situational access limitations despite available resources. This theme was consistent across Cases A, B, and C, as the presence of a gadget or some access did not automatically translate into consistent academic use. This pattern may reflect that access depends not only on physical resources but also on the ability to use them in the daily life of the learner. This observation aligns with the research of Tripathi (2024), who emphasized that educational technology access is heavily dependent on the social and economic conditions of the learners. Furthermore, Zhao (2023) highlighted that various situational conditions also play a critical role in determining how effectively learners can engage with digital tools. Thus, the cases were similar because real access was shaped by more than possession alone.

The difference lies in the situational barrier. Case A stood out because the learner reported access difficulties, while the informant suggested that resources were generally available, indicating a gap between opportunity and learner prioritization. Case B faced interruptions due to shared gadget use, household distractions, and the need for assistance. Case C faced the strongest situational limitation, as work and life responsibilities reduced the time available for study. This supports Azionya and Nhedzi (2021), who found that temporal and situational barriers often shape technology use more strongly than device availability itself. Therefore, while all three cases faced situational access limits, the source and severity of those limits differed.

The last theme is the mismatch between technological skills and academic use. This theme was similar only in Cases A and B, where both learners demonstrated a discrepancy between the utilization of gadgets for daily activities and their effective application for academic Mathematics tasks. This similarity may be attributed to the distinction between everyday digital familiarity and academic digital competence. This observation aligns with the findings of Angeli and Miliou (2023), who argued that digital skills for learning are distinct from general digital literacy. Furthermore, Korkmaz and Colak Kilic (2024) determined that frequent non-academic use of technology does not necessarily enhance academic performance. Consequently, Cases A and B exhibited similarities due to a clearer disparity between everyday use and school-related application.

Case C differed, as the primary challenge for the learner was less related to the misalignment between daily and academic digital use and more associated with limited time, workload demands, and restricted access to technology. This supports the work of Thaanyane and Jita (2026), who found that the mismatch between daily and academic usage varies depending on both the skill level and available learning opportunities. Therefore, the similarity is mainly observed in Cases A and B, whereas Case C diverged owing to more prominent structural limitations than the digital mismatch itself.

Coping strategies on the adoption of technology in mathematics education

Use of Online Platforms and Digital Tools as Learning Support. This coping strategy was similar across Cases A, B, and C, as all three learners used online platforms and digital tools to support their problem-solving in Mathematics. This similarity might be explained by the nature of self-directed digital learning, in which learners use available tools to search for answers and continue learning independently.

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This finding aligns with the research of Moris (2024), who found that digital tools promote learner autonomy when students search for answers and resources on their own. Furthermore, Blanc et al. (2025) observed that this independent engagement with digital resources fosters a sense of ownership over the learning process. Therefore, the cases were similar because each learner turned to digital tools when direct support was limited.

Case A showed greater independence and comfort with apps and digital resources. Case B also used digital tools but relied more often on external help when encountering difficulties. Case C used digital applications as support, but less regularly due to limited access. This aligns with the findings of Akhmetzhanova et al. (2025), who explained that self-directed learning varies significantly depending on the level of learner regulation. Similarly, Gürbüz et al. (2026) noted that the availability of external support often shapes the effectiveness of such strategies. Furthermore, Oinas et al. (2025) observed that physical and digital access conditions serve as a critical variable in how learners navigate independent study. Therefore, the cases were similar in their use of online tools but differed in how strongly this strategy was practiced.

Human support was similar across Cases A, B, and C, because all three learners depended on teachers, family members, or peers when they faced difficulty in Mathematics or in using technology. The ongoing role of social interaction in learning may explain this similarity. This observation supports the findings of Shao et al. (2024), who emphasized the critical role of knowledgeable others in the learning process. In a similar vein, Galamiton (2025) found that teacher and family support significantly improve Mathematics persistence and performance. Thus, the cases were similar because technology alone was not enough to meet their learning needs.

In Case A, support came primarily from teachers and the program structure; in Case B, support came from both teachers and family members; and in Case C, family support was more visible because of less direct contact with teachers. This finding aligns with the research of Sun and Liu (2023), who found that different sources of support shape learner confidence in unique ways. Furthermore, Rasul et al. (2025) observed that these varying support structures also influence levels of engagement differently depending on the source. Therefore, the cases were similar in relying on human support, but differed in the primary source of that support.

This theme was similar across Cases A, B, and C, because all three learners adjusted their learning methods when technology could not be used fully. This similarity may be justified by the role of resilience and flexibility in sustaining learning under constrained conditions. This supports Qiao et al. (2026), who found that successful learners change strategies when technology no longer meets their needs—furthermore, Bozkurt (2022) emphasized resilience as essential to learning under difficult conditions. Thus, the cases were similar because all three learners adapted rather than stopped learning. Case A moved more smoothly between technology and manual solving; Case B adapted when the learner reached a point where technological help or outside guidance became necessary; and Case C adapted more to the work schedule and daily responsibilities. Therefore, the cases were similar in being adaptive, but differed in how that adaptability was expressed in practice.

Finally, all three cases were similar in showing a blended learning approach, since all three combined technologies with human support in learning Mathematics. This similarity may be explained by the nature of blended learning, which combines digital resources with human guidance to deepen understanding. This aligns with Thomas et al. (2025), who described blended learning as the purposeful integration of technology and human support. In the ALS context, where learners often need both flexibility and direct explanation, this pattern is understandable. Thus, the cases were similar because none relied solely on technology or solely on human guidance.

The difference lies in the balance between these two supports. Case A appeared to have a more balanced relationship between technology and teacher support. Cases B and C both used technology alongside guidance from informed family members, but in both cases, the human element appeared more necessary when technology alone was insufficient. Therefore, while all three cases showed blended learning, the degree of independence and the weight given to human support differed.

Implication for Educational Practice

Findings from this study may have numerous implications for practices related to teaching ALS learners, particularly in Mathematics education using technology. Learners faced different barriers during instruction due to varied access to technology, digital skills, and learning conditions. This may suggest the need for more flexibility, inclusivity, and learner-centered pedagogy. ALS facilitators may apply differentiated instructional methods based on the technology skills, learning access, and personal conditions of the learners. These strategies may include traditional instructional practices and technology-based delivery to help learners remain engaged during lessons, regardless of their level of digital learning access. They may also include providing relevant learning tasks and activities, guided instruction (step-by-step), and unguided instruction (based on the needs of the learners), as well as varying strategies that support learner-centered and educator-led styles.

Additionally, the persistent challenges, such as unstable internet data, limited devices, and the cost of learning resources, suggest making institutionalized improvements. Program planners and stakeholders may work to improve the availability and accessibility of sustainable learning methods and opportunities. These may include support networks such as providing internet data, learning devices, and hardcopy learning materials. It is suggested that the CLC may be strengthened. Learners can benefit from improved CLCs that could provide structured and safe access to the required learning materials and resources. These resources may include internet data, devices, and physical learning content. Well-resourced CLCs can provide a better environment for ALS learners to learn and utilize technology to take part in technology-mediated instruction. Digital Divide Theory also applies to this study. Since there were varying levels of access to digital tools, it affected learners' ability to take advantage of technology to learn. It may be best if school policies are crafted to help bridge the gaps by allocating funds to improve access and infrastructure. The policy may also ensure CLCs are receiving the necessary tools to help cater to the needs of the learners.

Consequently, the Mathematics teachers may continually prepare lessons that make learning meaningful and applicable to real life. Through appropriate professional development focusing on how to maximize the use of technology, manage diverse learners, and implement new strategies, ALS teachers can translate their knowledge and skills to their learners. Also, the ALS learner trainers can participate in training on how to teach digitally using available technology. trainers may also benefit from training on managing learners with different technology skills and applying these strategies to teach Mathematics. Facilitators may also learn how to incorporate the use of videos as a form of instruction, communication applications, and social media as instructional tools. These strategies promote learner engagement and provide alternative methods to deliver math content for ALS learners. Also, family support may help increase the involvement of learners in ALS. ALS Program implementers may do this by finding ways to incorporate family members into the education of the learners, and providing families of the learners with an orientation or ALS support to help them guide learners at home. If more collaborations were initiated between educators, learners, and families, and the learning environment (CLCs), most likely, vast improvements in learner output and participation in ALS could be achieved.

Recommendation for Future Research

Future studies on technology use in ALS may delve more deeply into the various factors shaping the experiences of the learners to enhance ALS programs. First, there is a need to examine the learning experiences of ALS learners taking subjects other than Mathematics to see how technology influences their learning. Research on learners in other school subjects may provide background on whether they share the same perceptions toward ALS, encounter similar problems, and have developed coping mechanisms comparable to those of Mathematics learners. ALS implementers may use data from these studies to improve their ALS programs.

In particular, other researchers may examine the experiences of ALS teachers. Such research may focus on how they use technology to teach, how they carry out lessons, and the struggles they face when teaching their ALS learners. Studying experiences of the teachers provides data that are research-based, which may be used as a basis for the development of better teaching practices, establishing support for teachers, and empowering teachers in the classroom, specifically when teaching in digital and flexible learning environments.

Additionally, research may be conducted to examine specialized ALS

programs such as ALS para sa OFW (APO). The research may focus on how Overseas Filipino Workers (OFWs) utilize technology to continue their education. The research may provide data on how technology could support transnational and distance-based learning while identifying the different types of struggles that ALS learners face abroad. Future studies may also focus on the financial burden and resource inadequacies of ALS programs in relation to technology and learner support. Such research may help solidify claims regarding the Digital Divide Theory and help find long-term solutions to bridge inequalities.

In parallel, future researchers may also take it upon themselves to review the efficacy of video-based learning, communication platforms, and social media as teaching tools in ALS. As the education sector continues to utilize digital platforms to deliver content, research on this topic could provide valuable insights on how to improve learner engagement, increase accessibility, and help ALS learners achieve better learning outcomes. Moreover, studies may be conducted on family-related factors affecting the decision of the learners to persevere with the ALS program.

CONCLUSION

This study began as an inquiry into how ALS learners adopt technology for Mathematics, but it became more than an academic investigation. Engaging with participants revealed deeper narratives of persistence, sacrifice, and determination that went beyond issues of access. The perspective of the researcher evolved from viewing technology as the primary solution to recognizing the importance of relationships, guidance, and support, and from understanding that technology and human interaction should complement one another in the learning process.

The study also challenged the assumption that technological limitations would fully hinder learning. While the Digital Divide Theory emphasizes inequalities in access, ALS learners demonstrated resilience by using manual methods and seeking alternative ways to learn, underscoring their determination despite constraints. This reshaped the understanding of the researcher on the digital divide—not merely as a barrier, but as a condition that learners actively navigate. An important insight also emerged from engagement with the ALS focal person, highlighting that budget allocation limitations for programs and resources can pose challenges to program implementation. The need for partnerships with public and private organizations further reflects broader program-level constraints that influence the experiences of the learners.

Despite these challenges, the province of Davao de Oro shows promising progress, with inclusive programs in particular for learners with special needs that are continuously being strengthened. These initiatives demonstrate the commitment of the province to ensuring that education is accessible not only to ALS learners but also to those who require specialized support. The presence of such programs reflects a growing effort to address diverse learning needs through adaptive and inclusive educational practices. With sustained support, adequate funding, and strengthened partnerships, these initiatives may be further developed and showcased at the national level as models of inclusive education within the ALS framework.

The study also influenced the researcher personally, deepening appreciation for education as a transformative force that fosters hope, dignity, and opportunity beyond academic achievement. It underscored the importance of designing inclusive, flexible learning environments and affirmed the vital role of the Alternative Learning System in supporting diverse learners. While technology supports learning, it is the combination of available resources, human support, and learner resilience that sustains meaningful engagement. The findings underscore the value of collaboration, innovation, and context-sensitive approaches in education.

In conclusion, this research journey revealed that learning in ALS is defined not by limitations but by the ability to persist, adapt, and aspire of the learners. More than anything, it showed that behind every challenge is a learner striving to move forward with that, in itself, is the most meaningful outcome of education. Thus, this study highlights the need for continued support for the ALS program, particularly through enhanced instructional resources, improved digital access and skills, and stronger partnerships, to further support inclusive and equitable education for all learners.

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