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The Use of Semiotic Technologies to Foster Analytical, Creative, and Practical Skills of Gifted Students: Teacher Perspectives

Üstün Yetenekli Öğrencilerin Analitik, Yaratıcı ve Pratik Becerilerinin Geliştirilmesinde Semiyotik Teknoloji Kullanımı: Öğretmen Görüşleri

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Abstract

This study examines the role of semiotic technologies in gifted education, focusing on how these tools support differentiation and the development of analytical, creative, and practical skills in gifted students, as outlined by Sternberg's theory of successful intelligence. Using a qualitative case study design, six teachers from a gifted pull-out school (Science and Arts Center) in Turkey participated through semi-structured interviews and classroom observations. MAXQDA was used for thematic analysis. Thematic analysis revealed that semiotic technologies enable differentiated instruction by allowing teachers to tailor content and engagement strategies to students' needs. Analytical skills were supported through problem-solving tasks, creative abilities through digital design and experimentation, and practical skills through collaborative, real-world applications. However, teachers reported challenges, including limited infrastructure, lack of formal training, and the rapid pace of technological change, which hindered the full integration of these tools. Teachers expressed a strong need for ongoing professional development to enhance their proficiency and confidence in using semiotic technologies effectively. While the study highlights the potential of semiotic technologies to deepen engagement and learning, limitations such as the small sample size, reliance on self-reported data, and a single institutional context suggest caution in generalizing results. This research contributes to understanding technology's role in gifted education and emphasizes the need for further studies incorporating quantitative data and broader samples to comprehensively assess the impact of semiotic technologies on differentiation and skill development in diverse educational settings.

Keywords: Gifted education, semiotic technology, enrichment, talent development, instructional technologies, successful intelligence theory

Öz

Bu çalışma, üstün yeteneklilerin eğitiminde semiyotik teknolojilerin rolünü incelemekte ve bu araçların, Sternberg'in başarılı zeka teorisi doğrultusunda, üstün yetenekli öğrencilerin analitik, yaratıcı ve pratik becerilerini nasıl desteklediğini araştırmaktadır. Nitel bir durum çalışması deseninin kullanıldığı araştırmaya, Türkiye'deki bir Bilim ve Sanat Merkezinde görev yapan altı öğretmen, yarı yapılandırılmış görüşmeler ve sınıf gözlemleri yoluyla katılmıştır. Tematik analiz için MAXQDA kullanılmıştır. Tematik analiz, semiyotik teknolojilerin öğretmenlerin içeriği ve katılım stratejilerini öğrencilerin ihtiyaçlarına göre uyarlayarak farklılaştırılmış öğretimi mümkün kıldığını ortaya koymuştur. Analitik beceriler problem çözme görevleri aracılığıyla, yaratıcı yetenekler dijital tasarım ve deneyler yoluyla, pratik beceriler ise işbirliğine dayalı, gerçek dünya uygulamalarıyla desteklenmiştir. Ancak öğretmenler, sınırlı altyapı, himet-içi eğitim eksikliği ve hızlı değişen teknolojinin bu araçların tam entegrasyonunu etkili bir şekilde engellediğini bildirmişlerdir. Öğretmenler, semiyotik teknolojileri etkili bir şekilde kullanma konusundaki yeterliliklerini ve güvenlerini artırmak için sürekli mesleki gelişim ihtiyacını ifade etmişlerdir. Çalışma, semiyotik teknolojilerin katılımı ve öğrenmeyi derinleştirme potansiyelini vurgulamakla birlikte, küçük örneklem büyüklüğü, öz-beyanlara dayalı veriler ve tek bir kurumsal bağlam gibi sınırlılıkları nedeniyle sonuçların genellenmesinde dikkatli olunması gerektiğini göstermektedir. Bu araştırma, teknolojinin üstün yeteneklilerin eğitimindeki rolünü anlamaya katkı sağlamakta ve çeşitli sınıf ortamlarında semiyotik teknolojilerin farklılaştırma ve beceri gelişimi üzerindeki etkisini kapsamlı bir şekilde değerlendirmek için nicel veriler içeren daha geniş örneklemlerle yapılacak çalışmaların gerekliliğini vurgulamaktadır.

Anahtar Kelimeler: Üstün yeteneklilerin eğitimi, semiyotik teknoloji, zenginleştirme, öğretim teknolojileri, başarılı zeka kuramı

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1. Introduction

Gifted students, often defined by their advanced analytical, creative, and practical abilities, require specialized educational approaches to support their unique developmental needs (Sternberg, 2005; Aljughaiman - Ayoub, 2012). According to Sternberg's Triarchic Theory of Intelligence (TSI), these abilities extend beyond cognitive intelligence to include creativity and practical problem-solving, highlighting the multifaceted nature of giftedness. Analytical abilities involve problem-solving, critical thinking, and the capacity to evaluate and break down complex ideas, enabling gifted students to tackle both structured and abstract problems. Creative abilities focus on generating original ideas, exploring innovative approaches, and thinking divergently to develop unique solutions. Practical abilities encompass applying knowledge and skills to real-world contexts, including interpersonal and adaptive skills necessary for effectively implementing ideas in everyday situations (Sternberg, 2005; Sternberg - Grigorenko, 2007). Gifted learners typically possess characteristics such as curiosity, problem-solving skills, and a capacity for abstract thinking, which require tailored/specialised educational strategies (Renzulli, 1977; Kontostavlou - Drigas, 2019). These strategies, central to effective gifted education, focus on differentiating curriculum elements—content, instructional strategies, assessment, products, and learning environments—to provide learning experiences that cater to individual talents and cognitive diversity (Tomlinson, 2017; VanTassel-Baska - Stambaugh, 2005). This differentiated approach allows gifted students to explore complex concepts at advanced levels, promoting intellectual growth (Brevik et al., 2018).

Given the diverse abilities and needs of gifted students, effective differentiation strategies are essential to provide personalized and enriched learning experiences (Reis et al., 2021) . Enrichment strategies, such as problem-based learning, open-ended questioning, and independent research projects, have traditionally been employed to foster the development of analytical skills by encouraging students to engage in critical thinking, hypothesis testing, and complex problem-solving (Kim, 2016; Aljughaiman - Ayoub, 2012). For creative skill development, activities like brainstorming sessions, creative writing, and art-based exploration allow gifted learners to generate original ideas and express themselves innovatively. Practical abilities, on the other hand, are nurtured through real-world applications, such as collaborative group projects, role-playing scenarios, and service learning, which help students translate their knowledge into meaningful, real-life contexts. In this context, technology integration to such practices emerges as a powerful tool for enabling differentiation by enhancing content delivery and fostering the development of higher-order thinking skills. It also serves as a dynamic resource for enabling, enhancing, and transforming learning experiences (Chen et al., 2013). The "Enable, Enhance, and Transform" framework underscores how technology can broaden gifted education's capacity, improve the quality of instructional practices, and even create new modes of educational delivery. Technologies like interactive platforms, online research tools, and multimedia resources support individualized learning and creative exploration, allowing students to delve into advanced content and express their knowledge in innovative ways (Siegle, 2005; Önal - Önal, 2021; Yıldırım et al., 2024). For example, Reis et al. (2021) advocate for technology as a means of enriching curriculum through exploratory and investigative activities, supporting both cognitive and non-cognitive development in gifted students.

Semiotic technologies (hereafter STs) refer to digital tools that enable the creation, manipulation, and interpretation of signs and symbols, facilitating complex meaning-making processes (Simpson - Archer, 2019; Van Leeuwen et al., 2013). These tools—including digital media, collaborative software, and visualization applications, and hardware technologies such as 3D printers—are instrumental in enhancing learning experiences by providing multimodal ways for students to interact with and represent knowledge (Leeuwen et al., 2013). From a social semiotic perspective, STs afford users the flexibility to engage with multiple representational modes, making them highly relevant for differentiated education (Jewitt, 2009). Studies have shown that semiotic technologies encourage gifted students to engage in deeper analytical thinking and creative expression, supporting them as they navigate complex tasks that require critical analysis and problem-solving (Zhao - Djonov, 2017; Zhao - Zappavigna, 2018). In this respect, parallel to Chen's et al. (2013) suggestions for technology in general, semiotic technologies not only expand students' capacity to explore and innovate but also contribute to the development of higher-order thinking skills.

In gifted education, STs play a crucial role in reinforcing teachers' differentiation strategies by offering enriched, interactive learning experiences tailored to students' advanced abilities. By using STs, teachers can design activities that promote high-level cognitive engagement, practical problem-solving, and creative exploration. These technologies support the development of analytical, creative, and practical skills by allowing students to work independently or collaboratively on projects that require innovative thinking and real-world applications (Periathiruvadi - Rinn, 2012; Zimlich, 2017). Research indicates that semiotic technologies can act as both tools and agents in learning, providing affordances that enhance the educational experiences of gifted students by fostering a responsive and adaptive learning environment (Knight, 2021). Additionally, STs have the potential to support cognitive and non-cognitive skill development by offering differentiated instructional options that align with students' unique learning styles and preferences (Shaunessy, 2005). Teachers can thus leverage and employ these technologies to promote autonomous learning, creativity, and intellectual growth among gifted learners, contributing to their overall talent development.

Given that this study aims to investigate how semiotic technologies are used by teachers in gifted education to differentiate curriculum elements and support the development of students' analytical, creative, and practical skills. The study will focus on how these technologies enable teachers to implement differentiation strategies that address the specific needs of gifted students, enhancing their learning experiences and fostering talent development. To achieve this aim, the research will explore educators' perceptions of semiotic technologies and examine how these tools contribute to creating enriched learning environments. The research questions guiding the study are:

1 How do teachers use semiotic technologies to differentiate curriculum elements for gifted students?

2 What strategies do teachers employ to integrate semiotic technologies for supporting gifted students' analytical, creative, and practical skills?

3 What are educators' challenges regarding the utilization of semiotic technologies in supporting gifted students?

2. Methods

This study utilizes a qualitative case study design, allowing for an in-depth examination of how semiotic technologies are used by teachers in gifted education to support differentiation and the development of analytical, creative, and practical skills among gifted learners. Case study research is particularly suitable for exploring complex, real-world phenomena in specific contexts, such as gifted education, where the interplay between teacher strategies and student needs is nuanced and multifaceted (Yin, 2018). This design enables the collection of rich, detailed data on teachers' perceptions, practices, and challenges in integrating semiotic technologies within their instructional strategies for gifted students. The study was conducted within a gifted education pull-out school, Science and Art Centers (SAC), in Turkey, where students receive specialized instruction that extends beyond their regular school curriculum.

2.1 Participants

The study employed purposive sampling, specifically utilizing a criterion sampling strategy, to select six participants who were full-time teachers at a Science and Art Center (SAC), which is a pull-out school for gifted studnets, in south-eastern region of Türkiye. Purposive sampling involves identifying and selecting information-rich cases most relevant to the case under investigation (Creswell & Poth, 2018); in this case, teachers within Science, Technology, Arts, and Mathematics education fields who use semiotic technologies in their gifted classroom. All participants had at least five years of teaching experience, providing them with professional expertise and familiarity with the needs of gifted students. The sample included two science teachers, two arts teachers, one mathematics teacher, and one technology teacher, each contributing unique perspectives on how semiotic technologies support differentiated instruction and talent development in their respective fields. The diversity in subject backgrounds enriched the data, demonstrating the adaptability of semiotic technologies to various curriculum areas to meet the specialized needs of gifted learners. Participants' demographic details, including their experience, discipline, and training in gifted education, are summarized in Table 1. To protect their identities, pseudonyms were assigned. Participation was voluntary, with three male and three female teachers forming the study group.

Table 1. Participants' demographic profiles

Name	Gender	Age	Experience	Branch
Bensu	Female	31	5	Science
Cahit	Female	33	6	Mathematics
Cansu	Female	38	13	Arts
Cemil	Male	44	16	Arts
Ebrar	Female	32	9	Science
Sinan	Male	36	7	Technology

2.2 Development of Interview Questions and Pilot Interviews

The interview questions are developed according to three theoretical bases which are Sternberg's Theory of Successful Intelligence, (Brigandi et al., 2019) study, and the concept of semiotic technologies. The semi-structured format allowed for both consistency across interviews and flexibility for participants to elaborate on unique experiences or perspectives. The interview questions were designed around four core areas: (1) differentiation strategies, (2) use of technology, (3) supporting TSI skills development (analytical, creative, practical), and (4) the role of semiotic technologies in gifted education and the challenges they encounter. This approach ensures that data collection aligns with the study's aims and theoretical framework, allowing participants to reflect on how they use semiotic technologies to support students' cognitive and non-cognitive development (Patton, 2014). was secured both verbally and in writing to ensure comprehensive agreement. To ensure the reliability and validity of the interview questions, one expert from the gifted education field reviewed the interview quesions and two pilot interviews were conducted with experienced teachers who met similar criteria to the main study participants and did not join the study. The pilot process allowed for refinement of the interview questions to ensure they effectively captured insights into differentiation strategies, technology use, support for TSI skills development (analytical, creative, and practical skills), and STs. Piloting the interview questions is a recommended practice in qualitative research, as it helps to enhance the clarity, relevance, and depth of the questions, ensuring that they align with the study's aims and research questions. In the end of this process, 15 semi-structured and open-ended interview questions were developed.

2.3 Data Collection

Data were collected using semi-structured interviews and classroom observations, providing a comprehensive view of teachers' use of semiotic technologies in practice and their reflections on its impact.

Semi-Structured Interviews: In this study, data were gathered through a semi-structured interview form containing open-ended questions. The initial questions were developed using an inductive approach informed by a thorough review of relevant literature. To enhance content validity, an expert in gifted preschool education and se-miotic technology reviewed the draft questions, leading to revisions based on their feedback. Subsequently, two linguistic experts assessed the revised questions for grammatical accuracy and clarity. The questions were subse-quently pilot-tested with a small group of teachers. This preliminary testing allowed for refinement of the questions, eliminating any ambiguous or suggestive wording and ensuring that they encouraged open, thoughtful re-sponses. Feedback from this pilot phase informed revisions, leading to a finalized interview guide with questions that were clear, contextually relevant, and consistently reliable across diverse participants. Data collection was conducted within the institutional setting. Prior to the interview, participants were thoroughly informed about the study's purpose and the specific content of the interview. Consent for audio recording Each teacher participated in a semi-structured interview, which lasted approximately 60 minutes.

Classroom observations provided contextual data on the practical use of STs in real-time instructional settings. Observations were conducted during the implementation regularly-planned classroom activites in participating teachers' classrooms. Each observation lasted approximately 40 minutes and focused on capturing critical elements of STs integration, pedagogical strategies, content delivery, and differentiation practices. Primary author conducted the observations which were non-intrusive, allowing teachers to proceed with their planned lessons. To guide the observation process, a structured field note framework, based on the three theoretical basis explained in the interview questions development section, was used. The collected data from the observation was peer-reviewed with the second author. The aligments of interview data and field notes was evaluated by researchers. Observational data complement the interview responses, offering an additional layer of insight into the teachers' approaches and the impact of semiotic technologies on gifted students' learning experiences (Merriam - Tisdell, 2015).

2.4 Data Analysis

Data were analyzed using thematic analysis, supported by the qualitative data analysis software MAXQDA, which facilitated the organization, coding, and visualization of themes within the interview and observational data. MAXQDA's tools allowed for systematic data management and provided visual representations of emerging themes, enhancing the depth and clarity of the analysis process (Kuckartz - Rädiker, 2019). Data was analysed in following procedure outlined by Braun – Clarke (2006).

Data Familiarization: All interviews were transcribed verbatim, and classroom observation notes were carefully reviewed multiple times. Initial readings of the transcripts and observation notes were conducted within MAXQDA, allowing the researcher to become thoroughly familiar with the data before coding. This stage provided a foundation for identifying preliminary insights and areas of interest related to the study's aims.

Coding in MAXQDA: Open coding was conducted in MAXQDA, where each segment of the data was assigned a code representing relevant themes related to differentiation strategies, semiotic technologies, and the development of analytical, creative, and practical skills. MAXQDA's coding tools enabled the researcher to apply consistent codes across the dataset, track code frequency, and identify relationships among codes. Codes such as "technology for differentiation," "enhancing creativity," "practical applications," and "supporting analytical skills" were initially generated based on the data and refined through iterative coding rounds.

Theme Development and Visualization: After initial coding, the codes were grouped into broader themes that reflected the main findings of the study, such as "strategies for talent development," "challenges in technology integration," and "impact on TSI skills." MAXQDA's visualization features, such as code maps, word clouds, and matrix tables, were utilized to display connections between codes and highlight key themes. These visuals were instrumental in understanding how various elements related to semiotic technologies and differentiation strategies intersected across the dataset, facilitating the synthesis of findings.

Interpretation and Synthesis: The final themes, supported by visual maps and other analytical outputs from MAXQDA, were synthesized to construct a narrative on the role of semiotic technologies in gifted education. This narrative was informed by teachers' direct quotations and specific examples from classroom observations, providing concrete insights into how semiotic technologies contribute to the development of analytical, creative, and practical skills in gifted students. MAXQDA's visualizations also assisted in identifying patterns and confirming the consistency of themes, enhancing the study's analytical rigor. By utilizing MAXQDA for both coding and visualization, the data analysis process was able to maintain a high level of accuracy and coherence, supporting the credibility of the findings. The software's capabilities allowed for efficient organization and facilitated an in-depth thematic exploration, making complex patterns within the data more accessible and interpretable.

This study maintained validity and reliability in qualitative research by adhering to ethical guidelines (Merriam, 2013, 199). Participation was voluntary, confidentiality was protected, and pseudonyms were employed. To ensure credibility, the study incorporated triangulation, thorough data collection, participant validation, expert feedback, and researcher reflexivity (Merriam, 2013)Participants reviewed the da-ta to verify its accuracy. While qualitative findings are not universally genera-lizable, transferability allows readers to consider the findings' relevance wit-hin their own settings (Creswell, 2013). To support transferability, the study includes detailed descriptions and participant quo-tations. It is emphasized that the importance of making research data available for external review to verify the study's quality and integrity. In this research, all data and methodological steps were digitally stored to facilitate verifiability and data management.

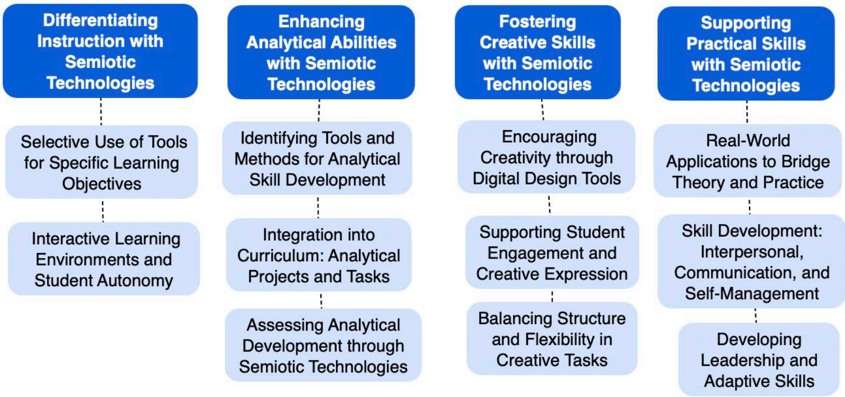
2.5 Ethical Considerations

Ethical approval was obtained from Harran University/Social Science Ethical Committee with number E-76244175-050.04-346654, and all participants provided informed consent before data collection began. To maintain confidentiality, pseudonyms (Bensu, Cahit, Cansu, Cemil, Ebrar, and Sinan) were used for each participant in the reporting of findings, and all data were securely stored with restricted access. Participants were also informed of their right to withdraw from the study at any time. The study adhered to ethical guidelines, respecting the privacy and autonomy of the participants while ensuring transparency in research practices (Creswell - Poth, 2018).

3. Results

The analysis of interview data from six participant teachers revealed significant insights into how semiotic technologies are utilized to support differentiation and the development of analytical, creative, and practical skills among gifted students. These findings address the specific aims and research questions of this study and provide a comprehensive view of the opportunities, challenges, and impact of integrating semiotic technologies into gifted education. A thematic map is created to show main themes and sub-themes derived from the data analysis (See Figure 1). This map makes easier to see how teachers viewed semiotics technologies in terms of supporting analytical, creative, and practical skills of gifted students. It also included themes on how teachers differentiate their teaching using semiotic technologies.

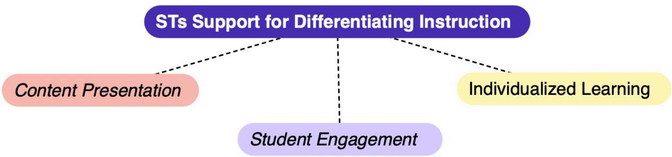
Figure 1. Thematic map of the findings



3.1. Differentiating Instruction with STs

Teachers across disciplines emphasized the role of semiotic technologies as essential tools for differentiating instruction, allowing them to tailor their teaching methods to meet the diverse needs of gifted students. Differentiation through these technologies encompassed various aspects of instructional design, including content presentation, engagement strategies, and individualized learning experiences.

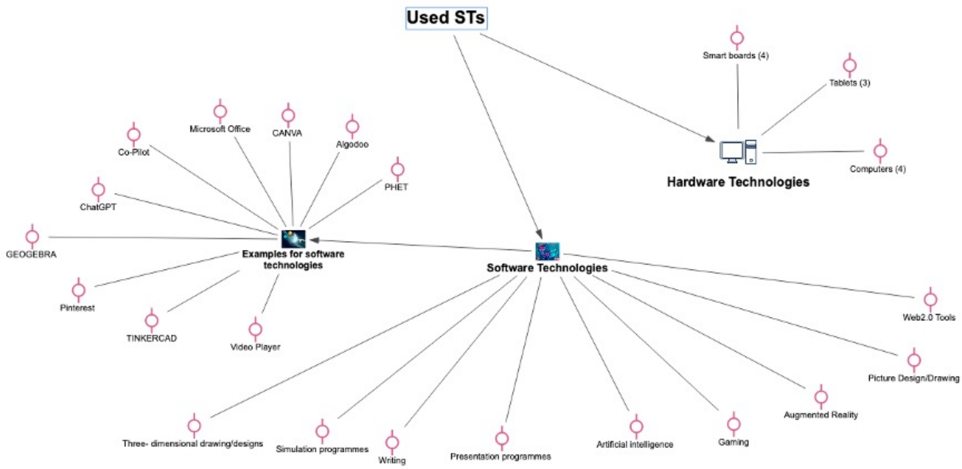
Figure 2. Differentiated Aspects of Instruction by STs



3.1.1 Selective Use of Tools for Specific Learning Objectives

Teachers selected semiotic technologies based on the specific learning objectives and unique characteristics of gifted learners Figure 3 shows the software and hardware technologies that teachers selected for their lesson activities. These technologies were chosen due to various reasons regarding differentiating the learning environment and equipment. For example, GEOGEBRA was widely used in mathematics to visualize abstract mathematical concepts, enabling students to interactively explore geometric relationships. Similarly, art and design classes integrated Canva and TINKERCAD to support students in digital creativity, providing options that would otherwise be difficult to replicate with traditional media. Science teachers employed PHET and Algodoo simulations to safely conduct virtual experiments that would not be feasible in a physical lab setting, due to cost, safety, or space limitations. This selective use of technologies allowed teachers to customize content and approaches based on both the subject matter and students' individual needs.

Figure 3. Hardware and software STs used by Teachers



3.1.2 Interactive Learning Environments and Student Autonomy

Teachers highlighted that semiotic technologies facilitated a shift from teacher-led instruction to student-centered learning, which allowed students to take greater ownership of their learning process. These digital tools provided a dynamic and interactive platform that engaged students in exploration and inquiry-based learning, essential components of differentiated instruction. Teachers reported that by using semiotic technologies, students could engage with complex tasks autonomously, making choices in how they approached problems and designed solutions. For instance, students in technology and design classes were often tasked with projects, generally TUBİTAK projects, that required independent decision-making within broad guidelines, which encouraged self-directed learning. This supports project-based learning that fits with the aims of SACs as pull-out gifted schools.

3.1.3 Challenges in Achieving Effective Differentiation

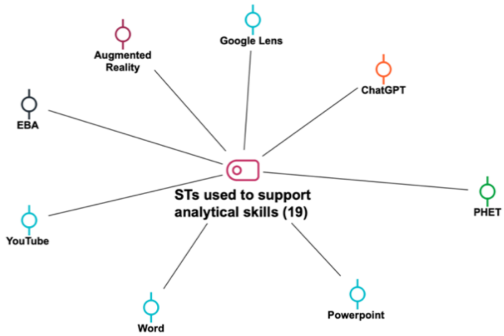
Despite the advantages, teachers noted several barriers to fully achieving differentiation with semiotic technologies. Limited infrastructure, such as insufficient access to digital devices and stable internet, was cited as a significant constraint. In general, teachers posit that technolgy is evolving and developing and each pace require new hardwares and softwares. Additionally, teachers acknowledged that the rapid evolution of technology outpaced their professional development opportunities, making it difficult to stay current with the latest tools and techniques for differentiation. Without structured training, teachers felt they lacked the knowledge to maximize the full potential of semiotic technologies in their classrooms. Teachers mostly express that ministries or universities can support their constant training needs.

3.2. Enhancing Analytical Abilities with STs

3.2.1 Identifying Tools and Methods for Analytical Skill Development

Participants identified specific semiotic technologies that they believed effectively supported the development of analytical skills in gifted students (See Figure 4). In mathematics and science, platforms like GEOGEBRA and PHET provided interactive, visual representations of complex concepts, enabling students to manipulate variables and observe real-time outcomes. In particular, math teachers highlighted the value of using digital games and interactive simulations for teaching problem-solving, as these activities required students to apply critical thinking, test hypotheses, and engage in logical reasoning.

Figure 4. Used semiotic technologies for analytical skill development.



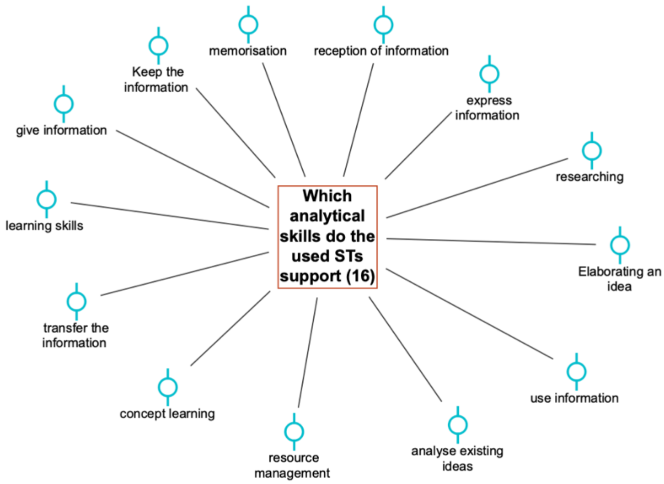
3.2.3 Integration into Curriculum: Analytical Projects and Tasks

Teachers incorporated these technologies into various curriculum activities designed to promote analytical thinking. Figure 5 shows teachers responses demonstrating the analytical skills supported by their integration of STs into their instruction. For example, one teacher described a mathematics activity where students used a digital simulation to explore the relationship between area and perimeter. This activity required students to calculate, strategize, and solve problems iteratively, reinforcing their understanding of mathematical principles through an applied, hands-on approach. Similarly, science teachers used simulation software to allow students to conduct "virtual experiments," where they could analyze variables and predict outcomes. These virtual labs provided a safe and flexible environment for students to explore scientific inquiry, especially in experiments that involved hazardous materials or complex procedures. Such projects allowed students to develop and refine their analytical abilities through structured exploration.

3.2.4 Assessing Analytical Development with STs

Evaluating analytical skill development presented a unique challenge. Teachers often relied on informal observations and student reflections rather than standardized metrics, due to the exploratory nature of activities involving semiotic technologies. Teachers observed that students who engaged deeply with these tools displayed improved critical thinking, as evidenced by their ability to articulate reasoning, make predictions, and solve multi-step problems. Teachers also reported that the iterative, trial-and-error nature of digital simulations fostered resilience in problem-solving and encouraged students to persist through challenges. While teachers expressed confidence in the positive impact of these technologies on analytical skills, they noted a need for more structured assessment tools to better capture students' cognitive progress. Figure 6 represents exemplary teacher replies regarding how can STs support analytical skills.

Figure 6. The analytical skills that STs support



3.3. Fostering Creative Skills with STs

3.3.1 Encouraging Creativity through Digital Design Tools

Semiotic technologies were particularly effective in nurturing the creative abilities of gifted students, with tools like Canva, TINKERCAD, and digital art programs providing an expansive array of resources for imaginative expression (See Figure 8). Teachers in art and design classes encouraged students to use these platforms to create unique logos, posters, and models, which allowed for a wide range of creative exploration and skill development. The tools offered a variety of colors, shapes, and templates that facilitated design work, supporting students in visualizing and implementing their ideas with a degree of freedom not possible in traditional media.

Figure 7. Teacher views about how STs can support analytical skills

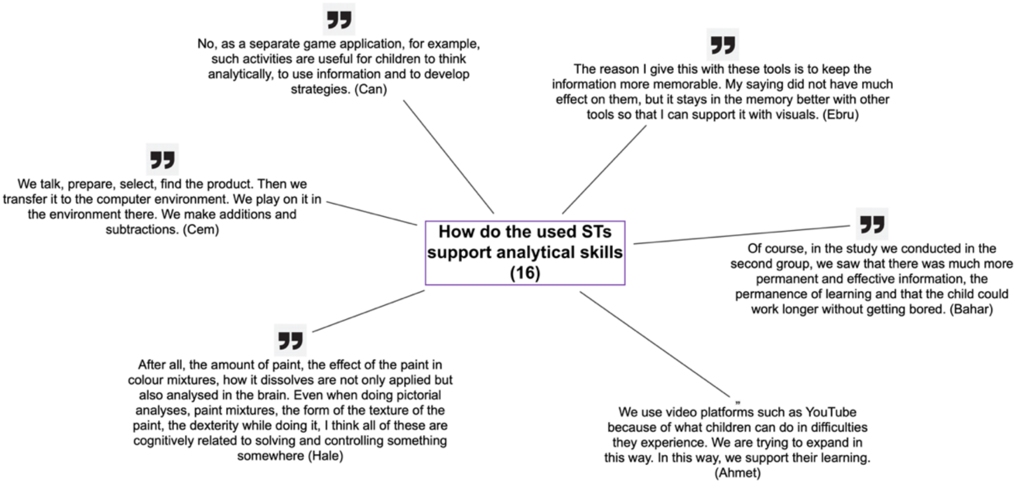
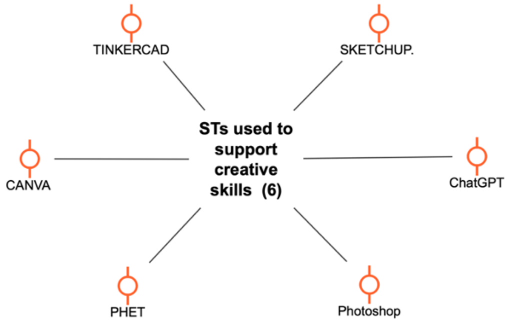


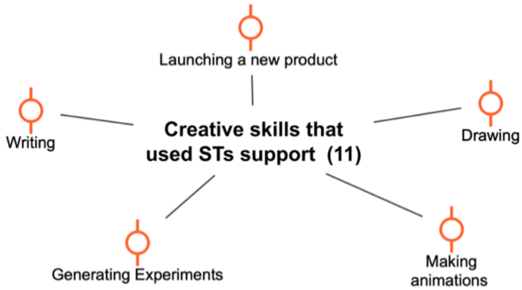
Figure 8. STs for creative expression



3.3.2 Supporting Student Engagement and Creative Expression

Teachers observed that digital tools like Canva and 3D modeling programs enhanced student engagement by enabling them to experiment with multiple design iterations without the limitations of physical resources. Figure 9 illustrates the STs that teachers integrated to their teaching practives to support their students' creative skills. Art teachers reported that students were more likely to take creative risks when they could easily undo mistakes or explore different design pathways. One participant described a project where students used 3D modeling to create dinosaur fossil replicas for a virtual museum, a task that required both creativity and critical planning. Teachers noted that these digital tools allowed students to develop artistic skills, explore unconventional ideas, and apply their creativity to construct meaningful, original projects. Figure 10 shows direct replies of teachers regarding how STs can support creative skills.

Figure 9. Cretive skills supported by STs



3.3.3 Balancing Structure and Flexibility in Creative Tasks

Teachers found that balancing structure with creative freedom was key to fostering creativity in gifted students. They typically provided a broad project framework—such as a design theme or goal—but allowed students significant autonomy in executing the project. This approach helped students feel empowered in their creative decision-making while ensuring that the projects aligned with instructional goals. Teachers observed that when students had the freedom to make their own creative choices within a structured task, they demonstrated greater innovation and originality in their work, suggesting that semiotic technologies, paired with flexible guidelines, support deeper levels of creative engagement. Figure 10 shows a learning product for which students used digital tools for creating and designing.

Figure 10. Exemplary teacher replies about how STs can support creative skills.

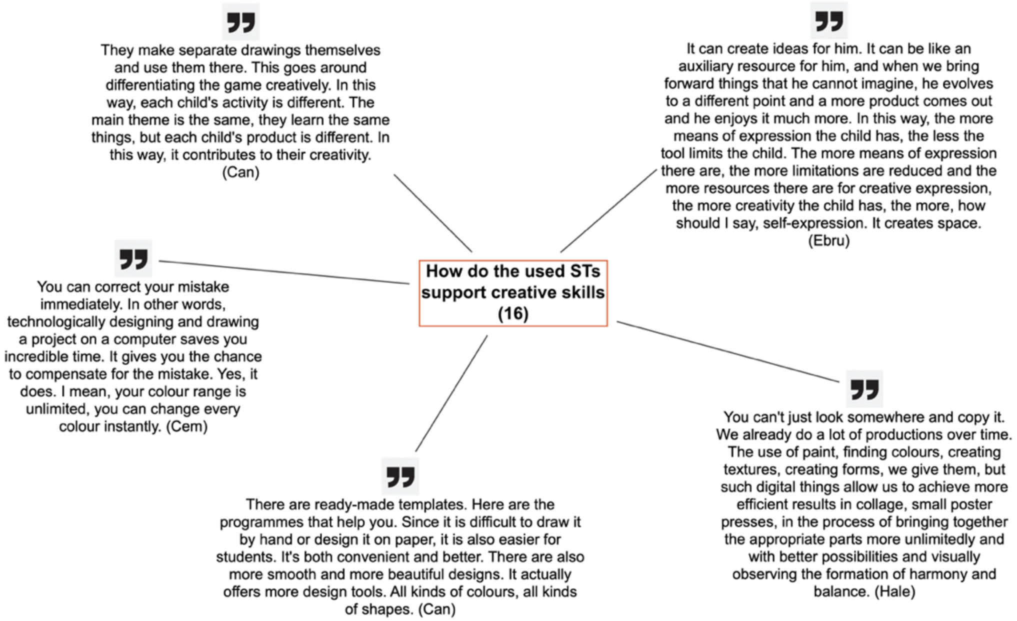


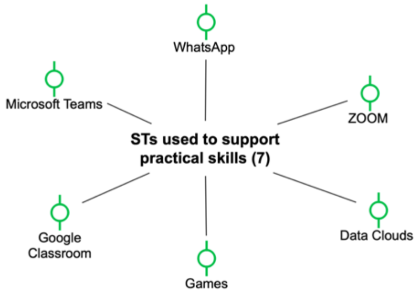
Figure 11. A learning product designed by a student

3.4. Supporting Practical Skills with STs

3.4.1 Real-World Applications to Bridge Theory and Practice

Teachers used STs to bring real-world relevance to classroom concepts, fostering the development of practical skills among gifted students. Figure 11 shows the STs that teachers employed in their teaching activities and they reported that these STs helps them support their students' practical skills. One science teacher described a project in which students used Google Lens to identify local plants and create information cards in Canva, a task that required research, resource management, and teamwork. Such projects bridged theoretical learning with practical application, helping students to see the real-world implications of their academic knowledge. Teachers found that when students worked on projects with real-life relevance, they were more motivated to engage fully and apply their skills meaningfully.

Figure 11. Used STs to support analytical skills.



3.4.2 Skill Development: Interpersonal, Communication, and Self-Management

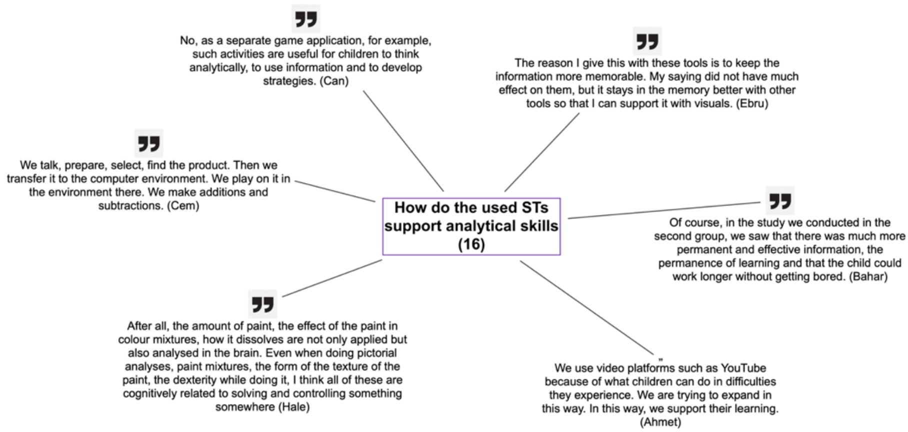
Participants noted that STs supported interpersonal and communication skill development through collaborative digital projects. By working together on shared digital platforms such as Google Classroom, Zoom, and Microsoft Teams, students learned to negotiate, share responsibilities, and manage their time effectively. Teachers described assigning specific roles within group projects to encourage responsibility and teamwork, observing that students developed self-management skills as they navigated tasks and deadlines. The collaborative nature of these projects also improved students' adaptability and interpersonal communication, skills that are essential for functioning effectively in diverse, real-world contexts. Figre 12shows an instant when students collaborate and discuss on creating a content on interactive white board.

Figure 12. A collaborative work with a whiteboard as ST

3.4.3 Developing Leadership and Adaptive Skills

Teachers found that semiotic technologies allowed students to take on leadership roles within group projects, which was particularly valuable for students with strong leadership tendencies. Some teachers noted, however, that managing strong personalities within teams could be challenging, especially when multiple students wanted to lead. To address this, teachers assigned complementary roles, fostering a collaborative spirit while allowing students to exercise their individual strengths. This experience in team dynamics helped students develop adaptability, a skill that teachers considered critical for future success. Figure 13 shows some exemplary replies regarding how can STs support practical skills of gifted students in their teaching practices.

Figure 13. Teacher views about how STs can support practical skills.



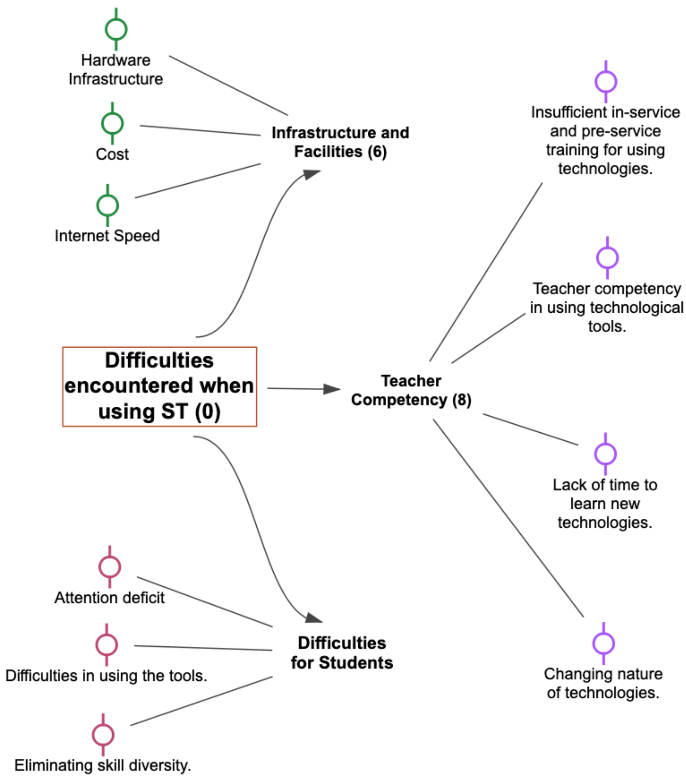
3.5. Teachers' Views Regarding Challenges in Using and Utilizing STs

Teachers were overwhelmingly positive about the impact of semiotic technologies on gifted education. They noted that these tools created opportunities for more personalized, engaging, and meaningful learning experiences, which were crucial in meeting the advanced cognitive and emotional needs of gifted students. Participants observed that semiotic technologies enhanced students' intrinsic motivation, especially when projects aligned with their personal interests. By providing students with autonomy and the ability to showcase their skills through differentiated tasks, semiotic technologies supported a student-centered approach that encouraged intellectual growth, curiosity, and self-confidence.

A recurring theme among participants was the challenge of limited resources, both in terms of technological infrastructure and professional development (See Figure 12). Teachers frequently cited insufficient access to devices, unreliable internet connectivity, and lack of dedicated spaces for digital learning as obstacles to fully integrating semiotic technologies into their classrooms. Additionally, participants expressed a strong need for structured, ongoing training in semiotic technologies. They noted that while they attempted to self-teach many of these tools, a more formalized training structure would enable them to use technologies more effectively and confidently.

Many teachers expressed aspirations for the future, envisioning dedicated digital workshops or labs where students could experiment with advanced semiotic technologies in depth. Teachers believed that access to resources like digital design studios, augmented reality labs, or 3D printing facilities could transform gifted education by allowing students to fully explore their talents in a variety of domains. They also emphasized the potential benefits of collaboration with specialists in technology and design to enhance their understanding of best practices in gifted education. Teachers hoped that with better resources, training, and support, semiotic technologies.

Figure 14. Challenges and difficulties in using and utilizing STs.



4. Discussion

The findings of this study offer valuable insights into the use of STs by teachers in gifted education to support differentiated instruction and the development of analytical, creative, and practical skills. By analyzing teachers' experiences and views, this research sheds light on both the opportunities and challenges associated with integrating semiotic technologies into classrooms for gifted learners. These findings extend current research, demonstrating how semiotic technologies can transform instructional practices and enhance learning experiences for gifted students.

The results of this study underscore the potential of STs to facilitate differentiated instruction, an essential strategy for meeting the unique needs of gifted learners. Teachers employed various digital tools to tailor lessons according to students' individual strengths and interests, allowing them to explore complex content and engage with it at advanced levels. This finding aligns with research (Tomlinson, 2017; VanTassel-Baska, 1988), who emphasize that differentiated instruction is a core component of effective gifted education. Semiotic technologies provide versatile resources for achieving this differentiation by enabling teachers to create diverse learning paths that accommodate students' cognitive and emotional needs.

In comparison with existing literature on differentiation, this study contributes new insights by examining specific technologies that teachers find useful in achieving differentiated learning outcomes. Technologies like GEOGEBRA, Canva, and TINKERCAD allowed teachers to present concepts in a range of modalities—visual, auditory, interactive—which is particularly beneficial for gifted students who often require a multisensory approach (Renzulli & Reis, 2009). This study supports Pyryt's (2009) suggestion that technology in gifted education acts not merely as a content delivery tool but as a means to transform and individualize learning experiences. However, unlike prior studies that predominantly emphasize the advantages of technology, the present study identifies notable infrastructure and professional development challenges that limit the extent of differentiation possible, a finding that resonates with Knight (2021) and indicates the need for further institutional support. This may be related to the lack or inadequacy of the professional training that teachers receive on gifted education. Such an inadequacy may cause ineffective use or interation of STs to differentiated instruction or instruction cannot be effectively differentiated.

The use of STs to support analytical skills, particularly through simulation software and 3D modeling platforms, was a prominent theme in this study. Teachers expressed that, according to their experiences in classroom, tools like GEOGEBRA, PHET, and Algodoo allowed students to engage in analytical reasoning, problem-solving, and critical thinking within a dynamic, interactive environment. This aligns with Djonov and Van Leeuwen (2022), who emphasize that semiotic technologies enhance analytical skills by enabling students to manipulate digital representations, thereby making abstract concepts more tangible. This imply that the flexibility and adaptability of digital tools may foster deeper analytical engagement, which this study corroborates through teachers' observations of improved logical reasoning and strategic thinking in gifted students.

The participants positted that STs can significantly enhance the creative skills of gifted students by providing diverse platforms for imaginative expression. Participants highlighted tools like Canva and TINKERCAD as essential in nurturing creativity, allowing students to experiment with design principles and visual aesthetics. Jewitt (2009) and Shaunessy (2005) emphasize that STs provide multimodal affordances, enabling students to engage with content in varied, meaningful ways. By allowing for trial and error, these tools encourage students to test creative ideas without fear of failure, a benefit noted by Siegle, (2005), who argues that digital tools can help gifted students push the boundaries of conventional thinking.

The flexibility and autonomy afforded by STs were particularly valued by teachers, who reported that students felt empowered to explore and innovate within the parameters of assigned projects. This finding resonates with the "Enable, Enhance, and Transform" framework proposed by Chen et al. (2013), which suggests that technology can enhance students' creative capabilities by offering flexible, adaptable resources that support open-ended exploration. Furthermore, the use of platforms like Canva allowed students to move beyond traditional media and experiment with advanced design principles, thus fostering a sense of ownership and pride in their work. This supports Renzulli and Reis's (2009) research, which found that technology enriches curriculum through exploratory activities that foster both cognitive and non-cognitive development. However, teachers in this study also encountered challenges in balancing structure with flexibility in creative tasks. While semiotic technologies offered vast creative potential, teachers described it necessary to guide students' exploration to maintain alignment with instructional objectives. This observation extends (Zimlich's (2017) findings on the need for structured guidance in technology-enhanced learning environments to prevent students from becoming overwhelmed or distracted. The present study suggests that while creative autonomy is crucial, a carefully designed framework that includes broad project guidelines can support a balanced approach to creative development in gifted students.

The findings of this study underscore the importance of STs in developing practical skills, such as resource management, communication, and teamwork. Teachers used digital platforms like Google Lens, Google Classroom, and Microsoft Teams to bridge theoretical learning with real-world applications. This approach aligns with Periathiruvadi and Rinn's (2012) suggestion that technology in gifted education should extend beyond content delivery to support life skills essential for gifted students' long-term success. By allowing students to work on projects that mimic real-world scenarios—such as creating information cards on local plant species—teachers enabled students to apply classroom knowledge to practical, hands-on tasks. Teachers also noted that semiotic technologies facilitated interpersonal and collaborative skill development, echoing findings by Shaunessy (2005), who asserts that teamwork and social skills are often overlooked in gifted education but are crucial for students' holistic development. Through collaborative digital projects, students learned to negotiate roles, manage conflicts, and work towards shared goals.

However, despite their enthusiasm, teachers reported several challenges that limited the full integration of semiotic technologies. Infrastructure constraints, such as inadequate access to digital devices and unreliable internet, posed significant barriers, reflecting challenges identified by Shaunessy (2005) and more recent studies by Chen-Dai-Zhou (2013). Teachers also highlighted the need for structured training in semiotic technologies, which is often lacking in gifted education programs. This mirrors findings by Renzulli-Reis (2009), who argue that educators require targeted professional development to effectively integrate advanced technologies into their instructional practices. Unlike previous studies, this research provides a detailed account of the specific types of training teachers desire, such as workshops on software applications relevant to their curriculum areas and ongoing support for emerging technologies. This finding suggests a need for educational institutions to prioritize ongoing professional development in semiotic technologies to fully capitalize on their potential benefits for gifted students.

5. Conclusions

This study has provided perspectives of teachers about the role of STs in gifted education, specifically regarding how these tools support the differentiation of instruction and the development of analytical, creative, and practical skills among gifted students. Through qualitative analysis of interviews with six teachers from a gifted pull-out school, several significant themes emerged, highlighting the transformative potential of semiotic technologies and the challenges educators face in implementing them effectively.

Teachers viewed that STs, including tools like GEOGEBRA, TINKERCAD, Canva, and AI applications, enable teachers to present content in diverse, interactive formats that cater to the varied learning styles and cognitve needs of gifted students. According to teachers, these tools not only foster differentiated learning experiences but also support skill development across multiple domains. Analytical skills support through activities that promoted problem-solving and critical thinking, creative abilities flourish with tools that encouraged imaginative expression and design, and practical skills are nurtured through collaborative and real-world applications..

Despite the potential of semiotic technologies, teachers reported that significant barriers to their optimal use, including limited infrastructure, lack of formal training, and rapid technological change. These challenges underscore the importance of providing professional development opportunities that equip teachers with the skills to use these tools effectively and of investing in the necessary infrastructure to ensure equitable access. By addressing these obstacles, schools can better support educators in creating enriched learning environments that meet the advanced educational needs of gifted students.

6. Implications

The findings of this study have several implications for future research and practice in gifted education. The study contributes to a nuanced understanding of teachers how STs support not only TSI skills which are essential for the holistic development of gifted students. Future research, such as ethographic researches, could further examine the use of STs in gifted classroom and collect student perspectives. Overall, this study contributes to the existing literature by providing a comprehensive analysis of teacher perspective about how STs are used in gifted education and by identifying both the strengths and limitations of these tools in supporting differentiated

7. Limiations

This study, while offering valuable insights into the use of STs in gifted education, has several limitations that impact its generalizability, depth, and applicability. The small sample size of six teachers from a single pull-out school limits the diversity of perspectives, and the reliance on self-reported data may introduce bias, with teachers potentially overemphasizing positive experiences. The study also lacks quantitative data to objectively assess the impact on students' skills, and without standardized assessments of teachers' technology proficiency, it is challenging to isolate the effects of technology from differences in teacher competency. Limited observational data and the narrow focus on a single educational setting may not capture the full range of semiotic technology applications or challenges faced in more traditional, inclusive environments. Infrastructure constraints and the rapid evolution of technology further complicate the findings, as tools may quickly become outdated. Additionally, potential bias in teacher selection, favoring those more experienced or enthusiastic about technology, may skew results, and the lack of student feedback means the study does not fully capture how students perceive or are impacted by these technologies. Future studies addressing these limitations could offer a more comprehensive understanding of semiotic technologies' role in differentiation and skill development across diverse educational contexts.

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