

Digital Transformation in Learning IPAS Based on the TPACK Approach for Students with Disabilities in Elementary Schools

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Abstract

Students with disabilities, such as deaf and verbally hyperactive students, have difficulty filtering valid information. Thus, digital literacy in deaf and verbally hyperactive students through the TPACK approach is a solution to this problem. This study aims to describe the digital transformation in IPAS learning based on the TPACK approach for students with disabilities in elementary schools. This study uses a qualitative descriptive method with data collection techniques: observation, interviews, and documentation. The results show that the application of the TPACK approach in IPAS learning at Giwangan Public Elementary School in Yogyakarta effectively improves the quality of learning, especially for deaf and verbally hyperactive students. The integration of technology, pedagogy, and content creates an engaging and relevant learning experience and improves student learning outcomes. However, improvements in technological infrastructure, teacher training, and more personalized learning strategies are needed for more optimal results. The results of this study are expected to contribute to the development of more effective and inclusive technology. This can also be a reference for educators who use the TPACK approach to improve digital literacy.

Keywords: Science Education, Elementary School, Students with Disabilities, TPACK, Digital Transformation.

Abstrak

Siswa dengan disabilitas, seperti siswa tuna rungu dan hiperaktif verbal, mengalami kesulitan dalam menyaring informasi yang valid. Dengan demikian, literasi digital pada siswa tuna rungu dan hiperaktif verbal melalui pendekatan TPACK merupakan solusi untuk masalah tersebut. Penelitian ini bertujuan untuk mendeskripsikan transformasi digital dalam Pembelajaran IPAS Berbasis pendekatan TPACK untuk Siswa dengan disabilitas di Sekolah Dasar. Penelitian ini menggunakan metode deskriptif kualitatif dengan teknik pengumpulan data: observasi, wawancara, dan dokumentasi. Hasil penelitian menunjukkan bahwa penerapan pendekatan TPACK dalam pembelajaran IPAS di Sekolah Dasar Negeri Giwangan Yogyakarta secara efektif meningkatkan kualitas pembelajaran, terutama bagi siswa tuna rungu dan hiperaktif verbal. Integrasi teknologi, pedagogi, dan konten menciptakan pengalaman belajar yang menarik dan relevan, serta meningkatkan hasil belajar siswa. Namun, perbaikan infrastruktur teknologi, pelatihan guru, dan strategi pembelajaran yang lebih personal diperlukan untuk hasil yang lebih optimal. Hasil penelitian ini diharapkan dapat berkontribusi dalam pengembangan teknologi yang lebih efektif dan inklusif. Hal ini juga dapat menjadi acuan bagi pendidik yang menggunakan pendekatan TPACK untuk meningkatkan literasi digital.

Kata Kunci: Pembelajaran IPAS, Sekolah Dasar, Siswa Disabilitas, TPACK, Transformasi Digital.

Introduction

The changing landscape of learning in the digital age brings both challenges and opportunities for primary education (Wati dan Nurhasannah 2024; Yuniarto dan Pradana 2024). On the one hand, digital technology opens up access and a variety of learning strategies that are more inclusive and interactive. However, on the other hand, it is still found that many elementary schools have not optimally utilized digital transformation to support students with disabilities (N. Azizah dkk. 2024; Wahyuni

dkk. 2025). For example, deaf students and students with verbal hyperactivity in inclusive schools often still experience barriers to access, a lack of adaptation of learning media, and a lack of teacher training in the integration of technology, pedagogy, and content.

In the context of Science and Social Studies (IPAS) learning in elementary schools, this challenge becomes even more apparent when students with special needs participate in regular classes (Noor dkk. 2025). In inclusive schools such as SD N Giwangan Yogyakarta, the phenomenon of “students with special needs (deaf and verbally hyperactive) in grade 5” shows that an adaptive and technology-based learning approach is needed so that all students can participate optimally.

Digital transformation in IPAS learning is important to improve accessibility and participation for students with disabilities. However, it is not simply a matter of “using technology”; rather, integration between IPAS content, inclusive pedagogy, and appropriate technology is also needed (Nugroho dkk. 2025). Knowledge frameworks such as TPACK (Technological Pedagogical Content Knowledge) serve as a foundation for understanding how teachers can integrate these elements into their teaching practices. For example, research shows that teachers who develop TPACK can significantly improve the quality of their teaching (Rahayu dkk. 2025).

However, there is a clear gap between the potential for digital transformation and learning practices in the field, especially in inclusive elementary schools. Factors such as the quality of teacher training, the availability of technological infrastructure, the adaptation of media for students with disabilities, and the readiness of inclusive classrooms often pose obstacles. (Pujiaty 2024). As an illustration, bibliometric studies show that the application of TPACK in primary education is still limited, with the focus still largely on teachers. (Pranyoto dan Berangka 2025; Shabira dkk. 2024).

Thus, the phenomenon at SD N Giwangan Yogyakarta, an inclusive elementary school with students with special needs in regular classes and the need for digital transformation in IPAS learning, is relevant and urgent to study. This study aims to understand how the TPACK approach can be applied in the digital transformation of IPAS learning for students with disabilities in elementary schools.

Research on the application of TPACK in elementary education shows that the integration of technology, pedagogy, and content is key to improving learning effectiveness Putri dkk., (2023) found that the application of TPACK in elementary schools after online learning helped teachers improve their ability to integrate

technology into learning.

More specifically, in the context of inclusion, studies by Rosnani dkk., (2025) shows that the integration of TPACK with the Universal Design for Learning (UDL) framework in intellectual disability education in Malaysia reveals that there are still many challenges related to the selection of low-high technology and teachers' understanding of the framework.

Furthermore, a systematic review of the literature by "Technical Pedagogical Content Knowledge (TPACK) in Special Education: A Literature Review" confirms that TPACK research production in special education is very limited only 5.59% of the total documents in the 2014–2023 period, and more research is directed at the university level than at the elementary school level. (Soto dan Herrera 2024).

Although previous studies have provided important insights, there are still significant shortcomings. First, there is very little research on TPACK in the context of inclusive elementary schools involving students with special needs (e.g., deaf or verbally hyperactive). Second, research specifically linking the digital transformation of IPAS learning to students with disabilities in regular elementary school classrooms is almost non-existent in both global and Indonesian literature.

Third, many studies emphasize teacher aspects (professional development, technology integration) but lack focus on the participation of students with disabilities and their learning experiences in classrooms that implement TPACK and digital technology. Rosnani dkk., (2025b) shows the challenges of integrating TPACK UDL, but the context is special education in secondary schools in Malaysia, not inclusive elementary schools in Indonesia.

This study is unique in that it practically explores how TPACK-based digital transformation of IPAS learning is implemented in regular classes at an inclusive elementary school in Indonesia, namely SD N Giwangan Yogyakarta, with a focus on deaf and verbally hyperactive students. Thus, this study offers a more specific contextual contribution to inclusive elementary education in Indonesia.

This study aims to: (1) describe how the digital transformation process in TPACK-based IPAS learning is implemented in grade 5 of SD N Giwangan Yogyakarta, which has students with special needs; (2) analyze the extent to which the TPACK approach can improve access, participation, and learning outcomes of deaf students and verbally hyperactive students in the context of IPAS learning.

The contribution of this study is to provide contextual empirical evidence on the

application of the TPACK model in digital transformation in inclusive elementary school classrooms in Indonesia, especially for students with disabilities. In addition, this study is expected to serve as a reference for policy developers, school principals, and inclusive elementary school teachers in designing and implementing more inclusive, technology-based IPAS learning that is tailored to the needs of students with special learning needs.

Method

The research method used in this study is qualitative, using a descriptive approach. This research was conducted at Giwangan State Elementary School (SD), which is located at Jl. Tegalturi No 45, Yogyakarta City from October to November 2024 with the research subjects of students with disabilities, deafness, and hyperactivityverbal class V and teachers as sources of information to obtain accurate data. The collection methods used were interviews, observation and documentation. The interview stage in this study aims to obtain accurate data from the fifth grade teacher in applying the TPACK approach to improve the digital literacy of students with disabilities, deafness, and hyperactivityverbal. The observation method used to observe the actual situation in class V. Documentation was used to support the research.

Data analysis in this study used the Miles & Huberman flow, which consists of four processes, namely: 1) data collection, 2) data reduction, 3) data presentation, and 4) data analysis. drawing conclusions (Muzaini 2026). The following research flow and techniques are presented in the figure below:

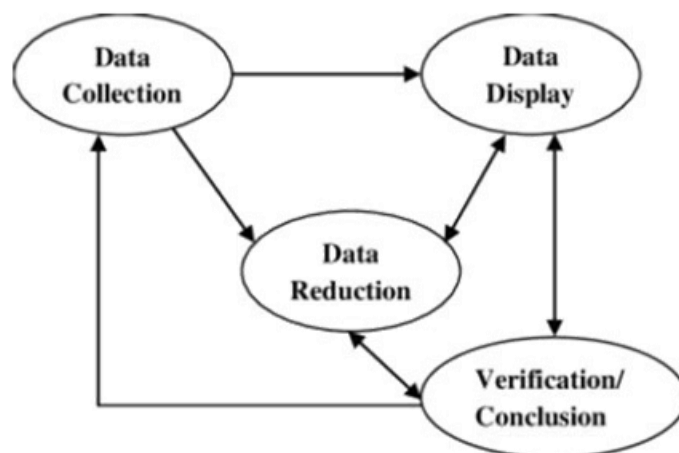


Figure 1. Data analysis using the (Miles dkk. 2020)

From the flow and research techniques above, the collected data is analyzed

through data collection, reduction, presentation, and conclusion drawing. The data collection stage uses observation, interviews, and documentation. The data reduction stage was carried out by filtering the data and focusing on the research objectives, namely analyzing the digital literacy transformation of students with special needs through the TPACK approach in IPAS subjects. Furthermore, the data is presented in the form of narratives or tables that facilitate analysis. The final stage is when the researcher concludes the results of the data analysis that has been carried out.

Results and Discussion

Implementation of TPACK Approach in IPAS Learning at Giwangan State Elementary School Yogyakarta

This study aims to analyze the application of Technological Pedagogical Content Knowledge (TPACK) approach in learning Natural and Social Sciences (IPAS) at Giwangan Yogyakarta State Elementary School. Based on observations, interviews, and documentation, several results were found that reflect how the TPACK approach is implemented in the school.

The Technological Knowledge aspect of teachers at Giwangan Yogyakarta Primary School shows a fairly good ability to use technology to support learning. The use of devices such as projectors, laptops, and digital-based learning applications such as Canva, Kahoot, and Google Classroom have become part of the teaching and learning process. The data from the teacher interviews show that:

"I utilize my laptop and Canva and other applications to create interesting presentation materials. Furthermore, I provide interactive quizzes through digital platforms. Then provide access to additional learning resources from the internet. However, there are obstacles in the form of limited technological facilities available at school. Some teachers also still need additional training to optimize the use of certain technologies."

The results of the interview were reinforced by observations, showing that:

"My assignment involves using a laptop and apps like Canva and other platforms to design engaging presentation materials. I also include interactive quizzes through digital platforms as part of the learning. In addition, I provide access to additional learning resources available on the internet. However, the challenge I face is the limited technology facilities in the school, coupled with the need for some teachers to undergo further training to optimize their use of technology."

From the description above, it can be concluded that teachers utilize laptops, Canva and digital platforms to create presentation materials, interactive quizzes and provide additional learning resources from the internet. However, the obstacles are the limited technology facilities at school and the need for training for some teachers to

optimize the use of technology. This is in line with the results of a study by Soro et al, showing that schools adopted strategies such as teacher training, the use of the Google Classroom Learning Management System (LMS), and interactive learning with applications such as Kahoot and Quizizz. The optimization of these strategies has had a positive impact, as seen in improved student grades, digital literacy, and active participation in learning (Soro dkk. 2024). A similar study also showed that students responded positively when teachers used digital technology in learning, this made students motivated in learning and improved student learning outcomes (F. W. Azizah dan Widiyati 2023).

The pedagogical approach used by teachers is quite varied. Teachers combine lectures, group discussions, experiments, and simulations. In IPAS learning, teachers often use a contextual approach that involves students in environmental exploration activities. For example, students are invited to observe the ecosystem in the school garden to understand the concept of food chain.

This approach has successfully increased student engagement in learning. However, the main challenge is the heterogeneity of students' abilities, which requires further differentiation strategies so that all students can achieve the expected competencies. The results of the teacher's statement show that:

"The pedagogical approaches used are quite diverse and effective. Teachers combine lectures, group discussions, experiments and simulations, all of which provide interesting learning experiences for students. The use of contextual approaches, such as exploration of the surrounding environment, is very relevant in IPAS learning. For example, inviting students to observe the ecosystem in the school garden to understand the concept of food chain helps students link theory with real-life experiences, thus increasing their engagement in learning."

The results of the interview were reinforced by observations, showing that:

"The main challenge that needs to be addressed is the diversity of student abilities in the classroom. This heterogeneity requires a more planned implementation of differentiation strategies, so that every student, both those with high abilities and those who need additional support, can optimally achieve the expected competencies."

In accordance with the statements in previous studies, it shows that the results of the study prove that TPACK-based basic science books can improve the learning outcomes of third grade students of SDN 16 Banda Aceh as evidenced by the evaluation of the results of student test questions obtained by 86% with very good criteria with details of 33 students completing it (Fina 2024). Another study also showed that

differentiated learning with digital teaching materials increased students' interest in IPAS Phase B from 69% to 85% (Kuway dkk. 2023).

The Content Knowledge aspect is that teachers have adequate mastery of IPAS material. This can be seen from their ability to explain scientific concepts with simple language and easily understood by students. Teachers are also able to connect the IPAS material with daily life phenomena, such as connecting the concept of water cycle with rain events that often occur in the Yogyakarta area. This is in accordance with the following statement that:

"The teachers have a fairly good mastery of the IPAS material. They are able to explain scientific concepts with simple language and are easily understood by students, so the material becomes more interesting. In addition, teachers can also relate the material to the phenomena of everyday life. For example, the concept of water cycle is explained by linking it to rain events that often occur in the Yogyakarta area. This approach really helps students understand the material contextually."

However, there needs to be improvement in the aspect of updating information. Some of the material presented by teachers still uses old references, making it less relevant to the latest scientific developments. This is in accordance with the following statement:

"Some of the materials presented still use old references, so they do not reflect the latest scientific developments. Efforts are needed to update learning resources and information so that the material presented is more relevant to the times."

This is in accordance with the latest research showing that the results of the study showed that there was an increase in learning outcomes before and after the implementation of Pedagogical Content Knowledge with a gain index of student learning outcomes of 0.51 in the medium category (Sukadi dkk. 2022). The percentage of the ability of prospective science teacher students FMIPA UM in making lesson plans, ability to manage learning, mastery of content (professional ability), and the total percentage of PCK (Pedagogical Content Knowledge) of prospective teacher students, respectively, is 88.78%, 85.66%, 86.90%, and 87.15% (Yulianti dan Pratiwi 2023). Based on data analysis, it was found that the TCK of subjects in Elementary School Teacher Education was quite good (Fuada dkk. 2020).

The implementation of TPACK can be seen from teachers' efforts to integrate technology, pedagogy and content holistically. For example, in learning about renewable energy, based on the interview results show that:

"I deliver the material using interactive videos. I also directed students to discuss in groups about the advantages and disadvantages of various renewable energy sources. Next, I ask students to make presentations using the PowerPoint application."

This is in accordance with the results of the birikut observation that the teacher:

"using interactive videos to deliver the material. Next, ask them to make a presentation using the PowerPoint application to present the results of their discussion."

This approach not only improves students' understanding of the material but also develops 21st century skills, such as collaboration, communication, and digital literacy. In a previous study, it was shown that the implementation of the HOTS-based TPACK approach in learning was successful and went well in accordance with the implementation steps (Wahyu dkk. 2024). Another study also showed that the use of TPACK-based learning tools in the chemistry learning process presents a number of opportunities, namely increased student engagement, improved concept understanding, improved critical thinking skills, improved long-term memory and understanding, and improved technological skills while the challenges include infrastructure and accessibility, insufficient teacher training, limited availability of resources, and difficulties in holistic integration of TPACK (Rumondor dkk. 2024).

Based on the results of the study, the application of the TPACK approach at Giwangan State Elementary School Yogyakarta provides some important implications for IPAS learning. The TPACK approach succeeded in creating more interactive and contextualized learning. The use of technology helps teachers present a more interesting and relevant learning experience for students. In addition, varied pedagogical approaches are able to meet the learning needs of students with different learning styles. Teachers also demonstrate a good ability to link IPAS content with appropriate technology and learning strategies. This is in line with the findings of Koehler et al., who emphasized that the integration of the three aspects of TPACK can improve the quality of learning (Koehler dkk. 2013).

From the presentation of the results and discussion related to the application of the TPACK approach in IPAS learning above, it can be concluded that the application of the TPACK approach in IPAS learning at Giwangan State Elementary School is effective in improving the understanding of deaf and verbally hyperactive students. The integration of technology, pedagogy, and content has a positive impact on student engagement and learning outcomes. However, to achieve more optimal results,

improvements need to be made in aspects of technology facilities, teacher training, and more individualized learning strategies (Dewi dkk. 2024; El Hiyaroh dkk. 2022). This approach has great potential to be developed as an inclusive learning model in other primary schools. With adequate support, the TPACK approach can be an innovative solution to create a fairer and more equitable education for all students, including those with special needs.

Evaluation of the Effectiveness of TPACK Approach in Improving Deaf and Hyperactive Verbal Students' Understanding of IPAS Materials

This study aims to evaluate the effectiveness of the Technological Pedagogical Content Knowledge (TPACK) approach in improving deaf and verbally hyperactive students' understanding of Natural and Social Sciences (IPAS) materials at Giwangan State Elementary School. Data were obtained through observation, interviews with teachers, and analysis of student learning outcomes.

Teachers at Giwangan State Primary School utilize technology to support the learning of students with special needs. Some of the strategies used include Video Learning with Sign Language, Interactive Apps, and Visual Media.

1. Sign Language Learning Video

Videos accompanied by text and sign language are used to help deaf students understand abstract concepts in IPAS. This is in accordance with the following statement that:

"I strongly support the use of videos accompanied by text and sign language in learning, especially for deaf students. This media is very effective for explaining abstract concepts that are often difficult to understand with just text or verbal explanation."

In a recent study, it was found that visual media such as schedules, multimedia (media that combine text, images, and interaction), flashcards, virtual reality technology, and mind mapping media can be an alternative in implementing science learning that can help improve concept understanding in deaf students (Ediyanto dkk. 2023). The learning video that has been developed is able to facilitate deaf people in understanding abstract theories through explanations in the form of text, infographics, and sign language in it. The sign language expressions displayed in the video are also able to attract students' attention and increase their motivation to learn (Mursalat dkk. 2023).

With videos, students can visualize the concepts being taught, such as the water cycle or planetary movements, so they can see the process concretely. The addition of text helps them understand technical terms and reinforces their understanding through reading. Sign language is a very important complement, as deaf students often pick up information more easily if it is delivered in the language they use on a daily basis. This also shows that inclusive learning can be achieved by accommodating their needs. This is reinforced by the following statement:

"besides helping deaf students' understanding, this method is also beneficial for other students, because learning becomes more interesting and interactive. So, I think this is an innovation that needs to continue to be developed in IPAS learning in elementary schools, especially in inclusive environments."

The use of videos with text and sign language is very effective in helping deaf students understand abstract concepts in IPAS. It visualizes concepts, reinforces understanding through text, and conveys information in a language that is familiar to them. In addition, this method also makes learning more engaging for all students, supporting inclusive learning.

In a recent study revealed that based on the results of research shows that deaf people use sign language as the main symbol in daily communication (Althanio 2024). In another finding shows that the teaching methods applied by teachers to deaf students at SLB Negeri Pembina Pekanbaru include the use of sign language (involving hand movements, body gestures, and facial expressions), oral methods (involving mouth movements and facial expressions), and total communication (a combination of sign language and oral methods). Sign language is considered more appropriate for students with severe hearing loss (Febriandi 2018).

2. Interactive App

For verbally hyperactive students, apps such as Kahoot and Quizizz are used to increase focus and participation through game-based activities. This is in accordance with the following statement that:

"In my opinion, the use of apps like Kahoot and Quizizz is very effective for verbally hyperactive students. Students with this characteristic tend to need interesting and dynamic activities to stay focused. These game-based apps provide an opportunity for them to channel their energy through healthy competition while learning."

Kahoot and Quizizz allow students to actively participate, answer questions quickly, and feel rewarded through scores or rankings. This not only improves their focus, but also makes learning more fun and interactive. In addition, verbally

hyperactive students often enjoy the opportunity to interact, so the discussion or reflection feature after the game can also be utilized to improve understanding, this app is a great tool good for improving verbal hyperactivity students' focus, participation, and engagement in the learning process.

Recent research shows that online learning apps such as Quizizz and Kahoot have various advantages in English language learning. Among other things, these applications are able to improve the ability and motivation of verbally hyperactive students to engage actively and communicatively in the English learning process (Sari dan Nurani 2021). In addition, other findings reveal that the use of educational games in learning Islamic Religious Education (PAI) can increase the learning motivation of verbally hyperactive students, strengthen students' understanding of the material, and create a more dynamic learning atmosphere (Abdillah dkk. 2024).

3. Visual Media

Teachers use pictures, graphs, and diagrams to support the delivery of material to deaf students. This is in accordance with the following statement that:

"The use of pictures, graphs and diagrams is very helpful in supporting deaf students' learning. This visual media makes it easier for students to understand abstract or complex material because they can see the information directly in a more concrete form."

When explaining science processes such as photosynthesis or the water cycle, diagrams and graphs provide a clear picture of the steps. Pictures also serve as a tool to introduce new concepts or explain something they can't hear through verbal explanations.

Recent research revealed that a learning video featuring screen-printed clothes with designs produced by deaf students, produced at Sablon Padaidi, played a role in helping deaf students learn screen-printing entrepreneurial skills according to their needs and communication abilities (Prasetyo dkk. 2024). Other research shows that teachers find this learning app very supportive in delivering material to students. Students also gave positive feedback, stating that the app helped them understand the lesson well and more easily. Overall, this learning app is considered feasible to use for speech-impaired students at the primary level (grades 1 and 2) (Muzaini dkk. 2024).

For deaf students, visual media like this is an effective bridge in understanding information because they rely more on vision. In addition, the use of pictures,

graphs and diagrams also attracts students' interest, so they are more focused and engaged in learning. This media is one of the important ways to realize inclusive and meaningful learning.

In applying the pedagogical approach at Giwangan State Elementary School, teachers adjust to the needs of students:

1. For deaf students

Teachers use sign language, picture cards and printed modules with enlarged text. A visual approach is predominantly applied to explain the IPAS concept. This is in accordance with the following statement that:

"This visual dominant approach is very effective, especially in IPAS learning for students with special needs. Sign language makes it easier for deaf students to understand direct explanations, while picture cards help visualize abstract concepts, such as natural cycles or ecosystems."

Printed modules with enlarged text are also very useful, especially for students with mild visual impairment or who need more focus on the written material. With this combination of visual tools, complex IPAS concepts become easier to understand.

According to research conducted by Wang and Tahir, Kahoot! increases student engagement in a fun way, especially for those who have high energy levels and need interactive activities to stay focused in learning. This study shows that students with hyperactive characteristics tend to be more responsive to gamification-based learning methods compared to conventional methods. This study also revealed that "game-based student response systems such as Kahoot! can boost motivation and attention, particularly for students who require constant stimulation and interaction" (Wang dan Tahir 2020).

Meanwhile, research conducted by Licorish et al., showed that Quizizz allows students to learn in a more relaxed and less stressful atmosphere, which is especially helpful for verbally hyperactive students who often have difficulty maintaining concentration on traditional learning. The study concluded that "students with high verbal activity levels find gamified quizzes to be an engaging and effective way to reinforce learning, as these platforms allow immediate feedback and active participation" (Licorish dkk. 2018).

Such an approach not only addresses students' needs but also creates inclusive, engaging and effective learning. Teachers feel confident that the method can be further developed to improve students' understanding in various IPAS topics.

2. For verbal hyperactive students

Teachers integrate physical activities, group games and discussions to channel students' energy while staying focused on the learning material. This is in accordance with the following statement that:

"I strongly support the integration of physical activities, group games, and discussions in learning. These methods are very effective, especially for students who have high energy or difficulty focusing in conventional learning." Physical activity helps students channel their energy in a positive way, so they are better equipped to focus on the material. Group games encourage collaboration and social interaction, which can strengthen concept understanding through cooperation. Discussions, on the other hand, provide space for students to express ideas and deepen their understanding.

According to research conducted by Donnelly and Lambourne, physical activity in the classroom can improve students' concentration and academic performance. They stated that "integrating physical activity into learning enhances cognitive function and engagement, allowing students to channel their energy constructively while improving their academic outcomes" (Donnelly dan Lambourne 2021). This shows that physical activity is not only beneficial for students' health but also has a positive impact on focus and information processing in learning.

In addition, research by Meltzer and Mindell, highlighted the importance of group games and discussions in improving students' social engagement and interaction. They revealed that "collaborative learning strategies, such as group discussions and interactive games, create an engaging environment that fosters deeper understanding and sustained attention" (Meltzer dan Mindell 2022). This shows that group games and discussions not only help students stay focused, but also improve their social skills and understanding of the learning material.

Not only does this approach make learning more fun, but it also ensures students remain actively engaged with the material. With strategies like these, learning objectives can be achieved in a more creative and inclusive way.

In the understanding of IPAS material by students, it can be seen from the results of the formative test showing an increase in students' understanding of IPAS material after the application of the TPACK approach.

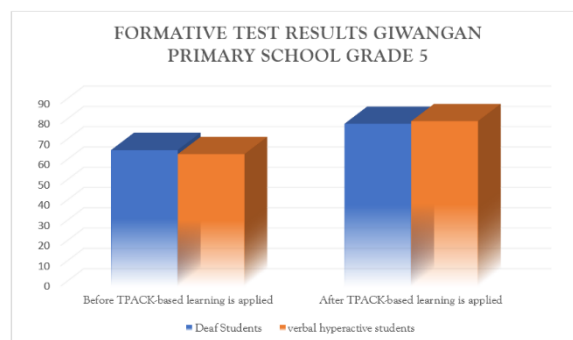
1. Deaf Students

Improved comprehension especially in visual materials such as the water cycle and animal life cycles. Visual media helps them relate concepts to everyday experiences.

2. Hyperactive Students Verbal

Showed improved understanding through practice-based activities, such as simple experiments. However, they still need more assistance when completing written assignments.

From the information above related to the increase in understanding of students with disabilities in understanding IPAS material can be seen in the following graphical image obtained from the assessment of learning test results.



Figur 2: Formative test results giwangan primary school grade 5

Based on the percentage graph above as a whole, there is an average increase of 25% in student test results compared to learning without the TPACK approach.

The implications for inclusive education from the results of this study indicate that the TPACK approach can be an effective inclusive learning model. The curriculum at Giwangan State Primary School can better support the use of technology as an integral part of learning. In addition, this approach can be adopted by other schools to create an inclusive and adaptive learning environment.

Based on the description of the results and discussion above, researchers can conclude that the application of the TPACK approach in IPAS learning at Giwangan State Elementary School is proven effective in improving the understanding of deaf and verbally hyperactive students. The integration of technology, pedagogy, and content provides significant results in improving student learning outcomes. However, to

achieve more optimal results, improved technology facilities, teacher training, and a more personalized approach are needed. With continuous improvement, the TPACK approach can be an innovative solution to create inclusive and equitable education for all students, including those with special needs (Andrean dkk. 2021; Cluley 2017; Moudina dkk. 2023). Further research at Giwangan State Primary School is also needed to explore the impact of this approach on other aspects, such as students' social and emotional skills.

Conclusion

The implementation of the TPACK approach in IPAS learning at Giwangan Yogyakarta State Elementary School shows great potential in improving the quality of learning. The holistic integration of technology, pedagogy and content succeeds in creating a more engaging, contextual and relevant learning experience for students. However, to optimize the results achieved, there is a need for improvement in the aspects of technology infrastructure, teacher training, and learning differentiation strategies. The application of the TPACK approach in IPAS learning at Giwangan State Elementary School proved effective in improving the understanding of deaf and verbally hyperactive students. The integration of technology, pedagogy, and content provides significant results in improving student learning outcomes. However, to achieve more optimal results, improved technology facilities, teacher training, and a more personalized approach are needed.

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