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THE ROLE OF DIGITAL INTERACTIVE BOARDS IN ENHANCING MATHEMATICS LEARNING MOTIVATION ON TRIGONOMETRY MATERIAL IN VOCATIONAL HIGH SCHOOL: A SELF-DETERMINATION THEORY PERSPECTIVE

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Abstrak. Mathematics learning in vocational high schools still faces motivational challenges, especially in trigonometry, because the topic requires visualization, logical reasoning, and conceptual understanding. This study aims to analyze the role of Digital Interactive Boards (DIBs/PID) in enhancing Grade XI students' mathematics learning motivation on trigonometry material at SMK Negeri 1 Muntok from the perspective of Self-Determination Theory. A descriptive qualitative approach was employed by involving one mathematics teacher and twelve Grade XI students selected purposively based on their involvement in learning activities using DIBs. Data were collected through semi-structured interviews, classroom observation, and documentation, and were analyzed using the Miles and Huberman model through data reduction, data display, and conclusion drawing. The findings show that before the use of DIBs, students experienced difficulty in understanding trigonometric concepts, showed low interest, and tended to be passive in classroom activities. After DIBs were implemented, students' motivation increased, as indicated by stronger attention, higher interest, more active participation, and greater confidence to solve problems in front of the class. Visualization, interactive multimedia, digital quizzes, immediate feedback, and direct screen interaction helped students understand abstract trigonometric concepts in a more concrete and engaging way. From the perspective of Self-Determination Theory, this motivational improvement occurred because DIBs supported the fulfillment of students' basic psychological needs for competence, autonomy, and relatedness. The study concludes that DIBs function not only as instructional media but also as pedagogical instruments that create interactive, meaningful, and student-centered mathematics learning experiences.

Keyword: Digital Interactive Board; Learning Motivation; Mathematics Learning; Trigonometry; Self-Determination Theory; Vocational High School

I. INTRODUCTION

Digital transformation has changed the way schools design learning experiences. In mathematics education, technology is no longer positioned merely as a presentation tool but as a learning environment that can expand representations, stimulate interaction, and help students construct meaning from abstract concepts. Educational technology also has a close relationship with student engagement because it can support behavioral, cognitive, and emotional involvement when it is integrated into purposeful pedagogy (Bond et al., 2020; Bedenlier et al., 2020).

Mathematics learning in vocational high schools still encounters several challenges, particularly the low motivation of students when they are faced with abstract materials. Trigonometry is one of the topics often perceived as difficult because students must understand angles, ratios, graphs, and spatial relationships at the same time. When these ideas are presented only through formulas and static drawings, students tend to experience difficulty in forming a complete mental representation of the concepts. This condition often leads to passivity, boredom, and limited classroom participation.

Initial observation at SMK Negeri 1 Muntok showed that before the use of Digital Interactive Boards (DIBs), hereafter also referred to as Papan Interaktif Digital (PID), students had difficulty understanding trigonometric concepts, were less interested in mathematics learning, and tended to be passive during classroom activities. The learning process was still dominated by conventional explanation and limited media, even though the teacher had attempted to create manual games to make the lesson more enjoyable. This situation indicates that the problem is not only related to content difficulty but also

to the lack of learning media that can transform abstract trigonometric ideas into visible, interactive, and meaningful experiences.

Digital Interactive Boards offer opportunities to combine text, images, animations, videos, quizzes, and direct touch-screen interaction within one classroom medium. Prior studies on interactive whiteboards have shown that their impact depends not only on the technology itself but also on how teachers use interactive features to promote exploration, discussion, and problem solving (Schmid, 2010). Interactive whiteboards have also been associated with motivation and learning gains in mathematics when they are used to involve students directly rather than to support teacher-centered presentations (Torff & Tirotta, 2010; Heemskerk et al., 2014).

Recent studies further suggest that technology-enhanced mathematics learning can increase student interest, motivation, and achievement when technology attributes are aligned with mathematical representation and classroom interaction (Poçan et al., 2023; Boadu & Boateng, 2024; St Omer et al., 2025). In trigonometry, learning designs that combine realistic contexts, visual representation, and game-based activities can help students engage with concepts that are usually perceived as abstract (Da et al., 2024; Wahyuni et al., 2024). However, the majority of previous studies focus on general digital media, mobile applications, online platforms, videos, or quantitative measures of learning outcomes. A qualitative exploration of how Digital Interactive Boards influence students' motivational experience in vocational mathematics learning, particularly on trigonometry material, remains limited.

This study uses Self-Determination Theory (SDT) as the analytical lens. SDT explains that high-quality motivation develops when three basic psychological needs are supported: competence, autonomy, and relatedness (Deci & Ryan, 2000; Ryan & Deci, 2017, 2020). In classroom learning, students are more likely to be motivated when they feel able to understand the material, have opportunities to participate and make choices, and experience meaningful connection with teachers and peers. Studies on online and technology-supported learning also indicate that digital environments can strengthen engagement when they provide clear structure, feedback, challenge, and social interaction (Chiu, 2022, 2023; David & Weinstein, 2024; Shank et al., 2025).

The novelty of this research lies in its qualitative examination of the mechanism by which Digital Interactive Boards enhance mathematics learning motivation through the fulfillment of students' needs for competence, autonomy, and relatedness. Unlike studies that primarily measure achievement scores, this research focuses on students' lived learning experiences, changes in attention, interest, active participation, and confidence, and the role of DIB features in shaping those motivational indicators. Therefore, this study aims to analyze the role of Digital Interactive Boards in enhancing mathematics learning motivation on trigonometry material among Grade XI students at SMK Negeri 1 Muntok from the perspective of Self-Determination Theory.

Author (Year)	Primary Focus / Problem	Methodology	Key Findings / Contributions
Ryan & Deci (2020)	Clarification of intrinsic and extrinsic motivation within Self-Determination Theory.	Theoretical and conceptual review.	Motivation quality depends on the fulfillment of competence, autonomy, and relatedness; this provides the psychological basis for interpreting students' learning motivation.
Bond et al. (2020)	Student engagement and educational technology in higher education.	Systematic evidence map.	Educational technology can support behavioral, cognitive, and affective engagement, although its impact depends on learning design and context.
Chiu (2022)	Student engagement in online learning through the lens of SDT.	Empirical study using SDT-based analysis.	Digital learning environments can support engagement when they satisfy psychological needs, especially competence and relatedness.
Kühl & Wohninsland (2022)	Interactive whiteboard use in classroom learning and its effect on vocabulary acquisition and motivation.	Experimental classroom study.	Interactive whiteboard-supported learning improved motivation and learning performance, showing the motivational potential of direct visual interaction.
Ní Shé et al. (2023)	Technology-enhanced resources in mathematics learning.	Literature review.	Technology can enrich mathematics learning, but research still requires stronger attention to engagement processes and theoretical explanations.
Boadu & Boateng (2024)	Technology integration, collaborative learning, motivation, and mathematics achievement.	Quantitative survey and mediation analysis.	Technology integration and collaborative learning contribute to mathematics achievement through students' interest and motivation.
Da et al. (2024)	Trigonometry learning based on realistic mathematics education and game-based learning.	Quasi-experimental study.	Contextual and game-based trigonometry learning improved students' confidence, participation, motivation, and conceptual understanding.
Shank et al. (2025)	Online secondary mathematics course design based on Self-Determination Theory.	Action research study.	Structured support, useful feedback, appropriate challenge, and peer interaction can enhance motivational experiences in mathematics learning.

The studies above confirm that SDT, educational technology, interactive whiteboards, and technology-enhanced mathematics learning have been widely discussed. Nevertheless, a specific research gap remains: there are still limited qualitative studies that examine how Digital Interactive Boards support learning motivation in vocational mathematics

classrooms, particularly in trigonometry, and how the motivational change can be explained through the needs for competence, autonomy, and relatedness. This study addresses that gap by focusing on the experiences of a mathematics teacher and Grade XI students at SMK Negeri 1 Muntok.

II. RESEARCH METHODS

This research employed a descriptive qualitative approach. This approach was selected because the study aimed to understand the role of Digital Interactive Boards in enhancing students' mathematics learning motivation as a psychological and pedagogical process formed through interaction among students, teacher, learning media, and classroom environment. Qualitative inquiry is appropriate for exploring meaning, perception, and experience in a specific educational context (Creswell & Poth, 2018).

The study was conducted at SMK Negeri 1 Muntok. The participants consisted of one mathematics teacher and twelve Grade XI students who were selected purposively. The selection was based on their direct involvement in mathematics learning activities using Digital Interactive Boards on trigonometry material. The context of SMK Negeri 1 Muntok was maintained because the study sought to understand the implementation of DIBs in an authentic vocational school classroom.

Data were collected through semi-structured interviews, classroom observation, and documentation. Interviews were conducted to obtain students' and teacher's perceptions of motivation, understanding, participation, and confidence before and after the use of DIBs. Observation was used to capture classroom behavior, interaction patterns, and student responses during learning activities. Documentation was used to support the interview and observation data, especially in relation to learning activities and the use of DIB features.

Data analysis followed the Miles, Huberman, and Saldaña model, which consists of data reduction, data display, and conclusion drawing (Miles et al., 2014). In the reduction stage, the data were coded thematically based on indicators of learning motivation, namely attention, interest, active participation, and confidence. The data were then interpreted using Self-Determination Theory by linking those indicators to the fulfillment of competence, autonomy, and relatedness. To strengthen the credibility of the findings, this study applied source triangulation, technique triangulation, and member checking.

III. RESULTS AND DUSCUSSION

Learning Motivation before the Use of Digital Interactive Boards

The findings indicate that before the implementation of Digital Interactive Boards, students faced several obstacles in learning trigonometry. They perceived trigonometry as difficult because the material required visualization of angles, graphs, and relationships among mathematical elements. The conventional explanation and static writing on the board did not provide sufficient support for students to imagine the concepts clearly. As a result, students showed limited attention and low interest in the lesson.

> *S1: "I often feel confused when learning trigonometry because I only see formulas on the board. When angles and graphs are explained only through writing, it is difficult for me to imagine them."*
>
> *S3: "Learning trigonometry often feels like arranging a very abstract puzzle, so it makes me dizzy and less interested."*

These statements show that the abstract character of trigonometry created a barrier to conceptual understanding and learning motivation. Students needed instructional media that could transform symbols and formulas into visual and interactive representations. Without such support, the learning experience tended to be teacher-centered and less stimulating for students.

Students' Interest after the Use of Digital Interactive Boards

After Digital Interactive Boards were used, students reported that the learning process became more interesting and easier to follow. DIBs enabled the teacher to combine pictures, videos, animations, digital quizzes, and direct interaction on the screen. This combination made the trigonometry lesson more concrete and attractive. Students were no longer only receiving information passively; they became more involved in observing, responding, and trying to solve problems through the interactive features.

> *S5: "After using the Digital Interactive Board, learning became more interesting because there were pictures, videos, and quizzes. I became more enthusiastic to follow the lesson until the end."*
>
> *S9: "When using the Digital Interactive Board, I do not get bored quickly because the learning is more interactive than before."*

The increase in students' interest is consistent with the idea that learning becomes more meaningful when verbal explanation is supported by visual and interactive representation. Technology-based learning can improve engagement when students can see, manipulate, and discuss learning objects rather than only listen to explanations (Bond et al., 2020; Ní Shé et al., 2023). In this study, DIBs helped students maintain attention and develop a more positive attitude toward mathematics learning.

Active Participation and Confidence

Observation and interview data also show that the use of DIBs encouraged active participation and confidence. Students were more willing to come to the front of the class, solve problems, play learning games, and try the touch-screen features. The classroom atmosphere became more participatory because interaction occurred not only between teacher and students but also among students themselves.

> *S6: "The lesson became more exciting. My friends and I took turns coming forward to solve questions and play games in front of the class."*
>
> *Teacher: "The students were very enthusiastic when I gave questions and games through the Digital Interactive Board. They took turns solving the questions without being appointed and without being afraid of making mistakes."*

The teacher also stated that students who previously hesitated to come forward became more curious and courageous after DIBs were introduced. They wanted to try drawing on the board and asked about new features. This indicates that the medium reduced students' fear of making mistakes and created a safer atmosphere for participation. Immediate feedback also helped students recognize errors and revise their answers, which supported the growth of confidence.

> *Teacher: "Students who previously were afraid to come forward became interested in coming forward after the Digital Interactive Board was used. They tried new things, such as drawing on the board and asking about its features."*
>
> *Teacher: "Now they come forward by themselves to try solving questions. Even when some answers are wrong, they still look happy."*

Ease of Use and Multimedia Support

Students did not experience significant technical barriers in using DIBs. They perceived the board as familiar because the touch-screen operation resembled smartphone use. This ease of use helped students focus more on the lesson than on the technical operation of the device. Ease of use is important because motivational benefits may disappear when technology becomes a burden rather than a support for learning.

> *S7: "The Digital Interactive Board is like a smartphone. It is easy to use; it only needs to be connected to the internet and then we can use it directly."*

The audiovisual features of DIBs also played an important role in strengthening students' understanding of trigonometry. Pictures, animations, and videos made abstract ideas more visible. Students could connect mathematical symbols with shapes and movements that they could observe directly. Therefore, DIBs contributed to both cognitive and affective aspects of learning: they supported understanding while also making students more motivated to participate.

Relationship between DIB Features, Motivation Indicators, and SDT Needs

DIB/PID Feature	Motivation Indicator	SDT Need	Empirical Evidence
Visualization of graphs and trigonometric animations	Increased attention and interest	Competence	Students understood angles and graphs more easily; classroom observation showed stronger focus.
Interactive quizzes	Active participation	Autonomy	Students volunteered to come forward without being called by the teacher.
Immediate feedback	Improved confidence	Competence	Students were willing to repeat exercises after seeing the result and receiving feedback.
Collaborative activities	Increased social interaction	Relatedness	Peer discussion and classroom interaction increased during DIB-based activities.
Interactive multimedia	Sustained interest and focus	Competence and relatedness	Students stayed longer in learning activities and perceived the lesson as more enjoyable.

Overall, the results show that Digital Interactive Boards enhanced students' mathematics learning motivation through several observable indicators: attention, interest, active participation, and confidence. These indicators were not independent from the learning features. They emerged because the DIB created visual, interactive, collaborative, and feedback-rich learning experiences that were previously limited in conventional instruction.

The findings of this study confirm that Digital Interactive Boards can function as pedagogical instruments for improving mathematics learning motivation. The motivational improvement was not produced merely by the presence of technology, but by the way the technology enabled students to see abstract trigonometric concepts, interact with learning tasks, receive feedback, and collaborate with peers. This is consistent with Schmid (2010), who emphasizes that the value of interactive whiteboards depends on pedagogical use, not on technological presence alone.

From the perspective of Self-Determination Theory, the first mechanism is the fulfillment of competence. Students felt more capable of understanding trigonometry because DIBs transformed abstract concepts into visual and interactive

forms. Graphs, animations, videos, and direct annotation helped students connect formulas with concrete representations. When students perceived that the material became easier to understand, their confidence and willingness to engage increased. This finding is in line with Ryan and Deci (2020), who explain that perceived competence is central to the development of high-quality motivation.

The second mechanism is the support for autonomy. DIB-based learning provided opportunities for students to choose to come forward, try problem-solving activities, participate in quizzes, and explore the board features. These opportunities gave students a sense of agency in the learning process. In SDT, autonomy does not mean learning without structure; it refers to the experience of willingness and ownership in doing an activity (Ryan & Deci, 2017). The classroom evidence shows that students participated not because they were forced but because the learning activity invited them to take part.

The third mechanism is the strengthening of relatedness. Digital Interactive Boards encouraged interaction between students, teacher, and peers. The board became a shared learning space where students could discuss answers, take turns, observe their friends' work, and respond to feedback. This finding is consistent with studies showing that technology-supported learning is more effective when it facilitates social interaction and meaningful connection, rather than isolating students from the learning community (Chiu, 2023; Ismailov & Chiu, 2022; Jeno et al., 2022).

The findings also correspond with previous research on educational technology and mathematics learning. Interactive and technology-enhanced resources can increase engagement when they support visualization, participation, and feedback (Bond et al., 2020; Bedenlier et al., 2020; Poçan et al., 2023). In mathematics, technology integration should help students experience concepts through multiple representations, especially in topics such as trigonometry that require spatial and graphical understanding (Da et al., 2024; St Omer et al., 2025). Therefore, the contribution of DIBs in this study is particularly relevant because the board supported the visualization and interaction needed in trigonometry learning.

This study also shows that the DIB is suitable for the vocational high school context. Students in SMK often need learning experiences that are practical, visual, and connected to active tasks. The board helped the mathematics teacher create a more dynamic classroom atmosphere and reduced students' anxiety about coming forward. The teacher's role remained central because the effectiveness of the board depended on how the teacher designed questions, games, explanations, and feedback. This supports the argument that teacher digital competence is important for transforming technology into meaningful learning experiences (Chiu et al., 2024).

The research contributes to the literature by offering qualitative evidence of how Digital Interactive Boards enhance motivation through SDT needs. The findings do not add new quantitative achievement data, and they do not claim that DIBs automatically improve all learning outcomes. Rather, the study demonstrates that when DIBs are used interactively, they can create conditions that make students feel more competent, more willing to participate, and more connected with the classroom community. These motivational conditions are important foundations for improving mathematics learning quality.

IV. CONCLUSION

This study concludes that Digital Interactive Boards play a positive role in enhancing mathematics learning motivation on trigonometry material among Grade XI students at SMK Negeri 1 Muntok. Before the use of DIBs, students tended to experience difficulty in understanding trigonometry, showed low interest, and participated passively. After the implementation of DIBs, students demonstrated stronger attention, higher interest, more active participation, and greater confidence in solving problems and presenting their work in front of the class. From the perspective of Self-Determination Theory, the motivational improvement occurred because DIBs supported three basic psychological needs. Visualization, multimedia, and immediate feedback strengthened students' sense of competence. Interactive quizzes, direct screen activities, and opportunities to come forward supported autonomy. Collaborative activities and shared classroom interaction strengthened relatedness. Thus, DIBs function not only as instructional media but also as pedagogical tools that can create interactive, meaningful, and student-centered mathematics learning. The practical implication of this study is that mathematics teachers can use Digital Interactive Boards to support abstract topics such as trigonometry, provided that the board is used for exploration, interaction, feedback, and collaboration rather than only as a presentation screen. Future research may expand the scope by involving more classes, comparing different mathematics topics, or combining qualitative findings with quantitative measures of motivation and achievement.

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