

Changes in Students' Learning Motivation Following Smart Panel Use in Islamic Higher Education

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Abstract. The availability of easy access to the interactive smart panel in higher education has potential to improve the motivation of students to learn and to increase interest in it. But the value of this tool in learning depends on the extent to which it is integrated into the teaching methods. This research investigated students' motivation to learn, self-reporting by students themselves, before and after implementation of smart panels in a higher education institution in Surabaya, Indonesia, and also reviewed the institution's perspective on the use of smart panels in the classroom. This research uses mixed approach, which consists of pretest-posttest evaluation on one group of 33 students of PAI-B class and descriptive interview with three institutional representatives. The average score of motivation increased from 11.18 (SD=1.72), at the *pretest* stage, to 13.27 (SD=2.05), at the *posttest* stage, with an increase of 2.09 points. Paired-samples t-test was used to compare the average of the two measurements. The results revealed a significant difference between the two measurements, $t(32) = -12.677$, $p < 0.001$, with a large effect size (*standardised mean difference*) ($|d^2| = 2.207$). The results of the interview indicate an increase in the use of technology in course preparation, the level of flexibility in multimedia presentations, the clarity of visual explanations, and student participation, but show different levels of technology adoption among the lecturers. Research results, based on the Technological Pedagogical Content Knowledge (TPACK) framework and Self-Determination Theory, indicate that the potential of smart panels to motivate students depends on their integration in pedagogically meaningful learning activities.

Keywords: smart panel; learning motivation; interactive learning media; Islamic higher education; TPACK; self-determination theory; mixed methods.

1. INTRODUCTION

Interesting learning media can encourage students to learn. Furthermore, the learning media can be used as a supporting medium in the educational process (Bdiwi et al., 2019). New technology is meant to make man's work in every day life easier. For example, people today can't escape from digital technology in the real world. This continuous progress of technology has good and bad effects too.

A more digital education world also changes how students interact with teachers. Students that are highly literate in technology get bored quickly when

learning happens in the traditional way. Thus, many students have little interest in lessons taught by teachers who continue to use traditional methods (Zhang et al., 2024). So teachers should try new things to push students in the teaching and learning process by using technology-based media (Xie et al., 2020). A good teacher today is someone who keeps up with the times and uses technology in the learning process.

An interactive smart board is an example of panel-based learning media. With an interactive smart board the number of students in the class can stimulate students. It can improve student engagement, interactivity and personalisation in the learning process (Zhang et al., 2024). The relationship between the use of learning media and students' motivation and academic achievement has been investigated.

The smart panels are interactive and can be used by the students in the classroom learning which increases the participation and engagement of the students and creates a lively and dynamic learning environment (Winayu, 2024). Hamdan et al. (2012) believe that smart board can make learning visual and interactive and therefore, complex material can be understood easily and become more interesting for students. Ahmad et al. (2021) found that digital learning media such as smart boards not only facilitate different learning styles but also increase students' willingness to learn, especially for material that requires visual explanations. Liu and Huang (2020) found that technology-based media in education had a positive effect on student performance. This is due to the opportunities for interactive learning, instant feedback and higher concentration. Guo and Huang (2021) contend that the application of smart panels may optimise the dynamic learning environment, improve the interaction between teachers and students, and promote the improvement of academic performance. This is by improving attention and keeping motivation in the teaching activities in classroom. Overall, previous research has shown that there is a positive relationship between media technology-based learning and student motivation. The research also emphasises the necessity of intelligent digital learning media in the current educational environment.

The educational experience is the motivation for students to act, to participate in learning activities, and to achieve their academic goals. Motivation and student engagement are highly correlated, but they are not to be confused. There are certain behaviours such as watching digital presentations or answering questions that can demonstrate either real interest or simply a passing enthusiasm coming from the evolution of technology. According to the Self-Determination Theory (SDT) a learning environment can also contribute to satisfying three basic psychological needs: autonomy, competence, and relatedness. In such environment, motivation can be more self-determined (Ryan & Deci, 2020). It is supported by the smart panel activities that use interactive technology to provide meaningful learning options, meaningful feedback, and an opportunity to work with others. Its motivation power is great, but finally depends on how to design the learning activity.

TPACK Technological Pedagogical Content Knowledge (TPACK) considers the integration of technology as the interaction of technology knowledge, pedagogical knowledge and content knowledge. Oleh karena itu, kesuksesan pendidikan pintar smart sangat bergantung pada kemampuan guru dalam mengadaptasi teknologi yang sesuai dengan tujuan dan strategi pembelajaran di bidang keilmuannya. For instance, interactive teaching, visual-audio materials and clear explanations can assist students in acquiring some linguistic and academic

skills. This sort of instructional value results from a conscious convergence of technology, pedagogy, and content, not simply from the technological features of the device. Other theoretical perspectives help us to understand aspects of technology integration.

The Technology Acceptance Model (TAM) emphasises the need for the educator to see technology as useful and easy to use. (Davis 1989, Scherer et al. 2019) However, according to the Cognitive Theory of Multimedia Learning, visual and verbal instructional materials should be developed in accordance with the cognitive processing capacity of students (Mayer & Moreno, 2003; Mayer, 2021).

In 2023, STAI Ar-Rosyid Surabaya has implemented a smart panel to support classroom learning, as the integration of educational technology continues to grow. The device installed provides a Windows based application, Internet access and digital writing and multimedia presentation capabilities. The lecturer also explained some advantages of projectors and conventional blackboard over instructional preparation and delivery of instructional materials. However, the extent to which perceived benefits are associated with changes in students' desire to learn is unclear. In this study, the PAI-B class was selected purposefully because it was known that the class had experienced improvement in interaction, creativity and learning motivation. In this more specific context, we had the opportunity to study the group motivation changes of the students in an effort to study the usage of a smart panel.

2. METHOD

2.1 Design and Study Setting

This study used a mixed-method design, combining a quantitative single-group pretest–posttest design with descriptive qualitative interviews. The quantitative part studied changes in students' learning motivation by examining the scores obtained from the same participants before and after smart-panel-supported teaching. The qualitative part provided insights into the implementation context of smart panels, especially perceived instructional benefits, classroom applications and challenges of adopting technology. The study sought to provide greater insight into changes in students' learning motivation in the institutional context by combining these two parts.

The quantitative component was a one group, pretest-posttest design without random assignment or comparison group. Therefore, the analysis was performed on the changes in the motivation scores of the participating group rather than the establishment of a causal relationship between the use of smart panels and learning motivation. The study was conducted at STAI Ar-Rosyid Surabaya, Indonesia which is an Islamic higher education institution that implemented smart panels in its instructional facilities in 2023.

2.2. Participants and Data Sources

The quantitative part was elaborated with 33 students of the class PAI-B, being 26 females and seven males. Purposive sampling was used to select participants because the class had already been identified as having problems with classroom interaction, creativity and learning motivation. The sampling strategy permitted an in-depth investigation of motivational change within the chosen learning environment. However, participants were selected from one class and the

sampling technique used was non-probability. As such, the findings cannot be assumed to represent the wider population of students.

The qualitative data were collected through interviews with three institutional representatives, Chair of STAI Ar-Rosyid, Head of Curriculum, and Arabic language lecturer. Participants were recruited from institutional roles in educational management, curriculum implementation, and classroom instruction. Their views provided background information on the actual use of smart panels, perceived benefits in teaching and challenges in their usage. Because students were not part of the qualitative interviews, the accounts of student participation were institutional observations, rather than students' own accounts of motivation.

2.3. Instructional Exposure and Measurements

The instructional exposure that was examined was the use of smart interactive panels in the classroom instruction. The devices offered a variety of instructional capabilities, including digital writing, document display, audiovisual presentations, and access to web-based applications. These features allowed lecturers to present learning materials in different formats and possibly to facilitate more interactive instructional activities.

Before and after the use of the smart panel, a questionnaire was given to measure students' learning motivation. Quantitative data consisted of reported total motivation scores. These scores were summarised using descriptive statistics and analysed for differences between the two measurement times. Research documentation available included means, standard deviations, and results of inferential statistical tests. However, the reported measures did not differentiate between specific motivational dimensions such as autonomy, competence, relatedness and intrinsic motivation. The quantitative analysis was therefore limited to changes in the total motivation score and not to changes in individual motivational constructs.

2.4. Analysis of Quantitative and Qualitative Data

The quantitative data were analysed using descriptive and inferential statistical methods. Descriptive statistics were performed, such as means and standard deviations, to provide an overview of the students' learning motivation scores before and after the use of smart panels. Next, a paired-samples t-test was performed to determine whether the mean difference between pre-test and post-test scores was statistically significant. This was a good procedure for comparing two related measures taken on the same participants.

Statistical analysis calculated paired differences by subtracting posttest from pretest scores. Thus, a negative t-value indicated that the mean motivation score was higher at posttest than at pretest. Using the reported test statistic and sample size ($n = 33$ students), the standardised paired change was $|d^z| \approx 2.207$. This effect size measure is the mean within-participant difference divided by the standard deviation of the paired differences and so should be distinguished from standardised mean differences calculated for independent groups. Quantitative analysis was performed using SPSS version 23.

The qualitative interview data were analysed by descriptive synthesis of institutional accounts of perceived instructional benefits of smart panels, classroom participation and lecturers adoption of the technology.

In the Results section, the quantitative and qualitative findings were merged through narrative comparison and the presentation of a joint display. This combination was intended to provide a context for the observed changes in motivation scores by taking into account institutional perspectives on the implementation of smart panels. Qualitative perceptions were treated as supportive contextual evidence rather than as independent validation of the quantitative findings.

3. RESULT

3.1. *Changes of Students' Learning Motivation (Descriptive)*

The results of descriptive analysis showed that students' learning motivation increased after using smart panel in classroom instruction. The mean score of motivation at pretest was 11.18 (SD = 1.72) and 13.27 (SD = 2.05) at posttest. The average increase was 2.09 points among the 33 students who participated in this study. This finding indicates that students' reported learning motivation was higher after the period of smart-panel-supported instruction than before its implementation. Table 1. Descriptive statistics of students' learning motivation at two measurement points The mean scores indicate a positive change, but these descriptive findings do not prove that the improvement observed was solely due to the use of smart panel.

Table 1. Descriptive Statistics of Students' Learning Motivation Before and After Using Smart Panel

<i>Measurement</i>	<i>N</i>	<i>Mean</i>	<i>Standard deviation (SD)</i>
Pretest	33	11.18	1.72
Posttest	33	13.27	2.05
Change (posttest – pretest)	33	+2.09	

3.2. *Paired-Samples Test and Magnitude of Change in Learning Motivation*

A paired-samples t-test was performed to determine if there was a significant difference between the pretest and posttest on students' learning motivation. The analysis revealed a statistically significant difference, $t(32) = -12.677$, $p < .001$. This indicates a significant increase in the mean motivation score after the period of smart panel usage.

The negative t-value is a function of the way the original calculation was done, subtracting pretest scores from posttest scores. Therefore, a negative value means that the motivation scores at posttest were higher, not the decrease of students' motivation for learning.

The magnitude of the observed change was assessed using the standardised paired effect size, which resulted in a large value ($|d^2| = 2.207$). This result suggests that the mean difference was large relative to the variability of individual change scores.

Statistical analysis indicates a significant increase in students' reported learning motivation, but the results are subject to the limitations of the research design. The lack of a comparison group specifically prevents the observed improvement from being solely attributed to smart panel use.

3.3 *Institution's Perspective on the Use of Smart Panel*

The qualitative component provided contextual information regarding the use of smart panels in the classroom. Interviews with three institutional representatives

identified several perceived benefits of the technology in instructional preparation, multimedia presentation, visual explanation and classroom participation.

Representatives from the institutions commented on the convenience of accessing instructional materials through familiar software applications and the availability of multiple digital resources on a single device. It was also observed that smart panels enable the presentation of learning materials through digital writing, audiovisual content and internet based resources.

Concerning student participation, institutional representatives indicated students seemed more attentive and actively involved with smart-panel-supported instruction. However, these are institutional perceptions and not independently measured classroom behaviours or students' firsthand experiences. The interviews also revealed variation in the extent to which lecturers integrated smart panels into their teaching practices.

Table 2. Descriptive Synthesis of Institutional Interview Findings

<i>Reported Focus</i>	<i>Summary of Institutional Interview Findings</i>
Instructional preparation and operation	Familiar software applications, convenient access to instructional materials, and reduced preparation effort were perceived as practical advantages.
Multimedia presentation and visualization	Digital writing, audiovisual materials, and online resources were considered useful for presenting and explaining instructional content.
Students' classroom participation	Institutional representatives perceived improvements in students' attention and participation during classroom activities.
Lecturer adoption	The extent of smart panel integration was reported to vary among lecturers.

3.4. Combining Qualitative and Quantitative Findings

The combination of quantitative and qualitative findings helps to understand in the context changes in students learning motivation after the use of smart panels. Quantitative analyses revealed higher motivation scores at posttest . Institutional interviews indicated perceived instructional advantages and improvements in classroom participation .

The same educational setting was studied in both parts of the study, but with different focuses on the learning experience. The quantitative component examined changes in reported learning motivation in students, while the qualitative component documented institutional perspectives on instructional practices, operational convenience, and observed classroom participation.

These findings were consistent, in which the increase in students' motivation scores occurred in the instructional environment where the smart panels were perceived to be useful in presenting learning materials and supporting classroom activities. However, the qualitative findings do not identify the factors responsible for the observed statistical change on their own.

Table 3 provides a combined presentation of the quantitative results together with the related qualitative data and interpretations that are supported by the evidence available.

Table 3. Quantitative Results and Institutional Perspectives on Smart Panel Implementation Joint Presentation

<i>Quantitative evidence</i>	<i>Qualitative context</i>	<i>Interpretation</i>
Higher mean posttest motivation score (+2.09).	Institutional representatives perceived multimedia presentations and visual explanations as beneficial for instruction	Higher motivation scores were observed following smart panel use.
Significant paired difference, $t(32) = -12.677$, $p < .001$.	Institutional representatives reported greater observable student participation during classroom activities.	Perceived improvements in participation were consistent with the quantitative findings but did not constitute an independent measure of learning motivation.
A large standardized within-participant change was observed	$d^z = 2.207$	Change magnitude is context-specific.

3.5. Understanding Changes in Students' Learning Motivation

The main finding of this study was that there was a significant increase in students' self-reported learning motivation from pre-test to post-test assessments after the use of smart panels. This improvement is particularly significant within the institutional setting as the class concerned had been previously identified as having problems with learning motivation and classroom interaction. This is in line with prior research indicating that digital technologies can offer opportunities to improve students' engagement when embedded in purposeful instructional activities (Bond et al., 2020). Likewise previous studies on interactive technologies in higher education have revealed the potential motivational benefits of introducing digital resources in teaching and learning processes (Guaña-Moya et al., 2024).

However, the agreement of the present results with the previous ones should be taken with caution. Differences in technological applications, instructional contexts, methodological approaches, and outcome measures prevent direct comparisons across studies. Therefore, the present findings provide evidence for changes in students' learning motivation in a specific context rather than showing the same effects of smart panels in different educational contexts.

There is a crucial methodological issue in distinguishing between observed changes in learning motivation and causal effects of technological interventions. Students reported significantly higher motivation scores after using the smart panel. However, the research design did not include a comparison group or additional measurement points. The observed improvement can therefore not be attributed to technology alone. Changes in instructional strategies, learning materials, classroom interactions, or students' familiarity with learning activities could have been responsible for the differences in pretest and posttest scores. Additionally, repeated administration of the questionnaire and the novelty of technology-supported instruction may have affected students' responses.

These considerations emphasise the significance of distinguishing observed changes over time from causal relationships. The present findings supported the conclusion that the reported learning motivation of students improved after the use of smart panels. But they do not verify that the technology alone caused this improvement.

The interpretation of motivational change is also dependent on the dimensions examined by the research instrument. Students' learning motivation consists of some interrelated features such as interest, persistence, perceived competence, task value, and reasons for participation in academic activities. The increase observed cannot be ascribed to any specific psychological component, because of the lack of detailed documentation of the questionnaire items and motivational dimensions.

Similarly, institutional reports of increased participation in the classroom should be distinguished from students' motivational experiences. Bergdahl et al. (2024) noted that behavioural indicators alone may not fully capture the multidimensionality of student engagement. Thus, the present study differentiates between reported learning motivation, observable classroom behaviour, and academic achievement rather than treating these outcomes as interchangeable.

3.6. Understanding Students' Learning Motivation: Self-Determination Theory

Self-Determination Theory (SDT) offers a relevant psychological framework to comprehend the changes in students' learning motivation. Ryan and Deci (2020) propose that education environments can support student motivation by fulfilling three basic psychological needs: autonomy, competence, and relatedness. These needs can be addressed in technology-supported learning environments through instructional activities that support meaningful decision making, provide constructive criticism, and promote positive interpersonal interactions.

Thus, the motivational potential of smart panels can be understood in relation to the learning experiences they enable and not only to their technological features. For instance, lecturers can support students' motivation by encouraging them to choose learning materials, find examples for discussion or decide ways to solve academic problems. Students may become more confident in their learning ability by understanding difficult concepts and seeing their progress through visual explanations, sequential demonstrations, and immediate feedback by lecturers. Likewise, collaborative activities such as sharing perspectives, developing shared explanations, and having meaningful discussions can promote positive relationships among students.

In this perspective, smart panels might offer opportunities for developing instructional environments responsive to students' psychological and educational needs. But these opportunities are contingent upon the pedagogical choices of the lecturers. Designing visually pleasant materials or embedding interactive applications does not necessarily result in substantial increases in students' learning motivation.

It is important to point out that the motivational processes proposed are theoretical interpretations and not empirically established relations in the present study. The questionnaire did not measure separately the three psychological needs identified by SDT or different types of motivational regulation. Furthermore, the qualitative part did not include direct descriptions of students' motivational experiences. Thus, SDT offers an interpretive framework to understand possible explanations for motivational change, rather than a theoretical model that can be directly tested with available data.

This distinction between temporary classroom enthusiasm and persistent motivation to learn is particularly pertinent in the setting of using interactive technologies for gamified learning activities. Smart panels showing digital quizzes

can encourage quick responses and visible participation. But their educational value depends on the instructional purposes they fulfill and the learning experiences they create. Sailer and Homner (2020) conducted a meta-analysis of gamification research and reported positive mean effects on motivational and learning-related outcomes, emphasising the significance of instructional design.

Lecturers should consider therefore the use of interactive questions not just to promote competition or reward fast answers but also to identify misconceptions, provide explanatory feedback and encourage reflection. These practices can build student confidence, deepen student understanding, and foster meaningful engagement in learning activities.

In this sense, smart panels should be considered as educational tools which can contribute to students' learning motivation through appropriate pedagogical practices, rather than as technologies which can autonomously produce motivational enhancements.

3.7. Smart Panels Integration in Teaching: The TPACK Approach

The Technological Pedagogical Content Knowledge (TPACK) framework offers a complementary rationale for the importance of instructional design in technology-supported learning environments. TPACK emphasises the significance of the intersection of technological knowledge, pedagogical knowledge, and subject-matter knowledge for the successful integration of educational technology (Mishra & Koehler, 2006). From this perspective, the educational value of smart panels is determined by how lecturers integrate technological functions with disciplinary learning goals and appropriate instructional strategies.

Based on the STAI Ar-Rosyid Surabaya, the smart panel offers a number of possible instructional applications, from traditional presentations to interactive annotations, multimedia demonstrations, and collaborative inspection of learning materials. Though these activities may be using the same technological device, their pedagogical implications are quite different.

For example, the use of a smart panel to show lecture notes only, may improve the convenience of the presentation, but does not change students' learning experiences significantly. In contrast, activities that require students to analyse information, explain concepts, compare interpretations, or provide answers may offer more valuable opportunities for active engagement.

One example of such an application may be the Arabic-language instruction. Audiovisual materials can help students in understanding pronunciation, vocabulary and communicative contexts. However, by having students locate linguistic expressions, mark their meanings, compare interpretations, and apply language through guided practice and feedback, their pedagogical value can be increased.

The example is an illustration of a suggested teaching application, not an observed classroom activity of the study. However, it does show how the functionality of smart panels can be linked to content-specific goals and participatory teaching strategies. Similar principles may apply to Islamic education where lecturers could leverage digital annotation and multimedia resources to facilitate textual interpretation, conceptual comparison and evidence-based discussion. The challenge in both cases is whether the integration of technology facilitates the desired learning outcomes.

Differences in the adoption of smart panels by lecturers were also pointed out

by the institutional interviews. This finding is particularly relevant to the TPACK framework because the presence of technology does not ensure its consistent or pedagogically effective use. Tondeur et al. (2017) reported that teachers' pedagogical beliefs and practices regarding technology are closely related, indicating that technology integration is influenced by instructional orientations and institutional conditions.

Such considerations underline the importance of professional development initiatives that go beyond technical training. Institutions may wish to consider supporting lecturers through collaborative lesson planning, peer observation, pedagogical experimentation and reflective evaluation of students' learning experiences. These initiatives can help lecturers to develop the capacity to integrate technological functions with appropriate teaching strategies and disciplinary content.

3.8. Technology Acceptance and Multimedia Learning Two Complementary Perspectives

In addition to TPACK and SDT, Technology Acceptance Model (TAM) offers a useful perspective in understanding the experience of the lecturers in the implementation of the smart panel. Institutional interview accounts pointed to the ease of use of familiar software applications, easy access to teaching materials, and flexibility in preparing and presenting learning content. These perceived benefits conceptually refer to two main constructs of TAM such as perceived usefulness and perceived ease of use (Davis, 1989).

Previous studies have shown the applicability of technology acceptance constructs to explain educators' adoption of digital technologies (e.g., Scherer et al., 2019). In the present context, improved operational convenience may have lowered technical barriers and facilitated lecturers' use of smart panels in instructional activities.

However, the interpretations are descriptive, as the study did not use a formal technology acceptance questionnaire nor collect objective data on the lecturers' use of technology. Therefore, perceived usefulness and ease of use cannot be considered empirically validated predictors or mediators for changes in students' learning motivation.

Another related perspective on the instructional potential of smart panels is the Cognitive Theory of Multimedia Learning. Effective multimedia instruction involves the coordinated presentation of verbal and visual information, taking into account the limitations of students' cognitive processing capacities (Mayer & Moreno, 2003; Mayer, 2021).

Smart panels can support these principles by allowing lecturers to pinpoint pertinent information, break down intricate explanations into digestible sequences, and integrate visual aids with verbal instruction. These features can help learners comprehend when the learning material is presented in a coherent and distraction-free manner.

Whereas excessive text, irrelevant animations, competing audio sources, and rapidly changing visual displays may contribute to unnecessary cognitive processing demands. Thus, technologically advanced presentations do not necessarily improve understanding unless their design is congruent with established principles of multimedia learning.

Institutional representatives considered smart panels useful for improving visual explanations, but the current study did not measure cognitive load or learning comprehension. Thus, the results do not allow for conclusions about whether instruction supported by smart panels reduced cognitive processing demands or increased students' understanding of course content.

Internet connectivity also provides opportunities for networked learning activities. Connectivist perspectives are concerned with learning through relationships between people and digital information resources, but the theoretical status of connectivism remains a topic of scholarly debate (Kop & Hill, 2008).

3.9. Implications for Teaching Practice and Institutional Development

Findings have some implications to instructional practice and institutional development in Islamic higher education. Although the study does not show a causal effect of smart panel use on students' learning motivation, it points out the necessity to consider how interactive technologies are integrated into educational activities.

First, the pedagogical objectives should guide the lecturers in the selection of smart panel functions and digital applications. The educational value of technology-supported instruction depends on the degree to which technological features support meaningful learning processes. For example, digital annotation can support close reading and conceptual clarification; audiovisual demonstrations can illustrate complex processes; and interactive questions can facilitate formative assessment.

However, such activities are more likely to promote meaningful learning when students are encouraged to interpret information, explain their rationale, compare alternative perspectives, and revise their understanding. Thus, the smart-panel-supported instruction should be based on active cognitive engagement, not passive exposure to digital content.

Second, professional development programs should incorporate technological proficiency with pedagogical and disciplinary skills. Training that emphasises operating devices, accessing documents or connecting to the Internet may increase technical familiarity but may not be enough to foster meaningful instructional improvement.

More comprehensive professional development should focus on the design of interactive learning activities, the delivery of formative feedback, the facilitation of equitable classroom participation, and the evaluation of student learning. Collaborative lesson planning and peer exchange may be especially useful in institutional settings where lecturers exhibit varying levels of technology adoption.

Third, institutional evaluation should be more than just the availability and frequency of smart panel use. Relevant indicators include the congruence of technology-supported activities with course learning outcomes, the quality of students' participation, instructional feedback, and multimedia materials.

Institutional support should also take into consideration technical maintenance, fair access to technological resources and the challenges that lecturers face when implementing. These considerations support the conclusion that the use of the smart panels is only one aspect of an overall instructional context and not a technological innovation for which educational benefits are automatically achieved by the installation of the smart panels.

3.10. Limitations of the Study and Suggestions for Future Research

Several limitations should be taken into account when interpreting the findings of the present study. First, the single-group pretest–posttest design limits causal inference because the observed changes in students’ learning motivation cannot be separated from other possible influences. Differences in pretest and posttest scores may have been confounded by maturation, repeated testing, change in instructional practices, and novelty of technology-supported learning.

Second, the findings have limitations because purposive sampling is used with 33 students from one class. The changes might be due to the students who took the course, the lecturers or the institutional setting itself. The results should therefore not be assumed to reflect students’ experiences in other courses or in other higher education institutions.

Third, the available documentation did not adequately describe the motivation questionnaire and its individual items, scoring procedures, validity evidence, and reliability estimates. Limitations constrain both the understanding of the measured construct and the practical significance of the observed change.

Fourth, the qualitative part was limited to interviews with three representatives of institutions. The lack of student interviews and systematically recorded classroom observations precluded the opportunity to study students’ motivational experiences directly. In addition, the materials available did not contain complete interview transcripts, formal coding procedures, or an independently auditable qualitative analysis process. The qualitative results should thus be seen as a descriptive synthesis of institutional perspectives, and not as a thematic analysis per se.

These limitations also apply to the interpretation of the relationship of the findings, both quantitative and qualitative. Institutional accounts offered contextual information for understanding smart panel implementation but did not independently validate mechanisms that may have contributed to the observed changes in students’ learning motivation.

Future research should employ more rigorous comparative or quasi-experimental designs to investigate whether instruction supported by smart-panel technology causes different improvements in students’ learning motivation than those observed under traditional teaching settings. Longitudinal studies with repeated follow-up measures would be useful to determine whether the improvements in students’ learning motivation will be maintained after initial exposure to the technology. Such investigations may help distinguish sustained motivational development from temporary enthusiasm associated with novelty of technology.

Finally, measures of academic achievement, conceptual understanding, and cognitive load should be incorporated to assess whether changes in students’ reported learning motivation are accompanied by meaningful gains in learning outcomes. This evidence would enhance understanding of the conditions under which smart panels can support students’ learning motivation and effective teaching practices in the Islamic higher education.

4. CONCLUSION

The results of this study indicate that the use of smart panels at STAI Ar-Rosyid Surabaya increased students’ learning motivation. The average motivation score of the 33 students in class PAI-B increased from 11.18 at pretest to 13.27 at

posttest. A paired-samples t-test revealed a statistically significant difference, $t(32) = -12.677$, $p < .001$, and a large standardised within-student change ($|d^z| = 2.207$). Institutional representatives interviewed indicated perceived benefits in lesson preparation, multimedia presentation, visual explanations and students' participation in class. However, different lecturers also had different usage of smart panels. The results show higher learning motivation scores for students in the intervention group, and contextual information on classroom implementation, but do not provide a direct causal link between the use of smart panels and the increase.

This study adds to the understanding of smart panel integration in Islamic higher education by interpreting the observed changes in students' learning motivation through the lens of Technological Pedagogical Content Knowledge (TPACK) framework and Self-Determination Theory (SDT). These perspectives emphasise the necessity of matching technological functions to pedagogical goals, meaningful learning activities, and students' psychological needs. However, the proposed explanatory mechanisms were not directly tested in the present study. The results show that smart panels should be conceptualised in terms of the quality of instructional practices and learning opportunities they provide, rather than their technological features, in terms of their educational value. Further studies are needed to provide stronger evidence of the conditions in which the application of smart panels may contribute to the sustained improvement of students' learning motivation.

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