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The Use of Interactive Smart TV in Elementary IPAS Learning: Effects on Student Creativity and Learning Outcomes

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Abstract

The use of digital technology in primary education is becoming increasingly important to enhance students' academic success and creativity. Although the presence of Smart TVs in educational environments is already common, there is still little research on their effectiveness as interactive learning tools, particularly in enhancing performance and creativity in subjects such as science and social studies for young students. This study aims to explore how interactive Smart TVs affect the academic performance and creativity of fourth-grade elementary school students. A quantitative method with a quasi-experimental design was used, including a control group and pre-test and post-test measurements. A total of 45 fourth-grade students participated in this study, with 23 allocated to the experimental group and 22 to the control group. Data were analyzed using an independent-samples t-test. The results reveal that the experimental group had significantly higher student creativity scores ($M = 62,52$) compared to the control group ($M = 52,36$). Similarly, the experimental group showed a significant improvement in learning outcomes ($M = 81,48$) compared to the control group ($M = 64,09$). These results indicate that interactive Smart TVs can effectively enhance both creativity and academic performance, offering a more engaging, interactive, and student-centered learning environment. This research adds value to the academic field by presenting empirical data on the effectiveness of interactive Smart TVs as teaching tools in science and social studies classes in primary education, thereby supporting their application in technology-based learning methods.

Keywords: Creativity; Elementary School; Learning Outcomes; Science And Social Learning; Smart TV.

1. Introduction

Interactive technology plays a significant role in primary education because it enhances learning quality and equips students with the skills essential for the 21st century [1]. Therefore, teaching Natural and Social Sciences (IPS) not only strengthens the conceptual framework but also develops creativity, critical thinking, problem-solving, and teamwork skills required in the digital age [2]. Therefore, the learning framework should be built to facilitate an interesting and meaningful

student-oriented learning experience. However, there are still various obstacles to the integration of Natural and Social Sciences (IPAS) in the framework of basic education. The educational technique is often based on a traditional teacher-led paradigm, which results in limited student participation, little creativity and poor educational outcomes [3]. This one-way teaching style makes the kids acquire more information instead of interactive learning, which fosters exploration. This example points to the need for new instructional tools that create a more engaging and dynamic learning environment.

Interactive digital learning media represent a strategic approach to addressing contemporary educational needs, particularly the increasing emphasis on active student participation in the learning process [4]. Unlike conventional teaching techniques, interactive audiovisual technologies serve not merely as channels for information delivery but also as pedagogical tools that facilitate conceptual understanding, enhance student engagement, and sustain attention throughout the learning process [5]. Within this context, Smart TV was selected as a learning medium because of its capacity to integrate diverse digital learning materials into a single device that can be accessed and utilized collaboratively within the classroom.

Beyond their conventional function of displaying videos, images, simulations, and interactive quizzes, Smart TVs can facilitate a more integrated, contextualized, and participatory learning environment. Their interactive and multimedia capabilities enable teachers to incorporate diverse instructional resources and learning activities into a coherent pedagogical sequence while fostering more direct interactions among students, teachers, and learning materials [6]. These characteristics position Smart TV as a potentially effective medium for supporting student-centered learning, promoting active participation, and facilitating meaningful inquiry and deeper conceptual understanding. In this respect, the use of Smart TV is consistent with key principles of 21st-century learning, particularly interaction, active participation, technology integration, collaborative engagement, and students' active involvement in knowledge construction.

Several studies published over the past five years have demonstrated the potential of interactive learning media to enhance both the quality of the learning process and educational outcomes at the elementary school level. Interactive digital media have been reported to improve students' learning performance while simultaneously increasing their interest and engagement in learning activities [7]. Similarly, the integration of Smart Apps Creator with Smart TV has been found to facilitate students' understanding of concepts across various subject areas in elementary education [8]. The use of Smart TV has also been associated with increased learning motivation, more active student engagement, and the development of creative thinking skills, particularly through the presentation of interactive and visually enriched learning content [9].

Evidence from specific subject areas further supports the pedagogical potential of Smart TV. In Social Science instruction, for example, the integration of Smart TV has been associated with improvements in students' academic achievement [10]. Likewise, inquiry-based learning supported by Smart TV has been reported to increase students' enthusiasm for learning while contributing to conceptual understanding and the development of scientific literacy [11]. Beyond these cognitive and motivational dimensions, Smart TV-supported learning environments may also facilitate creativity by strengthening students' engagement and concentration and providing opportunities for them to generate and explore new ideas [12].

Despite these promising findings, the existing literature does not yet provide a comprehensive account of the pedagogical contribution of Smart TV in primary school education. A notable limitation concerns the relatively small number of studies that examine creativity and learning outcomes simultaneously. Previous research has predominantly investigated learning outcomes, motivation, engagement, or conceptual understanding as separate dimensions, thereby providing limited evidence

concerning their potential interrelationship within technology-supported learning environments. In the context of 21st-century education, however, learning achievement should not be understood solely in terms of the acquisition of factual or conceptual knowledge. It also encompasses students' capacity to think critically, generate ideas, and construct knowledge creatively. Consequently, the relationship between Smart TV-supported learning, students' creativity, and learning performance remains insufficiently examined through empirical research [13].

In addition to the substantive research gap, the existing literature reveals a methodological gap. A substantial proportion of previous studies have employed Research and Development (R&D) or Classroom Action Research designs, primarily focusing on the development, validation, and instructional application of digital learning media. Although these approaches are valuable for establishing the feasibility, practicality, and potential pedagogical utility of Smart TV-based learning, they provide limited evidence for determining whether its implementation produces measurable differences in learning outcomes relative to a comparison group. Accordingly, further empirical investigation employing a quasi-experimental design with experimental and control groups is warranted to generate more rigorous evidence concerning changes in students' learning outcomes following the implementation of Smart TV as an instructional medium [14].

A further gap concerns the instructional context and specific learning characteristics examined in previous studies. Much of the existing research has been conducted within individual subject areas or under instructional conditions that preceded the implementation of the Merdeka Curriculum. In contrast, the Merdeka Curriculum emphasizes student-centred learning, conceptual understanding, exploration, discovery, and competency development as integral components of the learning process. Within this curricular context, empirical evidence concerning the pedagogical effectiveness of Smart TV in the teaching of Natural and Social Sciences (*Ilmu Pengetahuan Alam dan Sosial* [IPAS]) at the elementary school level remains relatively limited [15]. This contextual gap is important because the effectiveness of a learning technology may depend not only on its technical features but also on its alignment with curricular objectives, instructional approaches, and the learning characteristics of the subject being taught.

The originality of the present study lies in its empirical evaluation of Smart TV as an instructional medium through the simultaneous examination of two dimensions of student performance: creativity and learning outcomes. The study situates this evaluation within the implementation of the Merdeka Curriculum, specifically in the teaching of IPAS at the elementary school level. Rather than concentrating primarily on media development, validation, or feasibility, the present study evaluates instructional effectiveness by comparing students exposed to Smart TV-supported instruction with those receiving instruction in a control condition through a quasi-experimental design. This approach enables the study to provide empirical evidence concerning differences in students' creativity and learning outcomes associated with the implementation of Smart TV. Accordingly, the study seeks to extend the existing literature by providing more systematic evidence on the pedagogical effectiveness of Smart TV in supporting creativity and learning achievement in elementary IPAS education.

The success of this research stems from three aspects, as indicated by this gap. Initially, this research investigates the impact of interactive smart TVs on the learning outcomes and creativity of elementary school students, as well as in the field of science. Second, this study uses a quasi-experimental design that includes a control group for pre-test and post-test. As a result, the empirical evidence regarding the effectiveness of Smart TV is stronger compared to studies that only use media development approaches or classroom action research. Third, this research was conducted in the context of the implementation of the Merdeka Curriculum in science and study teaching in elementary schools, thus providing empirical evidence on the use of educational technology that is relevant to current educational policies.

This situation was also observed at Sadah 2 Elementary School. The interactive potential of Smart TVs in schools has not yet been fully utilized, as they are usually still used as video players or presentation tools, as observed in the initial observations. The hypotheses of this investigation are as follows:

1. Is there an influence of Smart TV media on the creativity of learning of the 4th grade learners of IPAS at Sadah 2 Elementary School?
2. Is there an influence of using Smart TV media on the learning outcome of IPAS students in the 4th grade at Sadah 2 Elementary School?

2. Methods

2.1 Research Methodology

This study was conducted quantitatively with a quasi-experimental design with a pretest-posttest control group. This design was used to examine changes in students' creativity and learning outcomes before and after the learning process in the experimental and control groups. The quasi-experimental method was used because the entire course was utilized; therefore, students were not individually randomized.

This research was conducted at the end of the 2025/2026 academic year at SDN Sadah 2. The population of this study consists of 45 fourth-grade children, namely 23 students in class IV-A as the experimental group and 22 students in class IV-B as the control group. The total sampling approach was used because all individuals in the population were involved as the sample. Both classes follow the Merdeka Curriculum and have the same learning materials and objectives, as well as identical study time allocations. All groups were taught by the same instructor, minimizing the impact of teacher differences on the research results.

2.2 Design and Implementation of Interventions

The learning intervention was implemented over two instructional sessions, with each session lasting 3×45 minutes. The instructional content covered fourth-grade Natural and Social Sciences (Ilmu Pengetahuan Alam dan Sosial [IPAS]), focusing on the parts of plants and their respective functions. The learning materials addressed the roots, stems, leaves, flowers, fruits, and seeds, including the structural characteristics and functions of each plant part in supporting plant growth and survival.

In the first session, instruction commenced with an introductory activity involving apperception and stimulus questions designed to activate students' prior knowledge. In the experimental group, an Interactive Smart TV was integrated into the learning process to present contextualized visual materials and videos concerning plant structures and functions. These materials were used to capture students' attention and establish connections between their existing knowledge and the concepts introduced during the lesson. During the main learning activity, students observed the visual materials displayed on the Smart TV, identified different parts of plants, and discussed and presented their observations and interpretations. The teacher subsequently used graphical illustrations, animations, and videos displayed through the Smart TV to explain the structural characteristics and functions of the identified plant parts. This activity was intended to facilitate students' understanding of the relationship between plant structures and their respective functions. The session concluded with reinforcement activities and an initial assessment administered through interactive questions presented on the Smart TV.

The second session focused on strengthening students' understanding of the relationship between the structure and function of plant parts. The teacher utilized the Smart TV to present images, videos, and contextualized problems illustrating how different plant structures perform specific functions.

Students were engaged in both individual and group activities in which they sought relevant information, proposed alternative explanations, formulated possible solutions, and expressed their interpretations of the concepts under investigation. During the assessment stage, interactive questions and quizzes were presented through the Smart TV to evaluate students' understanding of the instructional material. The lesson concluded with a discussion of students' responses and a reflection activity designed to consolidate their understanding and synthesize the concepts addressed across the two sessions.

The control group received the same instructional content, learning objectives, and total instructional time over the two sessions (3×45 minutes per session). However, instruction was delivered using the teacher's conventional instructional approaches and routinely available learning media, without the integration of Interactive Smart TV. Thus, the primary distinction between the experimental and control conditions was the integration of Smart TV as a multimedia and interactive instructional medium throughout the learning stages. To maintain comparability between the two groups, learning activities in both conditions involved observation, conceptual understanding, discussion, task completion, assessment, and reflection. The intervention therefore differed primarily in the instructional medium and its associated interactive features rather than in the learning objectives, content, or allocated instructional time.

2.3 Population and Sample of the Study

The study population comprised 45 fourth-grade students enrolled at Sadah 2 Elementary School. Because the population was relatively small and all eligible students were included in the study, total population sampling was employed. The sample consisted of 45 students distributed across two existing classes: 23 students from Class IV-A, which served as the experimental group, and 22 students from Class IV-B, which served as the control group.

The study employed a quasi-experimental design because participants were assigned to the experimental and control conditions according to their existing class membership rather than through individual-level randomization. The two classes were considered relatively comparable in terms of educational level, curriculum, instructional content, and general academic characteristics. This use of intact classes was intended to preserve the existing classroom structure while allowing a comparative examination of the effects associated with the integration of Interactive Smart TV into the learning process. Consequently, the experimental and control groups were differentiated primarily by the instructional treatment, while the core learning objectives, subject matter, and instructional time were maintained consistently across both groups.

2.4 Research Instruments and Variables

This research uses one independent variable, namely the use of Interactive Smart TV, and two dependent variables, namely IPAS learning outcomes and student creativity. Research data were obtained through learning outcome tests and creativity observation sheets.

The learning outcome test in the form of multiple-choice questions was prepared based on the IPAS learning objectives in the 4th grade of the Merdeka Curriculum and the information conveyed during the intervention. The test was administered to both groups as a pre-test before therapy and a post-test after treatment.

Student creativity is assessed using an observation sheet based on four characteristics of Torrance's creative thinking: fluency, adaptability, originality, and elaboration. These four indicators are adjusted to the IPAS learning setting. Fluency is the ability of students to provide several ideas or responses. Flexibility is the ability to use more than one method or perspective. Originality is the ability to generate different ideas. Elaboration is the ability to develop or detail ideas. Using four

main indicators, the assessment of creativity is conducted through observation during the learning process as follows:

Table 1. Indicators of Learning Creativity

Indicator	Score 1	Score 2	Score 3	Score 4
Fluency	One concept was produced, but its relevance is limited.	Two quite relevant concepts have been produced.	Generating many relevant concepts.	Having various relevant and diverse concepts.
Flexibility	Only able to have one solution.	Only able to have simple choices.	Able to have various alternatives.	Capable of having many alternatives with different perspectives.
Originality	The concept used comes from a friend.	Can create a slightly different concept.	Able to create a concept that is quite innovative.	Able to create a very innovative and inventive concept.
Elaboration	The idea that is held has not been developed yet.	The idea that has been developed partially.	Able to provide a detailed explanation of the concept.	Able to create concepts developed meticulously and methodically.

Each signal is described in a rubric with a rating scale of 1–4, from a skill that cannot yet be observed to a very good skill. Observations were conducted during the learning activities with predetermined behavioral criteria so that the assessment did not solely rely on the overall perception of the observer. The instructor and the researcher are the two observers who conduct the assessment. Before observing, they both agreed on what the indicators were and what the rubric requirements were. The originality scores of the children are based on the observations of both observers and averaged to eliminate subjectivity and potential observer bias.

2.5 Validity and Reliability of Measurement Instruments

The validity of the research instrument was established through both content validity and empirical validity. Content validity was examined by evaluating the extent to which each instrument item corresponded to the stated learning objectives, competency indicators, IPAS instructional content, and constructs intended to be measured. The instrument was subsequently pilot-tested with students who had characteristics comparable to those of the research participants. Empirical validity was assessed using Pearson's product-moment correlation coefficient with IBM SPSS Statistics version 27. An item was considered empirically valid when the calculated correlation coefficient (r -value) exceeded the critical r -value at the 5% significance level ($\alpha = 0.05$), or when the two-tailed significance value was below 0.05. Based on the pilot-test results, the calculated r -values for all items retained in the study exceeded the critical r -value of 0.294. Accordingly, all items included in the final instrument met the specified empirical validity criterion.

The reliability of the test instrument was evaluated using Cronbach's alpha coefficient. An alpha coefficient greater than 0.70 was considered indicative of acceptable internal consistency. The reliability analysis demonstrated that the instrument achieved the specified threshold, indicating that the items exhibited satisfactory internal consistency and were sufficiently reliable for assessing students' learning outcomes. For the assessment of students' creativity, consistency was further supported through the use of structured scoring rubrics and standardized assessment criteria. In addition, two

observers were involved in the assessment process to strengthen the consistency of scoring and reduce the potential influence of individual evaluator judgment.

2.6 Research Design

The research was conducted in four phases. The first step was the development of learning devices, the creation of instruments, validation and testing of the instruments, as well as collaboration with schools. The second phase was administering a pre-test to both groups to estimate their skills at the beginning.

The findings from the pre-test are used to ensure the equivalence of initial skills between the two groups. This comparison is not only stated based on class features but also validated by comparing initial scores. If the test results do not show a significant difference at the 0.05 level, both groups are considered to have substantially similar initial skills before the intervention.

The third level is the application of learning. In the stimulation stage, idea presentation, exploration, discussion, practice, evaluation, and reflection, the experimental group was given IPAS learning with Smart TV integration. The control group studied the same content in a traditional way. The fourth step was carried out by administering a post-test and observing creativity to obtain data after the intervention

2.7 Data analysis methods

Data were analyzed using IBM SPSS Statistics 27. Descriptive analysis was used to obtain an overview of changes in student achievement in the form of mean, standard deviation, minimum, maximum, and N-Gain. The normality test was conducted using Shapiro-Wilk when the number of participants in each group was less than 50. Levene's test is used to check the homogeneity of variances.

The research strategy is a pre-test–post-test; therefore, the comparison does not solely depend on the post-test results. The main analysis conducted was the Independent Samples t-test and ANCOVA, with post-test scores used as the dependent variable and pre-test scores as the covariate. We chose this strategy because it has the potential to statistically account for differences in initial abilities between groups and thus analyze the final results more accurately. A significance threshold of 0.05 is applied to the trial. H 0: There is no difference in achievement between the experimental group and the control group after adjusting for initial ability. H 1: There is a difference in achievement between the experimental group and the control group.

3. Results and Discussion

3.1 Results

3.1.1 Descriptive Statistics

Data from the descriptive research on the use of smart TV media in enhancing students' creativity and learning outcomes are as follows:

Table 2. Descriptive Research Data

Variable	Groups	N	Mean	SD
Student Creativity	Experiment	23	62.52	5.550
	Control	22	52.36	6.884
Learning Outcomes	Experiment	23	81.48	25.087

Table 2 – Continued from previous page

Variable	Groups	N	Mean	SD
	Control	22	64.09	30.120

The experimental group scored higher than the control group on both study measures, as shown in Table 2. On the student creativity variable, the experimental group scored an average of 62,52 (SD = 5.550) while the control group scored an average of 52,36 (SD = 6.884). Additionally, on the learning outcomes variable, the average of the experimental group was 81,48 (SD = 25.087), higher than the average of the control group, which was 64,09 (SD = 30.120). The findings show that interactive Smart TV usage helps pupils to learn scientific information and fosters creativity, active problem-solving, idea sharing and investigation of themes. Thus, this medium might improve the talents of the 21st century. It highlights the necessity of a balance between cognitive skills and creative abilities. The following is a graph demonstrating the comparison of the differences between creative and learning outcomes between the experimental and control classes:

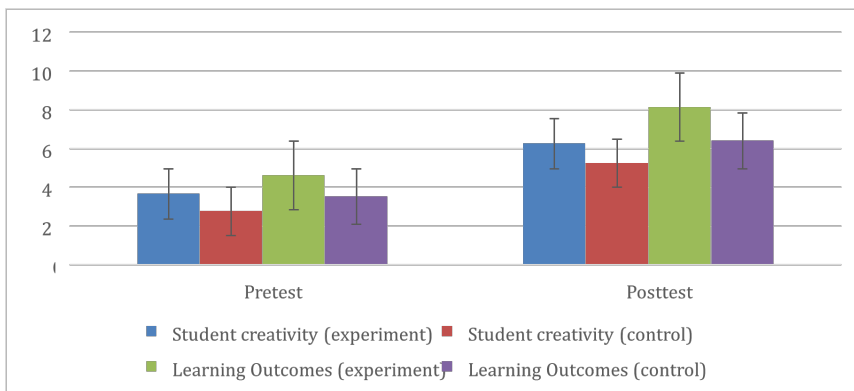


Figure 1. Comparison graph of the differences between the experimental class and the control class on the variables of creativity and student learning outcomes

Normality test prerequisites for the variables of creativity and student learning outcomes are as follows:

Table 3. Shapiro-Wilk Normality Test Results

Variable	Treatment	Groups	Statistic	df	Sig.
Student Creativity	Pretest	Experiment	.966	23	.601
		Control	.832	22	.102
	Post-test	Experiment	.845	23	.212
		Control	.967	22	.641
Learning Outcomes	Pretest	Experiment	.939	23	.175
		Control	.860	22	.305
	Post-test	Experiment	.767	23	.300
		Control	.832	22	.102

The p-value related to the pre-test and post-test data for learning outcomes and creativity presented in Table 3 is greater than 0.05. The learning outcomes have a range from 0.102 to 0.305, while the

significant values for creativity span from 0.102 to 0.641. The findings show that the data are regularly distributed, which meets a crucial assumption required for parametric testing. If this criterion is satisfied, the research hypothesis may be analysed using independent sample t-test. Homogeneity test scores necessary for creativity and student learning outcomes are:

Table 4. Results of the Homogeneity Test for the Variables of Creativity and Student Learning Outcomes

Variable	Levene Statistic	df1	df2	Sig.
Student Creativity	2.508	1	43	.121
Learning Outcomes	6.518	1	43	.214

Table 4 shows that the homogeneity test for creativity is 0.121 and for learning outcomes is 0.214. In summary, the difference between the experimental and control groups is homogeneous, since both values are higher than 0.05. These data show that the two groups are similar in a significant sense. Therefore, the differences in post-treatment results are likely to be related to the usage of the Interactive Smart TV rather than the fundamental attributes of the group. The homogeneity assumption is satisfied by the following test findings; thus, the study may be continued using the Independent Samples t-Test to examine the level of creativity and learning outcomes of the two groups:

Table 5. Results of the Independent Samples t-Test for the Variables of Creativity and Student Learning Outcomes

Variables	t	df	Sig. (2-tailed)
Student Creativity	5.461	43	$p < 0.001$
Learning Outcomes	2.108	43	0.041

The experimental and control groups showed significant differences in student creativity ($t = 5.461$; $p < 0.001$) and learning outcomes ($t = 2.108$; $p = 0.041$), as indicated by the results of the independent-samples t-test. Higher scores were obtained by the experimental group compared to the control group. These findings indicate that Interactive Smart TV significantly affects students' learning outcomes and creativity in the field of science. ANCOVA test for the variables of creativity and student learning outcomes is shown in Table 6.

Table 6. ANCOVA Test for the Variables of Creativity and Student Learning Outcomes

Variable	Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Student Creativity	Intercept	9578.319	1	9578.319	242.423	0.000
	Class	789.929	1	789.929	19.993	0.000
Learning Outcomes	Intercept	6435.966	1	6435.966	184.726	0.000
	Class	2282.422	1	2282.422	13.005	0.010

The ANCOVA results show that there is a substantial influence of Smart TV usage on students' creativity and learning outcomes. The class factor has an F value of 19.993 and a significance value of $p < 0.001$ in students' creativity. This means that there is a difference in creativity between the class using Smart TV and the control class after adjusting for covariates. Meanwhile, for student learning outcomes, the obtained F value is 13.005 with a significance value of $p = 0.010$, which also

indicates a significant difference in learning outcomes between the two groups after correcting for variables. Therefore, statistically, the use of Smart TV has a substantial impact on students' creativity and learning achievement.

The overall ANCOVA results indicate that the therapy significantly affects students' creativity and learning outcomes. The effect on creativity appears statistically greater, as evidenced by the higher F value and lower significance threshold. But statistical significance does not always mean a practical effect size. Therefore, to support the interpretation, these results should be complemented with effect sizes. This allows us to know how significant the difference is when using an interactive Smart TV, and not just whether the difference is statistically significant. The effect size results for the variables of student creativity and learning outcomes are as follows:

Table 7. Effect Size of the Creativity Variable and Student Learning Outcomes

Variables	Cohen's d	Category
Student Creativity	1.629	Very High
Learning Outcomes	0.629	Medium

An effect size analysis was conducted using Cohen's d to determine the magnitude of the treatment effect. The creativity factor showed a Cohen's d value of 1.629, which is recognized as a very large effect as per Cohen's criteria established in 1988. This was determined via analysis. The Interactive Smart TV has a significant effect on the improvement of students' inventiveness. The results indicate that the students involved in learning activities with the use of Smart TVs might be motivated to develop new ideas, try alternative ways of solving problems, and enhance their creative thinking skills.

3.2 Discussion

The findings indicate that the use of Interactive Smart TV was associated with higher levels of student creativity and learning outcomes in the experimental group than in the control group. The independent-samples t -test revealed statistically significant differences between the two groups in both student creativity ($t = 5.461$, $p < 0.001$) and learning outcomes ($t = 2.108$, $p = 0.041$). These findings indicate that the observed differences between the experimental and control groups were statistically significant. Furthermore, the ANCOVA results demonstrated statistically significant differences in student creativity ($F = 19.993$, $p < 0.001$) and learning outcomes ($F = 13.005$, $p = 0.010$) after adjusting for students' initial abilities. Taken together, these findings suggest that the integration of Interactive Smart TV into IPAS instruction was associated with improved creativity and learning outcomes compared with instruction without Smart TV integration.

The observed improvement in creativity can be understood in relation to the nature of the learning activities facilitated by the intervention. In the experimental group, Interactive Smart TV was used to present photographs, videos, animations, and contextualized challenges concerning plant structures and their functions. Students were therefore engaged not merely in receiving information but also in observing learning materials, responding to questions, discussing alternative interpretations, expressing their ideas, comparing responses, and formulating solutions to contextualized problems. Such activities provided opportunities for students to elaborate on their initial ideas, consider multiple perspectives, articulate diverse viewpoints, and generate alternative responses. Accordingly, the relationship between Smart TV use and students' creativity may be better explained by the learning activities facilitated through the medium than by the technological characteristics of Smart TV alone. The technology functioned as an instructional facilitator through which students could engage more actively in cognitively and creatively demanding learning processes. Interactive

Smart TV can support the presentation of learning content through multiple forms of representation by integrating videos, graphics, animations, simulations, and interactive activities [16]. These multimodal representations may help students establish connections between abstract concepts and objects, phenomena, or events that are familiar from their everyday experiences [17], [18]. In addition, students' interaction with information presented through digital media can provide more active learning experiences and facilitate the comprehension and mastery of instructional content [19]. The combination of visual and interactive representations is therefore potentially relevant to both conceptual learning and students' active engagement with the subject matter.

The findings can further be interpreted through the Cognitive Theory of Multimedia Learning, which proposes that learning can be facilitated when instructional information is presented through appropriately integrated visual and auditory channels [20]. In this context, Smart TV enables teachers to combine textual information, images, audio, videos, animations, and interactive activities within an integrated instructional environment [21], [12]. Nevertheless, the observed learning benefits should not be attributed solely to the presence of multimedia technology. Their pedagogical value depends substantially on how students interact with and process the information presented. When students use multimedia materials to observe, discuss, analyze, compare, and construct meaning, the technology can facilitate deeper cognitive engagement and conceptual development [22], [23]. Thus, Smart TV should be understood primarily as a technological facilitator of cognitive and interactive learning activities, while the effectiveness of the learning process depends on students' active participation in constructing and applying knowledge.

The findings of this study are consistent with previous studies that show that interactive learning environments can enhance student engagement and academic achievement. Technology-based learning has also been proven to yield higher learning outcomes compared to conventional learning, while the use of interactive digital media can improve conceptual understanding and academic performance of elementary school students [24]. These related findings support the concept that the use of interactive media can facilitate the learning process, but its efficiency depends on how the media is integrated into learning activities.

In terms of creativity, the results have a higher statistical significance compared to learning outcomes, as indicated by the *F* and *p* values from the ANCOVA analysis. This conclusion can be explained by the type of learning activities provided to the experimental group. The use of smart TVs is not limited to content delivery, but also involves observation, conversation, open-ended questions, problem-solving, and presenting alternative perspectives. These activities immediately offer space for the creation of signs of creativity, namely fluency, flexibility, originality, and elaboration. Previous research also shows that interactive and engaging learning environments can enhance cognitive flexibility, creativity, and the ability to find alternative solutions [25], [26], [27].

Compared to learning that only relies on content transmission [28], [29], [30], the inclusion of films, simulations, visualizations, and group activities can further expand students' learning experiences by offering additional opportunities to explore knowledge and deepen understanding. Therefore, the increase in creativity from this research should be seen as a result of the integration of Smart TV with learning activities that encourage investigation and expression of ideas, rather than as an inevitable consequence of using the technology.

These findings are also consistent with the constructivist view, where children acquire knowledge through experience, a safe environment, and active engagement in learning [31], [32]. In this study, students observe events, ask questions, engage in conversations, and evaluate various potential answers using visual stimuli and information provided by a smart TV [33]. This approach allows for the development of fluency, flexibility, creativity, and elaboration [34]. Thus, technology has become a method to expand the sources and types of learning experiences, and the development of creativity

continues to depend on the quality of interactions and activities planned by the instructor [35].

The results of this study theoretically support the use of Multimedia Learning Cognitive Theory and constructivist views in technology-based learning [36]. Empirically, this study provides evidence that creativity and learning outcomes can be researched simultaneously within the framework of an interactive learning environment [37]. The value of this contribution is that successful learning not only requires mastery of the subject matter but also provides students with the opportunity to develop ideas and creative thinking skills.

One of the practical implications of this study is that smart TVs should not be viewed merely as presentation devices. They are more useful when combined with question-based investigations, visual observations, conversations, problem-solving exercises, tests, and reflections [38]. This method encourages students to engage more actively with the content and allows teachers to create classes that emphasize creativity and academic achievement. However, the findings are not sufficient to support the general statement that smart TVs improve the overall quality of education; the data only confirm their effectiveness in the specific context of the Natural and Social Sciences (IPAS) subjects taught.

Several limitations should be considered when interpreting the findings of this study. First, the sample comprised only 45 students from a single elementary school, which limits the generalizability of the findings to other schools, educational contexts, and student populations. Accordingly, the results should be interpreted within the specific institutional and demographic context in which the study was conducted. Second, participants were assigned to the experimental and control groups according to their existing class membership rather than through individual randomization. Although the equivalence of students' initial ability levels was assessed through a pre-assessment and statistically controlled using ANCOVA, the use of intact classes means that unobserved differences in classroom characteristics and group composition cannot be completely excluded.

Third, the intervention was implemented over only two instructional sessions, with each session lasting 3×45 minutes. Consequently, the findings primarily reflect students' short-term responses to the intervention and do not establish whether the observed differences in creativity and learning outcomes would be maintained over an extended period. Fourth, although the instructional content, learning objectives, and time allocation were standardized across the experimental and control groups, other contextual factors may have influenced the observed outcomes. These factors may include differences in teacher-student interaction, teacher involvement in classroom management, the intensity of instructional interaction, individual student characteristics, peer dynamics, and other classroom-level conditions that are difficult to control completely in a quasi-experimental setting.

Given these limitations, the findings should be interpreted as preliminary empirical evidence concerning the use of Interactive Smart TV within the specific context of elementary IPAS instruction rather than as definitive evidence of its effectiveness across educational settings. Future research should consider larger and more diverse samples drawn from multiple schools and student populations, together with longer intervention periods, to examine whether the observed effects are replicable and sustained over time. Studies employing stronger experimental or quasi-experimental designs may also help address potential confounding factors and strengthen causal inference. In addition, future research should report effect-size estimates and confidence intervals alongside statistical significance tests. Such reporting would provide a more comprehensive assessment of the magnitude and practical significance of differences in creativity and learning outcomes associated with Smart TV-supported instruction.

This study shows that the use of interactive smart TVs along with activities such as observation, discussion, exploration, problem-solving, and assessment results in higher creativity and better student learning outcomes compared to teaching without the use of smart TVs in this study context. These findings indicate that the pedagogical benefits of interactive smart TVs lie not only in their technol-

ogy but more in their usage to create active and contextual learning experiences where students can discover and build their own ideas [39].

4. Conclusion

The findings of this study indicate statistically significant differences in both student creativity and learning outcomes between the experimental group, which received Interactive Smart TV-supported instruction, and the control group, which received instruction using conventional learning media. The independent-samples t-test revealed a significant difference in creativity ($t = 5.461$, $p < 0.001$), which was further supported by the ANCOVA results ($F = 19.993$, $p < 0.001$). Similarly, a statistically significant difference was observed in learning outcomes based on the independent-samples t-test ($t = 2.108$, $p = 0.041$) and the ANCOVA analysis ($F = 13.005$, $p = 0.010$). Taken together, these findings provide empirical evidence of differences in creativity and learning outcomes between students receiving Smart TV-supported instruction and those receiving conventional instruction.

However, the findings should be interpreted in light of several methodological limitations. The study was conducted in a single school with a relatively small sample, employed intact classes rather than individual randomization, and implemented the intervention over a relatively short period. In addition, the use of standardized instructional materials and the specific classroom context may limit the transferability of the findings to other educational settings. Differences in teacher implementation, classroom dynamics, and students' baseline characteristics may also have contributed to the observed outcomes despite efforts to maintain comparable instructional conditions.

Future research should therefore examine the use of Interactive Smart TV with larger and more diverse samples across multiple schools and educational contexts. Longer intervention periods would also be valuable for determining whether changes in creativity and learning outcomes are sustained over time. Furthermore, studies employing more rigorous experimental or quasi-experimental designs, together with appropriate effect-size estimates and confidence intervals, could provide stronger evidence regarding the magnitude and educational significance of the observed differences. Such research would contribute to a more comprehensive understanding of the conditions under which Interactive Smart TV can support creativity and learning outcomes in elementary education.

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