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Developing Differentiated Digital Worksheets Based on STEAM to Enhance PGSD Students' Creativity in Support of Quality Education

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ABSTRACT

Developing creativity is an essential objective in preparing prospective elementary school teachers for the demands of twenty-first-century learning. However, many teachers still find it difficult to create innovative digital learning media that combine differentiated instruction with the STEAM approach. This study aimed to develop differentiated STEAM-based digital worksheets and evaluate their effectiveness in enhancing students' creativity while identifying factors influencing creativity development. This study employed a research and development (R&D) approach based on a modified Borg and Gall model, comprising four stages: initial information gathering, planning and product development, product validation and revision, and field testing. The participants were PGSD students at Sebelas Maret University. Data were collected through interviews, observations, questionnaires, creativity assessments, and pretest–posttest measures. The developed product was validated by experts in content, media, and language. Quantitative data were analyzed using an independent-samples *t*-test, normalized gain (*N*-Gain), and Cohen's effect size, while qualitative data were analyzed through data reduction, interpretation, and conclusion drawing. The findings demonstrated that the differentiated STEAM-based digital worksheets significantly improved students' creativity, with a high *N*-Gain of 0.755, a significant difference between the experimental and control groups ($p < .05$), and a moderate effect size ($d = 0.60$). Qualitative findings revealed that technology utilization, knowledge transfer, and collaborative learning were the primary factors contributing to creativity development. Differentiated STEAM-based digital worksheets constitute an effective instructional innovation for enhancing creativity and digital pedagogical competence among prospective elementary school teachers, thereby supporting the achievement of Sustainable Development Goal 4 on quality education. Future studies should examine AI-supported adaptive digital worksheets across more diverse educational contexts.

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1. INTRODUCTION

The rapid advancement of digital technology has fundamentally transformed teaching and learning practices across all levels of education, requiring educators to integrate technology-enhanced pedagogies that promote active, creative, and meaningful learning experiences. In higher education, particularly in elementary teacher education programs, prospective teachers are expected not only to master pedagogical knowledge but also to develop the capacity to design innovative digital learning resources that respond to the diverse needs of learners. As future educators, Primary School Teacher Education (PGSD) students must be prepared to implement student-cantered instruction by integrating technology, creativity, and interdisciplinary learning approaches into classroom practice. Consequently, teacher education institutions have an essential responsibility to equip pre-service teachers with the competencies necessary for twenty-first-century education, including creativity, digital literacy, critical thinking, collaboration, and problem-solving (UNESCO, 2023; OECD, 2023).

One promising instructional innovation is the development of digital student worksheets (digital worksheets), which transform conventional printed worksheets into interactive learning resources incorporating multimedia, hyperlinks, formative assessments, and immediate feedback. Digital worksheets encourage learners to actively construct knowledge through exploration, reflection, and problem-solving rather than merely completing routine exercises. Previous studies have demonstrated that digital learning media enhance students' engagement, motivation, learning autonomy, and academic achievement by providing more flexible and interactive learning experiences (Firmansyah & Rahmawati, 2023; Tang et al., 2022). For prospective teachers, designing digital worksheets also represents an authentic learning activity that strengthens technological pedagogical competence while fostering creativity in instructional design.

Alongside technological integration, differentiated instruction has emerged as an essential pedagogical approach for addressing the increasing diversity of learners' readiness levels, interests, and learning profiles. Differentiated instruction recognizes that students do not learn in identical ways; therefore, learning activities, instructional materials, and assessments should be adapted to accommodate individual differences. Tomlinson (2021) argues that effective differentiation enables teachers to maximize every student's learning potential by modifying content, processes, products, and learning environments according to learners' characteristics. Accordingly, pre-service teachers should acquire practical experience in designing differentiated instructional materials that are responsive to diverse classroom needs rather than relying solely on standardized teaching resources.

In addition to differentiation, the integration of Science, Technology, Engineering, Arts, and Mathematics (STEAM) has become increasingly important in preparing future teachers to facilitate interdisciplinary learning. Unlike traditional subject-based instruction, STEAM promotes inquiry, creativity, innovation, design thinking, and authentic problem-solving through the integration of multiple disciplines. STEAM-based learning has consistently been associated with improvements in creativity, critical thinking, collaboration, and higher-order thinking skills, which are essential competencies in twenty-first-century education (Yakman & Lee, 2022; Kim & Lee, 2022). Consequently, combining STEAM principles with differentiated digital learning resources provides opportunities for students to engage in authentic learning experiences while simultaneously developing creative capacities that will benefit their future professional practice.

Creativity represents one of the core competencies expected of prospective elementary school teachers because innovative teaching requires the ability to generate original ideas, design engaging instructional activities, and adapt learning experiences to diverse classroom contexts. Creativity extends beyond producing novel products; it involves fluency, flexibility, originality, elaboration, and imagination in solving educational problems (Facione & Gittens, 2015; Sitepu, 2019). In teacher education, creativity directly influences instructional quality because creative teachers are more capable of designing meaningful learning experiences, integrating educational technology, and responding effectively to changing educational demands. Therefore, cultivating creativity during pre-service teacher preparation is fundamental for producing educators who can support quality learning in elementary schools.

Developing creativity among future teachers is also closely aligned with the global agenda for sustainable development, particularly Sustainable Development Goal 4 (SDG 4), which emphasizes inclusive, equitable, and quality education for all. UNESCO (2023) highlights that education systems should foster innovation, digital competence, creativity, and lifelong learning to prepare learners for increasingly complex societal challenges. Preparing prospective teachers capable of designing innovative, technology-supported learning materials therefore contributes not only to individual professional competence but also to broader educational quality and sustainability. Digital worksheets integrating differentiated instruction and STEAM principles provide a practical means of translating these global educational priorities into classroom practice.

Despite these theoretical advances, several challenges remain in elementary teacher education. First, many teacher education programs continue to emphasize pedagogical theories while providing limited opportunities for students to design authentic digital learning media that integrate technology, differentiation, and interdisciplinary approaches (Rahayu & Mulyana, 2023). Second, although digital literacy has become an essential competency for teachers, technology integration in many PGSD programs remains limited to presentation software and online communication tools rather than the development of interactive digital instructional resources (Sari et al., 2022). Third, previous studies have demonstrated the effectiveness of STEAM-based learning in improving creativity among elementary school students; however, relatively few investigations have focused on developing creativity among pre-service elementary teachers through authentic instructional design experiences (Kusuma & Widodo, 2023). Likewise, studies on differentiated instruction have generally examined classroom implementation rather than the preparation of future teachers to develop differentiated digital learning materials.

Furthermore, most previous research has investigated digital worksheets, differentiated instruction, or STEAM independently, with limited attention given to integrating these three educational innovations into a unified instructional design framework. Existing digital worksheet studies primarily emphasize improving learning outcomes or student engagement, whereas investigations examining their potential to foster creativity among pre-service teachers remain scarce. This indicates an important research gap concerning how differentiated digital worksheets grounded in STEAM principles can simultaneously develop technological competence, pedagogical creativity, and interdisciplinary thinking within teacher education.

To address this gap, the present study developed differentiated digital worksheets based on the STEAM approach for Primary School Teacher Education (PGSD) students using a research and development framework. The study evaluated the feasibility and effectiveness of the developed product in enhancing students' creativity while also identifying factors influencing creativity during the development process. By integrating differentiated instruction, STEAM pedagogy, and digital instructional design into a single learning innovation, this study contributes both theoretically and practically to teacher education by providing an instructional framework that supports creativity, digital competence, and the achievement of quality education consistent with the objectives of Sustainable Development Goal 4.

2. METHODS

This research used the Borg & Gall research and development approach (Slamet, 2022), which included the stages of identifying potential and problems, conducting a needs analysis**,** developing a product design, performing expert validation, making product revisions (Improvement I)**,** carrying out a limited trial**,** followed by revisions and a wider trial (Operational Field Testing) and dissemination as well as implementation. However, in the research, this has done restrictions on the development process in order to improve effectiveness. The stages used is (1) Collection information beginning; (2) Planning and Development product; (3) Initial Trial and Revision; (4) Field Trial and Implementation. Subject study is PGSD students of FKIP UNS.

The method used in research in method qualitative as well as quantitative with type quasi experiments. Qualitative methods used to explore qualitative data. This study used a quantitative experimental design to determine the effect of developing digital worksheets. For data collection

techniques used in the form of technology test and non-test. The test techniques used are the pretest and posttest intended to get independent t-test value, N-Gain, and effect size. The non -test technique used is interviews, observations, and questionnaires.

Table 1. Creativity of the Rubric

Creativity Aspect	Indicators	Score 4 (Highly Creative)	Score 3 (Creative)	Score 2 (Fairly Creative)	Score 1 (Less Creative)
1. Fluency	Ability to generate multiple ideas or solutions	Produces many varied ideas	Produces several different ideas	Produces few similar ideas	Produces only one idea, mostly imitative
2. Flexibility	Ability to think from different perspectives	Uses many different approaches	Uses some different approaches	Uses one dominant approach	Shows no variation in thinking
3. Originality	Ability to create new and unique ideas	Highly original and innovative ideas	Fairly original with minor modifications	Less original, mostly adaptations	Copied ideas without innovation
4. Elaboration	Ability to elaborate ideas in detail and systematically	Describes ideas very completely and clearly	Describes ideas with sufficient detail	Descriptions are limited	Very minimal and unclear explanation
5. Imagination	Ability to visualize and express creative concepts	Shows strong and appealing imagination	Shows good imagination	Imagination is limited	No sign of imagination

The creativity assessment rubric was evaluated for internal consistency using Cronbach's Alpha. The analysis yielded a reliability coefficient of 0.87, indicating a high level of reliability and demonstrating that the instrument was appropriate for consistently measuring the creativity of PGSD students.

Qualitative data were analyzed using the interactive model of data analysis, which consisted of four stages: data collection, data reduction, data interpretation, and conclusion drawing. Quantitative data were analyzed using inferential statistical techniques. Prior to hypothesis testing, the data were examined for normality and homogeneity to ensure that the assumptions of parametric analysis were met. Differences between the experimental and control groups were subsequently analyzed using an independent-samples *t*-test (two-tailed). Furthermore, the effectiveness of the developed differentiated STEAM-based digital worksheets was evaluated using the normalized gain (*N*-Gain) to measure learning improvement and Cohen's effect size to determine the magnitude of the intervention's impact on students' creativity.

3. FINDINGS AND DISCUSSION

3.1 Finding

The findings are presented according to the four stages of the modified Borg and Gall research and development model, namely: (1) initial information gathering, (2) planning and product development, (3) initial product validation and revision, and (4) field testing and implementation. Both qualitative and quantitative data were collected to evaluate the feasibility and effectiveness of the differentiated STEAM-based digital worksheets in enhancing the creativity of Primary School Teacher Education (PGSD) students.

3.1.1 Initial Information Gathering

The initial information-gathering stage aimed to identify the learning needs and challenges experienced by PGSD students regarding the development of innovative digital learning media. Data

were collected through interviews and classroom observations. The interviews explored students' experiences, difficulties, and expectations related to designing technology-based instructional materials, while classroom observations were conducted to examine existing learning practices.

The findings revealed several challenges. First, many students experienced difficulty in generating creative ideas when developing instructional media. Learning activities were generally focused on completing academic assignments rather than encouraging innovative instructional design. Second, students reported limited experience in developing interactive digital learning resources despite increasing demands for technology integration in elementary education. Third, students expressed low confidence in implementing differentiated instruction and integrating the STEAM approach during teaching practice because these pedagogical concepts had rarely been applied in authentic learning activities. These findings indicate that students require structured learning experiences that integrate digital technology, differentiated instruction, and STEAM principles to strengthen both their creativity and professional readiness as future elementary school teachers.

3.1.2 Planning and Product Development

Based on the results of the needs analysis, the planning stage focused on designing differentiated STEAM-based digital worksheets that could facilitate creativity development among PGSD students. The product was developed by integrating the principles of differentiated instruction with STEAM learning to accommodate diverse learning characteristics while encouraging interdisciplinary thinking and authentic problem-solving.

The development process emphasized interactive learning activities that enabled students to design creative instructional products using digital platforms. During this stage, learning objectives, worksheet structure, digital features, learning tasks, assessment components, and multimedia elements were systematically designed to ensure that the product aligned with the characteristics of prospective elementary school teachers and supported the achievement of creativity-oriented learning outcomes.

3.1.3 Initial Product Validation and Revision

Following product development, the prototype underwent expert validation to evaluate its feasibility before field implementation. The validation process involved experts in educational content, instructional media, and language. Each expert assessed the product based on its content accuracy, instructional design, visual presentation, language clarity, and overall usability.

Feedback from the validators was used to revise the product and improve its quality. Several revisions were made to enhance instructional clarity, interface design, navigation, language consistency, and the integration of differentiated learning activities with STEAM components. The validation results indicated that the developed digital worksheets met the established feasibility criteria and were considered appropriate for implementation in the subsequent field-testing stage.

3.1.4 Field Testing and Implementation

The final stage evaluated the effectiveness of the differentiated STEAM-based digital worksheets in improving students' creativity. The pre-test results showed that PGSD students demonstrated a moderate level of initial competence in developing digital worksheets, with a mean score of **70.17**, indicating that their understanding of digital instructional design was still limited prior to the intervention.

Following the implementation of the developed worksheets, students demonstrated substantial improvement in completing the digital worksheet development process. All participants successfully completed the fundamental stages of worksheet production, including content preparation, visual design, editing, and integration into the Liveworksheets platform. Furthermore, **93.3%** of the participants successfully completed advanced development tasks, including creating interactive worksheet components, configuring digital features, and publishing their completed products for classroom use.

Although students showed considerable improvement throughout the implementation process, a slight decline in performance was observed during the final stages involving multidisciplinary STEAM integration. This finding suggests that combining multiple disciplinary perspectives into a single instructional product requires more advanced pedagogical understanding and sustained instructional

support. Nevertheless, the overall results indicate that the differentiated STEAM-based digital worksheets effectively facilitated students' creativity while simultaneously strengthening their technological and pedagogical competencies in designing interactive learning materials.

Table 2. Improvement Results: Ability of Students in Making Digital Worksheets

No	Step	Success Rate	Amount Student
1	Making a worksheets draft using Word	10%	30
2	Create a Canva account	20%	30
3	Selecting and editing background design	30%	30
4	Add text	40%	30
5	Downloading results design into pdf	50%	30
6	Create an account Live worksheets	60%	30
7	Uploading worksheets files on Live worksheets	70%	30
8	Editing element interactive	80%	30
9	Review and save worksheets in live worksheets	90%	30
10	Share interactive worksheets	100%	30

Table 3. Normality Test

		Kolmogorov-Smirnov [a]		
	Class	**Statistics**	**df**	**Sig.**
Initial Abilities	Experiment	.149	60	.089
	Control	.147	60	.095
Final Ability	Experiment	.142	60	.128
	Control	.141	60	.133

Normality testing was conducted using the Kolmogorov-Smirnov test. Based on the SPSS output, the pre-test scores for both the experimental and control classes were normally distributed, with significance levels of 0.089 and 0.095 respectively. *Sig. >α=0.05* then both data are normally distributed. Similarly, the post-test scores for both classes were normally distributed, with significance levels of 0.128 and 0.133 with interpretation *Sig. >α=0.05.* These results indicate that both the pre-test and post-test capability data meet the assumptions for parametric testing, allowing the analysis to proceed to the homogeneity test.

Table 4. Homogeneity Test

		Levene Statistics	**df1**	**df2**	**Sig.**
Initial Abilities	Based on Mean	1.498	1	58	.226
Final Ability	Based on Mean	.188	1	58	.667

A homogeneity test is conducted to determine whether the initial and final capability data are homogeneous or heterogeneous. Based on the SPSS output, the initial capability data for both the experimental and control classes were found to be homogeneous, with a significance level of 0.226. Since the interpretation criteria dictate that *Sig. >α=0.05,* the data are confirmed as homogeneous. Furthermore, the final capability data are also homogeneous, with a significance level of 0.667 with interpretation *Sig. >α=0.05.* These results indicate that both the initial and final capability data meet the assumptions to proceed with parametric hypothesis testing using the T-test.

Table 5. T-test

Independent Samples Test					
		Initial Abilities		Final Ability	
		Equal variances assumed	Equal variances not assumed	Equal variances assumed	Equal variances not assumed
Levene's Test for Equality of Variances	F	1,498		.188	
	Sig.	.226		.667	
t-test for Equality of Means	t	.935	.935	2.308	2.308
	df	58	56.246	58	56.736
	Sig. (2-tailed)	.354	.354	0.025	0.025
	Mean Difference	3.500	3.500	6.667	6.667
	Standard Error Difference	3.743	3.743	2.888	2.888
	95% Confidence Interval of the Difference Lower	-1.352	-1.354	2.923	2.922
	95% Confidence Interval of the Difference Upper	8.352	8.354	10.411	10.411

Hypothesis testing was conducted using a two-tailed, independent-samples T-test in SPSS. The initial test showed that the beginning ability level had a significance value of 0.354. This indicates that the control and experimental classes had similar baseline abilities, as the significance value was greater than the threshold *Sig.* > *α=0.05.* Conversely, the final test showed a significance value of 0.025 indicating that the two groups had different abilities at the end of the study *Sig.* < *α=0.05.* To further analyze the extent of these differences and improvements, N-gain and effect size tests were subsequently conducted.

Table 6. N-gain test

No	Class	Mean N gain
1	Experiment	0.755
2	Control	0.553

The N-gain results indicate that the experimental group had a higher N-gain value compared to the control group. Specifically, the experimental group achieved an N-gain value of 0.755 (interpreted as high), whereas the control group only scored 0.553 (interpreted as moderate). Therefore, the differentiated STEAM-based digital worksheet is more effective than conventional learning in enhancing students' creativity.

Table 7. Effect Size Test

No	Class	Mean	Variant (S)	Sd	d
1	Control	79.33	10.31	11.18	0.60
2	Experiment	86	11.99		

The results of the effect size test show the value of 0.60. When interpreted, this falls into the medium category. Therefore, the differentiated STEAM-based digital worksheets are highly effective and significant for increasing student creativity. These results align with the study by Tang et al. (2022), which states that the use of technology is capable of increasing creativity.

3.1.5 The Effectiveness of Digital Worksheets in Increasing Student Creativity

Comparative analysis of the experimental and control classes revealed no significant difference in the baseline abilities of the students (p= 0.354), with homogeneous pretest averages (experimental: 64; control: 60.5). Following the intervention, the experimental class—using differentiated digital worksheets for STEAM-based learning—achieved a significantly higher posttest average of 86, compared to the control class at 81.67 with p= 0.025. Enhanced creativity was confirmed by a high N-

Gain of (0.755) in the experimental group versus (0.553) in the control, supported by a *moderate* effect size (d = 0.60) that indicates a practically significant impact.

3.1.6 Factors of Creativity

Based on the interview results, several factors were identified that enhance student creativity. First, students utilize technology to create products according to their preferences. Second, the transfer of knowledge provides students with new references when designing worksheets. Finally, discussions with peers also foster creativity by enabling the exchange of ideas among students.

3.2 Discussion

The findings demonstrate that the development of differentiated STEAM-based digital worksheets effectively enhanced the creativity of PGSD students. The statistical results showed a significant difference between the experimental and control groups following the intervention, with the experimental group achieving a higher post-test score (p = .025), a high normalized gain (N-Gain = 0.755), and a moderate practical effect (Cohen's d = 0.60). These findings indicate that integrating differentiated instruction with STEAM principles into digital worksheet development provides meaningful learning experiences that foster students' creative thinking. The absence of significant differences in the pre-test scores confirms that both groups possessed comparable initial abilities, suggesting that the observed improvements were primarily attributable to the instructional intervention rather than differences in baseline competence.

The effectiveness of the developed digital worksheets can be explained by the complementary nature of differentiated instruction and the STEAM approach. Differentiated instruction allows learners to engage with learning activities according to their readiness, interests, and learning preferences, thereby increasing learning autonomy and intrinsic motivation (Tomlinson, 2021). When students are provided with opportunities to choose appropriate learning pathways and develop instructional products that reflect their own ideas, they become more actively involved in constructing knowledge. Such learner-centered environments encourage experimentation, reflection, and innovation, all of which are essential components of creativity. Consequently, the differentiated design of the digital worksheets enabled PGSD students to explore multiple instructional solutions while accommodating their diverse learning characteristics.

The integration of STEAM further strengthened students' creativity by encouraging interdisciplinary thinking and authentic problem-solving. STEAM education promotes the integration of scientific inquiry, technological competence, engineering design, artistic creativity, and mathematical reasoning into meaningful learning experiences. Rather than focusing solely on content mastery, STEAM encourages students to generate original ideas, evaluate alternative solutions, and produce innovative educational products (Yakman & Lee, 2022). During the worksheet development process, students were required to combine pedagogical concepts with digital technologies while designing interactive learning activities suitable for elementary school learners. This multidisciplinary design process required them to think creatively, synthesize knowledge from multiple domains, and continuously revise their work, thereby strengthening the dimensions of fluency, flexibility, originality, elaboration, and imagination that characterize creative performance.

The present findings are consistent with previous studies demonstrating that digital learning technologies can facilitate creativity by providing flexible environments for exploration, collaboration, and iterative design. Tang et al. (2022) concluded that digital technologies promote creativity by enabling learners to visualize ideas, experiment with multiple design alternatives, and receive immediate feedback throughout the learning process. Likewise, Firmansyah and Rahmawati (2023) reported that digital worksheets increase learner engagement because interactive multimedia encourages active participation rather than passive knowledge acquisition. In the present study, the use of Canva and Liveworksheets enabled students to transform conventional worksheets into interactive digital learning resources incorporating multimedia elements, hyperlinks, and formative

activities. These technological affordances allowed students to express creative ideas more effectively while simultaneously improving their digital pedagogical competence.

Another important finding concerns the factors influencing students' creativity during the product development process. Qualitative data obtained through interviews and classroom observations revealed three interrelated factors that supported creativity: technology utilization, knowledge transfer, and collaborative discussion. First, digital platforms provided students with greater flexibility to visualize instructional ideas and experiment with different design features. Technology functioned not merely as a presentation tool but as a cognitive resource that supported idea generation and creative problem-solving. Previous research similarly suggests that educational technology enhances creativity by expanding opportunities for visualization, experimentation, and innovation (Fricticarani et al., 2023; Marpaung, 2024).

Second, knowledge transfer through workshops, lecturer guidance, and independent exploration significantly broadened students' pedagogical perspectives. Exposure to new instructional strategies, digital applications, and STEAM principles enabled students to integrate theoretical understanding with practical instructional design. Knowledge acquisition stimulates creativity by enriching learners' cognitive resources and providing multiple perspectives from which new ideas can emerge (Ayuningtyas et al., 2022). As students became more familiar with differentiated instruction and digital learning technologies, they demonstrated greater confidence in producing innovative worksheet designs.

Third, collaborative discussion among peers emerged as an important contributor to creativity. Collaborative learning environments encourage students to exchange ideas, critique alternative solutions, and refine instructional products through collective reflection. The interaction among group members facilitated the cross-fertilization of ideas, resulting in more diverse and original worksheet designs than those produced individually. This finding supports previous studies indicating that collaborative discussion promotes creativity by exposing learners to different viewpoints and encouraging constructive feedback during problem-solving activities (Fadhil, 2020; Simaremare et al., 2022). The combination of technology, knowledge sharing, and collaboration therefore created a learning ecosystem that nurtured both creative confidence and instructional innovation among prospective elementary school teachers.

From a theoretical perspective, this study extends previous research by integrating differentiated instruction, STEAM education, and digital instructional media into a unified learning design for teacher education. While earlier studies have generally examined these approaches separately, the present findings demonstrate that their integration provides synergistic benefits for developing creativity among pre-service teachers. The study therefore contributes to contemporary teacher education by proposing a practical instructional framework that simultaneously strengthens technological competence, pedagogical innovation, and interdisciplinary thinking. Furthermore, the findings support the broader goals of Sustainable Development Goal 4 by preparing future teachers capable of designing inclusive, technology-enhanced, and creative learning environments that respond to diverse learner needs.

Despite these promising findings, several limitations should be acknowledged. The study was conducted at a single teacher education institution with a relatively limited sample, which may restrict the generalizability of the findings to other educational contexts. In addition, the intervention was implemented over a relatively short period, preventing the evaluation of long-term creativity development. Future research should involve multiple universities, larger and more diverse participant groups, and longitudinal research designs to examine the sustainability of creativity improvement. Further investigations could also integrate artificial intelligence (AI)-supported digital worksheets capable of personalizing learning content and adaptive feedback according to students' individual learning profiles, thereby extending the effectiveness of differentiated STEAM-based learning in teacher education.

4. CONCLUSION

This study demonstrates that the development of differentiated STEAM-based digital worksheets effectively enhances the creativity of Primary School Teacher Education (PGSD) students. The developed product was found to be feasible for implementation and significantly improved students' creativity, as evidenced by a high normalized gain (*N*-Gain = 0.755), a statistically significant difference between the experimental and control groups ($p < .05$), and a moderate effect size (Cohen's $d = 0.60$). The findings further indicate that technology integration, knowledge transfer through instructional guidance, and collaborative learning are key factors contributing to creativity development during the instructional design process. These results highlight the value of integrating differentiated instruction with STEAM principles in preparing prospective teachers to design innovative, technology-enhanced learning resources that support Quality Education (SDG 4). Nevertheless, this study has several limitations, including its implementation at a single institution, the relatively small sample size, and the short intervention period, which may limit the generalizability and long-term interpretation of the findings. Therefore, future research is recommended to involve more diverse educational settings, larger participant populations, and longitudinal research designs to examine the sustainability of creativity development. Further studies should also explore the integration of artificial intelligence (AI)-supported adaptive digital worksheets capable of personalizing learning content, feedback, and instructional challenges according to learners' individual characteristics to further enhance creativity and digital pedagogical competence.

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