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Fostering creativity in kindergarten: The impact of collaborative project-based learning

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Background: Early childhood education (ECE) is crucial in cultivating creativity, especially in today's tech-savvy world. This study explores the impact of collaborative project-based learning (PjBL) with computer and play motivation on kindergarten children's creativity.

Aim: Our research aimed to determine if collaborative PjBL, combined with computer-based activities, enhances creativity compared to independent PjBL. We also examined the influence of play motivation on computer-based creativity.

Setting: The study was conducted in Makassar Lotus Kindergarten, Indonesia, involving 30 Grade B kindergarten students.

Methods: We employed a post-test control group design and systematically selected two matched classes. The experimental group engaged in collaborative PjBL, focussing on computer activities to foster creativity, while the control group experienced independent PjBL. Creativity assessment encompassed originality, art, fluency, flexibility, self-actualisation, and creative skills.

Results: Collaborative PjBL had a more significant impact on children's computer-based creativity than independent PjBL. Children with high play motivation also exhibited higher creativity levels during computer-based activities.

Conclusion: This study underscores the potential of collaborative PjBL in promoting creativity among kindergarten children in the digital era. It highlights the significance of innovative teaching methods and children's intrinsic motivation in nurturing creativity.

Contribution: These findings contribute to the ongoing discourse on effective ECE strategies that harness technology to foster creativity.

Keywords: collaborative play; project-based learning; creativity; computer media; childhood; kindergarten.

Introduction

In a 21st-century classroom, project-based learning (PjBL) can be a crucial strategy for empowering students to become independent and critical thinkers. Project-based learning offers a pedagogical approach that holds appeal and can be applied in history and across various academic disciplines (Lim et al. 2023). In higher education, PjBL, where students engage in meaningful learning through real-world projects that foster self-directed learning, has gained increasing attention (Peng et al. 2022). However, the fundamental principles of PjBL are also highly relevant and adaptable for early childhood education (ECE), where the focus is on exploration, creativity, and meaningful play-based learning.

Additionally, these technologies can aid in improving learning outcomes for students (Haleem et al. 2022). Nevertheless, completing authentic projects entails a multifaceted process, posing challenges for many students, particularly those with lower academic performance. The study integrated computer-based scaffolding into a project-based programming course to address this challenge, making complex PjBL more accessible to students (Peng et al. 2022).

There is a transition from conventional methods to more comprehensive and practical 21st-century approaches, wherein children actively select themes that pique their interest, enabling them to exercise their problem-solving and critical thinking skills (Woolley 2020). Following constructivist theory, a project-based learning model requires critical strategies to assist children in cultivating creative thinking abilities, ultimately fostering their independence as thinkers and learners through active learning tools and collaboration with peers (Lim et al. 2023). Digital books can stimulate critical thinking skills by utilising electronic media, incorporating information in text, images, audio, video, and graphics, supported by tools that can be applied to interactive, creative, and communicative activities (Matthew et al. 2022). The results indicate that the digital book STEM–PjBL (Science, Technology, Engineering, and Mathematics–Project Based Learning) is valid and significantly effective in enhancing students' critical thinking skills while positively influencing 21st-century learning skills (Susanti, Sari & Fitriani 2022). Moreover, the data suggest that students express satisfaction and enthusiasm for learning through active teaching methods incorporating information and communication technology (ICT) tools and STEM–PjBL elements (Pramasdyahsari et al. 2023).

The findings underscore the positive role of computer-based scaffolding in making complex learning through real-world projects accessible to a diverse range of students, effectively narrowing achievement gaps between high- and low-performing students (Espinosa et al. 2019). In light of the widespread adoption of smartphones and other wireless technology devices among the general population, it becomes increasingly pertinent for educational institutions, including those dedicated to ECE, to integrate technology within the classroom effectively (Haleem et al. 2022). Recent research on PjBL has highlighted its substantial benefits in enhancing the comprehension of abstract concepts and fostering essential soft skills such as problem-solving, communication, decision-making, and self-regulation (Peng et al. 2022).

To explicitly address the application of these principles in ECE, it is crucial to note the adaptability of PjBL and technology use by younger learners (Lestari & Jumiatin 2021). Early childhood education benefits immensely from integrating computer-based activities, providing a foundation for developing critical thinking and problem-solving skills from a young age (Miftah et al. 2020). Technology is tailored to be developmentally appropriate in this context, focussing on interactive and engaging platforms that foster creativity, collaboration, and a positive attitude towards learning (Couchenour & Chrisman 2016).

Effective PjBL immerses students in a profound learning experience, enabling them to discover the nuances of language, content, and various skills within authentic contexts (Li et al. 2022). Utilising the revised Bloom's Taxonomy as its analytical framework, this study assessed how project-based learning enhances specific critical thinking skills among college students studying English as a Foreign Language (EFL). It also explored how students demonstrate these critical thinking skills, including analysis, evaluation, and synthesis, through a book report project in a reading course (Wang 2022). Project-based learning, widely recognised as a leading approach in vocational education (Ahmad et al. 2023), also holds significant potential in higher education, particularly in teaching EFL. This approach not only enriches the learning experience with authentic contexts and facilitates a deep understanding of language and content, but also encourages the development of critical skills essential for success in the contemporary workplace (Samarji 2020). Therefore, the adoption of PjBL as a pedagogical strategy is gaining momentum nationally, not just within vocational education but also in higher education, because of its ability to make learning more engaging for students and to emphasise the acquisition of skills crucial for success in today's workplace (Hidayati et al. 2023).

Through PjBL, even at the early childhood level, the fusion of knowledge, skills, cooperation, and learning capabilities occurs effortlessly (Chen & Yang 2021). Project-based learning's student-centred approach and emphasis on independent learning experiences shift the teacher's role from primarily authoritative to mainly facilitative. This educational method enriches young learners with language skills and offers additional benefits, such as the foundation for acquiring content knowledge and cultivating teamwork and cooperation skills from an early age (Ferrero et al. 2021). In today's diverse and technology-driven classrooms, PjBL has become essential for fostering independent learning and critical thinking among young children. Its appeal is not limited to any single discipline, but extends across a wide range of subjects, making it particularly suitable for the curious and tech-savvy generation of young learners (Soedjono et al. 2022). By integrating technology into ECE, PjBL can significantly increase engagement and participation, leveraging electronic devices to spark interest and encourage active participation (Recalde et al. 2020). This makes PjBL a standout educational model, not just in vocational training≈but starting from the earliest stages of education. It highlights the critical importance of developing these skills in students as early as possible to lay a strong foundation for their future learning and development.

This study aimed to assess the impact of a collaborative PjBL approach, integrated with computer-assisted play, on fostering creativity among children aged 5 years – 6 years. The significance of this research lies in its comprehensive approach to addressing key factors that underscore its importance and potential impact on ECE. The study ventures beyond traditional behaviouristic approaches by integrating constructivist methodologies, such as the computer-based collaborative project learning model, offering insights for educators and parents to enhance learning through computer-mediated play (Zhang & Ma 2023). It delves into how collaborative project-based learning, supported by technology, can foster creativity among young children, thus addressing a critical gap in strategies for nurturing creative thinking and problem-solving skills early (Brown & Jain 2020). Furthermore, the research emphasises the crucial role of thoughtful technology integration in early learning environments, responding to the growing presence of digital devices and the Internet. It aligns with contemporary educational goals, preparing children for academic success and lifelong learning and adaptability in a fast-evolving world (Dedi Kuswandi et al. 2020). In sum, this study aims to make a significant contribution to the field of ECE by advocating for pedagogical strategies that are both innovative and grounded in educational theory, thereby equipping young learners for the challenges and opportunities ahead.

The primary objective of this research was to evaluate whether collaborative PjBL, integrated with computer-based activities, enhances children's creativity in comparison to independent PjBL. Additionally, the study sought to explore the influence of children's play motivation on their computer-based creativity. The following research questions guide the study: What is the impact of collaborative PjBL integrated with computer-based activities on children's creativity compared to independent PjBL? How does children's play motivation influence their computer-based creativity?

Research methods and design

Study design

The study design employed in this research is a post-test control group design. This design is chosen to evaluate the impact of collaborative PjBL and play motivation on the creativity of kindergarten children during computer-based activities (SongwutEgwutvongsa 2021). This design divided the sample into two groups, one group receiving collaborative PjBL treatment and the other receiving independent PjBL treatment. The study design aims to compare the effectiveness of these two learning methods in fostering creativity in children when engaged in computer-based play activities (Denervaud et al. 2021). Data were collected through observations of the children's performance, focussing on various aspects of creativity such as originality, art, fluency, flexibility, self-actualisation, and creative skills during computer play (Wulandari, Pujiati & Subakti 2021). The post-test control group design allows for a systematic examination of the impact of these teaching strategies on creativity, enabling a thorough evaluation of the research questions.

Setting

The research was conducted in the context of Makassar Lotus Kindergarten, Makassar, Indonesia. This educational setting serves as the primary environment for the study, where the participants, a group of 30 Grade B kindergarten children, were recruited. The kindergarten is situated within a vibrant community in Makassar, providing a diverse and dynamic backdrop for the research. The school is known for its commitment to innovative and interactive educational approaches, making it an ideal setting for exploring the impact of collaborative PjBL and play motivation on young children's creativity during computer-based activities (Anwar et al. 2019). The school's emphasis on fostering creativity and digital literacy within the context of ECE aligns with the research objectives, allowing for a comprehensive exploration of the research questions within this educational community (Paixão & Borges 2018).

Study population and sampling strategy

The study focussed on a specific population of Grade B kindergarten children from Makassar Lotus Kindergarten, Indonesia. The inclusion criteria for this population were children in Grade B actively engaged in computer-based activities within the school setting. There were no specific exclusion criteria, as the aim was to capture a representative sample of children within this age group with access to computer-based learning. A systematic sampling strategy was employed to select the participants, aiming for a sample size of 30 children. Practical implementation involved accessing school records and working closely with the school administration and teachers to identify eligible participants and obtain relevant information about their computer play skills. The systematic sampling method (Kim, Bang & Choi 2017) ensured that the selected sample was representative of the broader population of Grade B kindergarten children in the school, allowing for meaningful insights into the research questions.

Intervention

In this research, intervention and comparison groups were established to evaluate the impact of different teaching methods on children's computer-based creativity. The intervention group participated in collaborative PjBL activities, including painting, pattern making, image modification, and constructing shapes on the computer. These activities were designed to foster creativity through active participation and problem-solving and intentionally incorporated play motivation elements. Play motivation was integrated by selecting engaging and enjoyable activities that matched children's interests and encouraged them to explore and experiment creatively within a collaborative setting.

In contrast, the comparison group engaged in independent PjBL activities, focussing on individual tasks that similarly aimed to promote creativity without the collaborative element. The distinction allowed for a nuanced examination of how collaborative versus independent approaches influenced creativity, with a specific emphasis on how the motivational aspects of play – such as enjoyment, engagement, and the intrinsic motivation to explore – contributed to the creativity observed in the intervention group.

By delineating how play motivation was weaved into the fabric of the intervention group's activities and observing its effects on creativity, this research aims to illuminate the role of motivational play in enhancing computer-based creativity among children. This detailed account of how play motivation was incorporated and observed aims to provide deeper insights into the effectiveness of teaching strategies that leverage both collaboration and play to stimulate creative outcomes.

Data collection

Data collection for this study primarily involved using observational tools to assess the creativity of kindergarten children during computer-based play activities. The tools evaluated various aspects of creativity, including originality, art, fluency, flexibility, self-actualisation, and creative skills. These tools were developed to ensure their validity in capturing the creative expressions and skills exhibited by the children. Data collection occurred within the school setting, and researchers actively engaged with the children to observe their computer-based play (Chandio et al. 2022). To establish a rapport with the participants, the researchers spent time with the children in their formal classes three days a week, creating a comfortable environment for data collection. The school administration and responsible teachers closely guided the data collection process to ensure the children's well-being and compliance with ethical standards (Singh & Sagar 2022). Practical challenges, such as language barriers, were addressed using non-verbal and universally understood communication methods to interact with the children. This approach allowed for the comprehensive assessment of the children's creativity in a meaningful and sensitive manner.

Data analysis

The data analysis process in this study was conducted meticulously to ensure the reliability and validity of the findings. Data capturing involved systematic observation of the children's computer-based play activities, where their creative expressions were noted across various aspects such as originality, art, fluency, flexibility, self-actualisation, and creative skills. Once the data were captured, it was checked and cleaned to eliminate errors or inconsistencies. The analysis primarily involved statistical tests to evaluate the impact of collaborative PjBL and play motivation on children's creativity. Descriptive analysis was initially employed to provide an overview of the data, followed by parametric difference tests after fulfilling the assumption tests (Oe & Yamaoka 2022). For hypothesis testing, the analysis of variance (ANOVA) test was used to assess the interaction between learning methods and computer play motivation on children's computer-based creativity (Marga Putri 2018). This comprehensive data analysis approach allowed for a robust evaluation of the research questions and ensured the statistical soundness of the results.

Results

Measurement results

The following section presents an overview of the measurement results per cell, as detailed in Table 1, and provides a comprehensive breakdown of children's computer creativity data based on various groups and criteria. The data have been organised to illustrate the impact of different learning methods and motivation levels on children's computer creativity. Specifically, it explores the learning methods employed (A1: collaborative methods, A2: independent methods) and the participants' motivation levels (B1: high motivation, B2: low motivation). Each cell within the table highlights key statistical information, including the number of samples (*n*), the average learning outcome score (M), and the standard deviation (s). This detailed examination of the data will enable a more profound understanding of the interplay between learning approaches and motivation in shaping children's computer creativity, providing valuable insights for further analysis and discussion.

Normality test

Table 2 summarises the results of the normality tests conducted on computer-playing creativity data across various data groups. Each group has a distinct sample size (*n*) and has been subjected to the Lilliefors test (Lt) to assess its adherence to a normal distribution. The Lilliefors statistic (Lh) is compared against the critical value (Lt) at the 0.05 significance level (α = 0.05), with the 'Conclusion' column providing insight into whether the data in each group can be considered normally distributed. Table 2 plays a fundamental role in establishing the robustness and validity of the statistical analyses conducted in the research.

Table 2 demonstrates that each Group's calculated Lilliefors prices (Lh) are consistently lower than the corresponding table Lilliefors prices (Lt). As a result, it is reasonable to infer that the study's sample is drawn from a normally distributed population. This crucial finding supports parametric statistical analyses for this study's data, reinforcing the validity of such methods in our analytical approach.

TABLE 2: Result of normality test on computer-playing creativity data.

Data group	*n*	Lh	Lt (α = 0.05)	Conclusion
Group A1	32	0.074	0.157	Normal
Group A2	32	0.073	0.157	Normal
Group B1	32	0.094	0.157	Normal
Group B2	32	0.095	0.157	Normal
Group A1B1	16	0.121	0.213	Normal
Group A2B1	16	0.098	0.213	Normal
Group A1B2	16	0.098	0.213	Normal
Group A2B2	16	0.117	0.213	Normal

Note: A1, Group of children who follow learning with collaborative methods; A2, Group of children who follow learning with independent methods; B1, Group of children who have high motivation to play computer; B2, Group of children who have low motivation to play computer.

n, number of samples; Lt, Lilliefors test; Lh, Lilliefors statistic.

TABLE 1: Description of children's computer creativity data.

Group of children	A1			A2			A1&A2		
	n	M	SD	*n*	M	SD	*n*	M	SD
B1	16	65.88	6.39	16	61.25	6.30	32	61.44	7.85
B2	16	59.75	6.36	16	57	6.52	32	60.50	6.58
B1 & B2	32	62.81	7.00	32	59.13	7.01	64	60.69	7.29

Note: A1, Group of children who follow learning with collaborative methods; A2, Group of children who follow learning with independent methods; B1, Group of children who have high motivation to play computer; B2, Group of children who have low motivation to play computer.

n, Number of samples; M, Average learning outcome score; SD, Standard deviation.

Homogeneity test

We conducted tests to evaluate the homogeneity of variances for children's creativity scores across the four experimental groups: A1B1 (Collaborative PjBL with high play motivation), A2B1 (Independent PjBL with high play motivation), A1B2 (Collaborative PjBL with low play motivation), and A2B2 (Independent PjBL with low play motivation). Table 3 displays the variance for each group, combined variance, calculated chi-squared value, and critical chi-squared value. The 'Conclusion' column summarises whether each group's variance homogeneity assumption is met.

The results of the variance homogeneity test, as detailed in Table 3, support the null hypothesis (Ho), indicating no significant difference in variance among the four experimental groups. This suggests that children's creativity scores in computer-based activities are consistently assessed across these groups, implying that our experimental design involving these specific groupings draws from a homogeneous population.

Data analysis with analysis of variance

The data analysis in this study was conducted using a Two-Way ANOVA to investigate the effects of collaborative PjBL and play motivation on the creativity of kindergarten children during computer-based activities. The results, presented in Table 4, summarise the ANOVA findings, which are instrumental in understanding the impact of these factors on children's computer-based creativity. This table provides a breakdown of various sources of variance, degrees of freedom (*df*), sums of squares (SS), mean sums of squares (MSS), F-values, and critical values. These statistical analyses are crucial for drawing meaningful conclusions regarding the relationships and interactions between the investigated variables.

From the ANOVA analysis presented in the Table 4, several conclusions can be drawn:

1. The first null hypothesis (Ho1) is rejected because the F-statistic (F calculate) of 6.26 is greater than the critical F-value (F table) of 4.00. Therefore, we accept the first alternative hypothesis (Hi1), which indicates a significant difference in children's creativity when playing with computers between the groups that use collaborative and independent learning methods.
2. The second null hypothesis (Ho2) is accepted because the F-statistic (F calculate) of 0.002 is much lower than the critical F-value (F table) of 4.00. Thus, the second alternative hypothesis (Hi2) is rejected. This means there is no significant difference in children's creativity when playing with computers between the groups with high and low computer play motivation.
3. The third null hypothesis (Ho3) is rejected because the F-statistic (F calculate) of 15.60 exceeds the critical F-value (F table) of 4.00. Consequently, the third alternative hypothesis (Hi3) is accepted, indicating a significant interaction between learning methods and computer play motivation in shaping children's creativity when playing with computers, as seen in Figure 1. This interaction is highly significant, denoted by (**).
4. The fourth hypothesis, which suggests differences in creativity when playing computers between the group with high computer play motivation treated with collaborative learning methods (A1B1) and the group with high computer play motivation treated with independent learning methods (A2B1), is accepted as accurate. This is based on the Tukey test results ($Q = 8.165 > Q\ t = 3.74$) at α 0.05. Therefore, the hypothesis states that the creativity of playing computers for the group with high computer play motivation and treated with collaborative learning methods (A1B1) is higher than the group with high computer play motivation and treated with independent learning methods (A2B1), and is accepted as accurate.
5. The fifth hypothesis is rejected, which suggests differences in creativity when playing computers between the group with low computer play motivation treated with collaborative learning methods (A1B2) and the group

TABLE 3: Summary of variance homogeneity tests for children's computer-playing creativity scores in the four experimental groups.

Data group	Variance	Combined variance	Bartlett's test	Calculated Chi-squared (χ^2)	Critical Chi-squared (χ^2)	Conclusion
Group A1B1	40.78	40.87	96.7	0.16	7.82	Homogeneous
Group A2B1	39.73	-	-	-	-	-
Group A1B2	40.40	-	-	-	-	-
Group A2B2	42.56	-	-	-	-	-

Note: A1, Group of children who follow learning with collaborative methods; A2, Group of children who follow learning with independent methods; B1, Group of children who have high motivation to play computer; B2, Group of children who have low motivation to play computer. Variance: Within-group variance for each data group. Combined Variance: Combined within-group variance for each data group. Bartlett's Test: Bartlett's test statistic for variance homogeneity. Calculated Chi-Squared (χ^2): The calculated chi-squared value. Critical Chi-Squared (χ^2): The critical chi-squared value at the specified significance level. Conclusion: Assessment of variance homogeneity, whether 'Homogeneous' or otherwise.

TABLE 4: Summary of two-way analysis of variance.

Source of variance	Degrees of freedom (*df*)	Sum of squares (SS)	Mean sum of squares (MSS = SS/*df*)	F observed	F critical (alpha = 0.05)
Between columns (A)	1	256.00	256.00	6.260†	4.00
Between rows (B)	1	0.06	0.06	0.002 ns	4.00
Interaction A × B	1	637.56	637.56	15.600†	4.00
Between groups	3	893.63	297.88	7.290	2.76
Within groups	60	2452.13	40.87	-	-
Total	**63**	**3345.8**	**-**	**-**	**-**

Note: † indicates a significant interaction between learning methods and computer play motivation in shaping children's creativity when playing with computers, based on ANOVA analysis, † is relevant for the first and third lines.

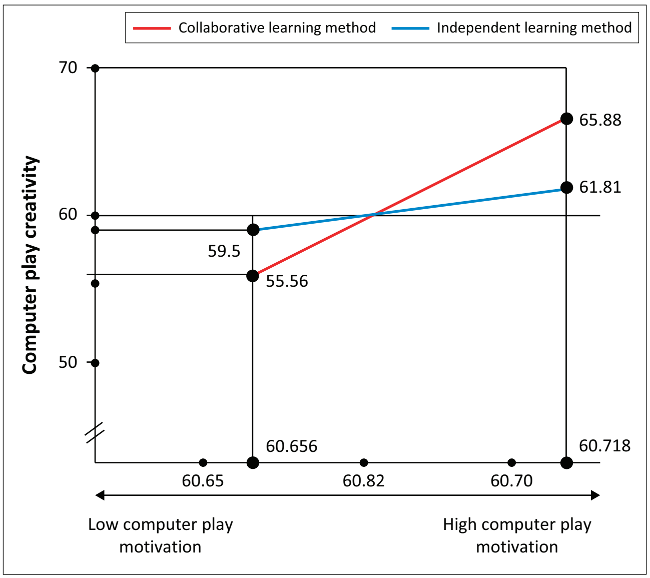

FIGURE 1: Interaction of learning methods with computer play motivation on computer play creativity.

with low computer play motivation treated with independent learning methods (A2B2). This is based on the Tukey test results (Q = 1.39 < Q t = 3.74) at α 0.05. Therefore, the hypothesis that states the creativity of playing computers for the group with low computer play motivation and treated with independent learning methods (A2B2) is higher than the group with low computer play motivation and treated with collaborative learning methods (A1B2) is rejected. In other words, the creativity of playing computers) for the group with low computer play motivation and treated with independent learning methods (A2B2) is not higher than that of the group with low computer play motivation and treated with collaborative learning methods (A1B2).

Discussion

Summarisation of key findings

This study addressed the research problem of evaluating the impact of collaborative PjBL with computer use and play motivation on fostering creativity in kindergarten children. The major findings indicated that collaborative PjBL significantly enhanced children's creativity when playing with computers compared to independent PjBL, underlining the effectiveness of the collaborative approach. Surprisingly, play motivation alone did not exert a significant influence on creativity. However, the study uncovered a highly significant interaction between learning methods and play motivation, emphasising the need to consider both factors for promoting children's creativity during computer activities. Notably, children with high play motivation and exposure to collaborative learning demonstrated the highest creativity scores, while those with low motivation showed no significant difference between collaborative and independent learning methods. These findings underscore the importance of well-structured collaborative PjBL in ECE for fostering creativity.

Interpretations of the research findings

The research findings underscore the effectiveness of collaborative PjBL in fostering creativity among kindergarten children engaged in computer-based play, aligning with the study's hypotheses. This supports the notion that collaborative learning environments significantly contribute to creative outcomes, as evidenced by similar studies (Ferrero et al. 2021). The observation that play motivation alone did not substantially impact creativity underscores the complex interplay between learning methods and motivation. This complexity is echoed in the literature, where the synergy of collaborative environments and intrinsic motivation is highlighted as a catalyst for creative expression (Barrett et al. 2021).

Contrary to expectations, the limited direct effect of play motivation on creativity suggests that the structured nature of PjBL may channel children's motivation more effectively towards creative outcomes, a phenomenon observed in other educational contexts (Du et al. 2019). This finding invites a deeper examination of how specific learning environment elements contribute to motivation and creativity, suggesting that the structured collaboration inherent in PjBL plays a pivotal role.

The unexpected finding regarding play motivation in our study underscores creativity's multifaceted nature and suggests that motivation alone may not be enough to foster creative outcomes without scaffolding a supportive learning environment. This revelation led us to reflect on our employment of the revised Bloom's Taxonomy as our analytical framework, guiding our exploration of the cognitive processes underpinning creativity. Through this framework, we have discerned how varying degrees of cognitive engagement, bolstered by collaborative PjBL, significantly impact young learners' creative expression. Acknowledging the absence of motivation's role in the introduction, it becomes imperative to underscore motivation's pivotal role in learning and creativity from the outset, thereby enriching the context of PjBL exploration. This method harmonises with our analytical framework, accentuating cognitive processes, and situates our findings in a larger conversation about motivation's influence on educational outcomes. Ultimately, this integrated approach, coupled with literature references and a detailed discussion of our analytical framework, seeks to provide a more comprehensive interpretation of our findings. It accentuates the criticality of structured, collaborative learning environments in nurturing creativity and recognises the intricate role of motivation, laying the groundwork for further inquiry into these interrelated dynamics.

Implications of the research

This research holds profound implications for ECE by underscoring the pivotal role of collaborative PjBL in nurturing creativity among kindergarten children during computer-based activities. By emphasising the significance of collaborative methods in this context, the study provides educators and curriculum developers with valuable insights into effective strategies for enhancing creativity from an early age. These findings align with existing literature on the benefits of collaborative learning approaches and contribute a novel perspective by revealing a substantial interaction between learning methods and play motivation, a crucial factor in fostering creativity. This discovery calls for a more holistic and tailored approach to ECE, empowering educators to craft curricula that capitalise on this dynamic interplay, ultimately shaping young minds to be more creative and adaptable in the digital age.

Limitations

While valuable in its exploration of the impact of collaborative PjBL and play motivation on creativity in kindergarten children during computer-based activities, this research is subject to certain limitations. The study's confined focus on a specific age group, learning environment, and computer activities may restrict the generalisability of the findings to a broader context. Individual variations in creativity and other potential influencing factors remain unexplored. However, these limitations do not diminish the results' validity for addressing the research question within the defined scope. The findings offer practical insights for educators working with young children, emphasising the need for comprehensive learning methods and considering the interplay between motivation and pedagogy in fostering creativity, thus holding significance despite the research's inherent constraints.

Recommendations

The practical implementation of this research involves the integration of collaborative PjBL into ECE to foster creativity during computer-based activities. Educators can create learning environments emphasising peer interaction and creative exploration using technology, encouraging children to think critically, express original ideas, and collaborate. It is essential to incorporate strategies to enhance play motivation, designing engaging computer activities tailored to children's interests. Future research can focus on long-term effects and individual differences in creativity development, contributing to a more comprehensive understanding. Comparative studies across various educational settings and age groups, coupled with teacher training and an exploration of emerging technologies, will aid in adapting and optimising pedagogical approaches to meet the evolving needs of young learners in the digital age.

Conclusion

In conclusion, this research addressed the question of how collaborative PjBL and play motivation impact creativity in kindergarten children during computer-based activities. The findings offer valuable insights into the role of collaborative learning methods in enhancing creativity and emphasise the significance of considering both learning approaches and play motivation. The study revealed that collaborative PjBL can substantially contribute to fostering creativity among young learners, particularly when combined with intrinsic motivation to play with computers. Importantly, the interaction between learning methods and play motivation was pivotal in shaping children's computer-based creativity. The implications of this research are far-reaching, advocating for integrating these strategies into ECE to prepare children for the challenges of the digital age. The key takeaway from this study is that fostering creativity in young children requires a multifaceted approach that combines pedagogical strategies with intrinsic motivation, which can lead to more adaptable and creative minds for the future.

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Competing interests

The authors declare that they have no financial or personal relationships that may have inappropriately influenced them in writing this article.

Authors' contributions

In this research, P.P played a pivotal role in conceptualisation, methodology design, and took charge of writing, reviewing, and editing the article. P.P was also responsible for acquiring the necessary funding for the study. S.N.I. contributed by drafting the original article and managing the resources. M.Y.B. handled formal analysis, investigation, and ensured the validation of the study's findings. K.M. was responsible for data curation and played a key role in the validation process.

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Data availability

The data that support the findings of this study are available from the corresponding author, P.P., upon reasonable request.

Disclaimer

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