

## THE EFFECTS OF SYSTEM-PACED, LEARNER-PACED AND LEARNER-ATTENUATED SYSTEM-PACED CONDITIONS ON PROJECT-BASED LEARNING OUTCOMES

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### ABSTRACT

*This study explored how different pacing conditions of a pedagogical agent persona affected student outcomes in project-based learning at Kumasi Senior High Technical School. Researchers randomly assigned 61 Visual Art Students to three pacing groups: system-paced, learner-paced, and learner-attenuated system-paced. The study adopts a sequential explanatory mixed methods approach. The study measured creativity, craftsmanship, suitability and design skills using pre-test and post-test assessments and semi-structured interviews. Analysis of Variance (ANOVA) revealed significant differences between groups, with learner-paced and learner-attenuated system-paced conditions outperforming the system-paced group. The mean scores for creativity, craftsmanship, suitability and design were higher in the learner-paced and learner-attenuated system-paced groups compared to the system-paced group, with  $p$ -values indicating statistical significance ( $p < 0.05$ ). Specifically, the mean creativity score in the learner-paced group was 8.5 compared to 7.2 in the system-paced group. These findings suggest that learner-controlled pacing, facilitated by pedagogical agent personas, can significantly improve student performance in project-based learning environments, highlighting the value of learner-centred instructional approaches.*

**Keywords:** System-paced, learner-paced, learner-attenuated system-paced, project-based learning outcomes.

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## **INTRODUCTION**

Competing concerns around the effectiveness of software with pedagogical agent personas have been documented in the literature. By and large, studies suggest that students find agent personas to be more motivating than other forms of instruction and are more likely to evoke emotional involvement in learners (Dai et al., 2022; Alfaro et al., 2020). A pedagogical agent is a component of the interface or an intelligent software agent that fulfils a pedagogical role, that is, a learning companion, a tutor, a mentor, or any other kind of knowledgeable other (Alfaro et al., 2020). Learners tend to view pedagogical agents as more believable and more reliable sources of information than instructional text (Tao et al., 2022; Lin et al., 2020). There is very little evidence in this area that tests performance outcomes from learning with pedagogical agent personas in different pacing conditions and learning without them (Davis et al., 2021; Mathews, 2021). The present study aims to address pedagogical agent personas' effectiveness in system-paced, learner-paced and learner-attenuated system-paced conditions on the academic performance of students.

This study offers a unique contribution in its focus on learners in a real-world classroom who are using a software-based agent in three pacing conditions to work on a project as opposed to learners engaging in a single pacing condition of learning with an agent. Also, there is a dearth of literature on the use of pedagogical agent persona in different pacing conditions to test the project-based learning outcomes of learners in Ghana. This study thus synchronises with the vision of Transforming Teaching and Learning (T-TEL) to equip teachers with knowledge on differentiated learning techniques so that teachers can meet the needs of learners (T-TEL, 2023; Armah, 2018).

Project-based learning is one of the learning methods which have been implemented in Visual Art education in Ghanaian Senior High Schools to promote creative and critical thinking among students. However, its effectiveness is still questionable (Dempsey et al., 2008). This research attempts to do a comparison by evaluating the effectiveness of the three learning conditions (system-paced, learner-paced and learner-attenuated system-paced) on the project work of learners. In the case of Mathews (2021), a southeastern United States study involved comparing a persuasive agent persona and a neutral one, as it was easier to explore the cause-and-effect pattern. This research, however, chooses to use a tutor-like agent persona in three different pacing conditions to determine the effectiveness of the pacing conditions for project-based learning. The pacing condition influences learning outcomes through structured learner-agent interaction. In learner-paced and learner-attenuated system-paced conditions, students had the ability to control the progression of content via pause-and-proceed functions or segmented videos. These options allowed time for reflection and cognitive processing, which facilitated deeper understanding, increased engagement, and self-regulated learning. By contrast, the system-paced condition limited learners' flexibility, leading to reduced alignment with personal learning rhythms and potentially increasing cognitive load.

### **Purpose of this Study**

The purpose of this study was to explore how the pacing of a pedagogical agent persona may impact students' academic performance in a project-based learning classroom environment. Specifically, the study looked at the pacing of the tutor-like pedagogical agent in a lesson based on perspective drawing under three different pacing conditions. The design of this study was experimental with both a pre-test and a post-test, and it consisted

of three pacing conditions. The study sought to answer the following research question.

RQ: How effective is the pacing (system-paced, learner-paced and learner-attenuated system-paced conditions) of a Pedagogical Agent Persona on students' academic project work?

## REVIEW OF RELATED LITERATURE

### Pacing Conditions and Academic Performance

The effectiveness of pedagogical agents depends significantly on the pacing conditions under which they operate (Lui et al., 2020). Pacing matters, especially how fast students interact with the agent and learn the material in the project-based learning context. Avila (2019) emphasises that project-based learning enriched with well-paced pedagogical support leads to better academic performance and engagement (Avila, 2019). Moreover, Morris & Chen (2020) posit that the learner-paced condition, where students can themselves determine the pace of learning, is associated with increased satisfaction and also superior educational outcomes as compared to the contrast group of the animation materials being system-paced by the instructor (Morris & Chen, 2020). This is supported by the findings of Stiller et al. (2009), who found that learner-paced multimedia instructions considerably reduce mental strain while improving performance, especially when visual texts are included. Additionally, Sikström et al. (2022) discovered that adaptive communication by pedagogical agents in learner-paced environments improves learning by delivering timely feedback and scaffolding. Ba et al. (2021) found that learner-controlled pacing, reinforced by emotional cues from agents, can reduce cognitive load and improve knowledge retention, resulting in higher academic achievement. The studies

mentioned collectively highlight the necessity of pacing in maximising the educational advantages of pedagogical agents in PBL contexts.

### Collaborative Learning and Agent Persona

Pedagogical agents also facilitate collaborative learning in virtual environments (Wei et al., 2025). Guimarães et al. (2023) explored the use of pedagogical agents in collaborative distance learning environments, revealing that agents not only motivate students and correct misconceptions but also facilitate new knowledge acquisition. This is particularly relevant in PBL settings where collaboration is crucial. The study by Sikström et al. (2022) highlights that pedagogical agents support learning in a group by facilitating discussions and directing students' collaboration, thereby enhancing the quality of collaborative interactions (Sikström et al., 2022). Armando et al. (2022) also noted that gender-specific designs of pedagogical agents could impact collaborative learning dynamics, suggesting that androgynous agents might mitigate gender biases and enhance group learning experiences (Armando et al., 2022). Integrating pedagogical agents with collaborative communication tools could enhance synchronous and/or asynchronous interactions among students, enabling learners to learn collaboratively with pedagogical agents and not only with their peers or teachers (Guimarães et al., 2023).

### Theoretical Frameworks

This study is based on four interrelated theories: the Cognitive Theory of Multimedia Learning, Constructivist Learning Theory, Cognitive Load Theory, and Experiential Learning Theory. Each theory contributes to understanding how pacing, agent interaction and project-based learning affect learner outcomes.

## **Cognitive Theory of Multimedia Learning (Mayer, 2005)**

Mayer’s Cognitive Theory of Multimedia Learning (CTML) posits that people learn more effectively from words and pictures than from words alone. The use of a pedagogical agent in varying pacing conditions is intended to optimise cognitive processing by balancing information delivery with learners’ individual processing needs. In the learner-paced and learner-attenuated system-paced conditions, learners can regulate input, reducing cognitive overload and enhancing retention and transfer of knowledge.

## **Constructivist Learning Theory**

Constructivist Learning Theory suggests that learners construct their understanding and knowledge of the world through experiences and reflection (Piaget, 1970; Vygotsky, 1978). In this study, the pedagogical agent serves as a scaffold, offering guidance that supports autonomous exploration, which is a hallmark of constructivist learning environments.

## **Cognitive Load Theory**

Cognitive Load Theory emphasises managing the mental effort required for learning by minimising extraneous load and maximising germane load. The LASP condition in this study is theoretically rooted in CLT’s assertion that reducing extraneous cognitive load enhances

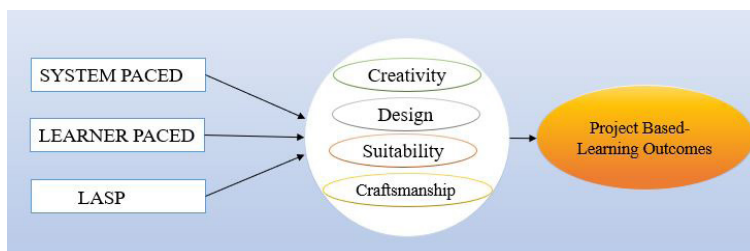
learning. The hybrid nature of LASP, which combines system guidance with learner control, helps prevent cognitive overload while maintaining instructional structure. Unlike rigid system pacing, which may rush learners through content, or unrestricted learner pacing, which can lead to distraction or inefficiency, LASP offers a “middle path” that optimises cognitive processing.

## **Experiential Learning Theory**

Experiential Learning Theory views learning as a process whereby knowledge is created through the transformation of experience. The study’s use of hands-on visual art tasks, guided by a pedagogical agent, supports learners through a cycle of concrete experience, reflective observation, abstract conceptualisation, and active experimentation (Hayashi, 2025). Each pacing condition provides varying degrees of opportunity for learners to experience, reflect, and iterate on their work, thereby influencing learning depth and project quality.

## **Conceptual Framework**

The conceptual framework of this study, as shown in Figure 1 below is grounded in the interaction between pacing condition (independent variable) and project-based learning outcomes (dependent variables: creativity, craftsmanship, design, suitability).



**Figure 1.** Conceptual Framework

## RESEARCH DESIGN

To make the current investigation efficient enough, the researcher used a three-group randomised experimental design which provided a clearer understanding of the situation to compare various pacing conditions. Participants were randomly assigned to the three pacing groups using a computer-generated randomisation sequence created with the Research Randomiser tool (Urbaniak & Plous, 2013). To ensure baseline equivalence, a one-way ANOVA was conducted on pre-test scores for creativity, design, craftsmanship, and suitability. No significant differences were found across the groups, confirming statistical equivalence before the intervention ( $p > .05$ ) (Field, 2018).

### Participants

Sixty-one participants ( $n = 61$ ) were recruited from the Visual Art department at Kumasi Senior High Technical School. The sample had 50 male participants and 11 female participants. Participants were randomly assigned to the system-paced condition ( $n = 20$ ), learner-paced condition ( $n = 21$ ) and LASP condition ( $n = 20$ ). A priori power analysis was conducted using G\*Power 3.1 (Faul et al., 2009). For a one-way ANOVA with three groups, an effect size  $f = 0.25$  (medium),  $\alpha = 0.05$ , and power  $(1-\beta) = 0.80$ , the required sample size was 52. The actual sample of 61 participants therefore exceeded the minimum requirement, increasing statistical robustness. Random sampling was used to eliminate selection bias and enhance the internal validity of the experimental design.

### Data Collection

Quantitative data was gathered using the assessment criteria: Creativity (20%), Design (30%), Craftsmanship (40%) and Suitability (10%) from the Ghana Education Service's Teaching Syllabus for Picture Making (CRDD, 2008). These indicators align with WASSCE visual arts rubrics and were employed to

evaluate the technical and conceptual quality of students' artwork. To establish baseline measures of their project skill competencies, pre-test assessments were conducted with a still-life drawing project. For the post-test, participants were placed in different pacing groups (SP, LP, LASP) to interact with the pedagogical agent and work on a project in their respective pacing conditions. Treatment fidelity was ensured through session logs and system-tracked interaction data. These logs ensured that each group received its designated pacing intervention as intended (Moeller & Reitzes, 2011). This was done to measure the impact of the pacing conditions on student outcomes in project-based learning. Semi-structured interviews were also conducted to gather qualitative data on the participants' experiences and the effectiveness of the PAP module in the three different pacing conditions.

### Data Analysis

Quantitative data from the pre-test and post-test assessments were statistically analysed using Jamovi 2.2.5 to compare the outcomes across the different pacing conditions. Qualitative data from the interviews were analysed using thematic analysis to identify patterns and themes. At the end of the data collection period, participant comments were compiled in an Excel spreadsheet. The data from the three pacing groups were read, coded and analysed independently while ensuring respondent anonymity. Then, the data from the three pacing groups were combined and examined to identify common themes.

### Pre-Intervention

Before the intervention, the researcher conducted pre-test assessments to establish baseline measures of creativity, craftsmanship, design and suitability (Boakye et al., 2024). The participants were Visual Art Students from Kumasi Senior High School who were

randomly assigned to different groups: system-paced, learner-paced, and learner-attenuated system-paced. The purpose of the pre-intervention phase was to gather initial data on the participants' academic performance in the project-based learning environment. This data served as a basis for comparison with the post-intervention results to evaluate the effectiveness of the pacing of the pedagogical agent persona.

### **Intervention**

During the intervention phase, participants engaged in project-based learning activities with the pedagogical agent under their respective pacing conditions. The system-

paced group followed a predetermined pacing set by the system, while the learner-paced group had control over their pacing with the learning material through short videos. The learner-attenuated system-paced group also had control over their pacing, but they used a full video as their learning material. The purpose of the intervention was to assess how the different pacing conditions influenced student outcomes, including creativity, craftsmanship, design suitability, and overall academic performance. The pedagogical agent played a central role in guiding and supporting students throughout the project-based learning tasks.



**Figure 2.** Students receiving instructions from the Pedagogical Agent Persona

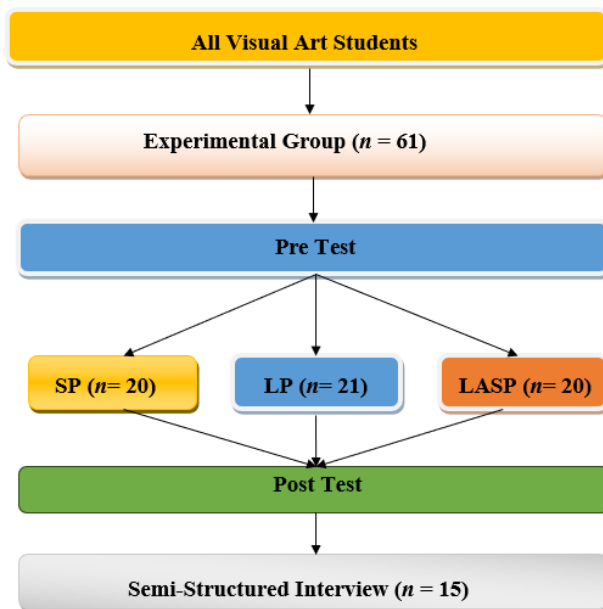
### **Post-Intervention**

Following the intervention period, post-test assessments were conducted to measure the impact of the pacing conditions on student outcomes. Participants' creativity, craftsmanship, design and suitability were reassessed to determine any changes or

improvements resulting from the intervention. Analysis of Variance (ANOVA) was used to compare variances across the means of the three different pacing conditions (Rouder et al., 2016). ANOVA was used to compare the post-intervention results across the different pacing conditions and their earlier scores. The

purpose of the post-intervention phase was to evaluate the effectiveness of the pedagogical agent's pacing strategies in enhancing student academic performance in project-based learning environments. Semi-structured interviews were conducted to gather qualitative data on participants' experiences, aiming to evaluate the effectiveness of the pedagogical agent's pacing strategies in

enhancing student academic performance in project-based learning environments. Thematic analysis was used to analyse and code participant responses, identifying and reporting emerging themes to understand the impact of different pacing conditions on learners' academic performance (Nowell et al., 2017).



**Figure 3.** Experimental Process of the Study

### **Ethical Consideration**

Ethical approval for this study was obtained from the Ashanti Regional Education Directorate (Ref: 14/90/148). Additionally, written informed consent was obtained from parents or guardians of all student participants, along with assent from the students themselves, as required for research involving minors (UNESCO, 2016). Participants were assured of their anonymity and confidentiality. All information collected was anonymised during analysis and reporting, ensuring that no individual could be identified. Participation in the study was voluntary, without any form of coercion.

## **RESULTS AND DISCUSSIONS**

### **Comparison between Pre-Test Scores and Post-Test Scores**

A paired samples t-test was conducted to compare the pretest scores in a traditional classroom setting with the post-test scores after students were introduced to an Agent Persona in a project-based learning classroom. The results are presented in the table below:

Table 4.1 Comparison between Pre-Test Scores and Post-Test Scores

Drawing project competencies	Experimental Class	No. Of Students	Mean	Standard Deviation	Mean difference	T-Statistic	P-Value	Interpretation																																		
Creativity	Pre-test	61	11.28	2.42	2.705	5.96	< .001	There is a significant difference																																		
	Post-test	61	13.98	3.76					Design	Pre-test	61	17.80	4.32	2.918	4.39	< .001	There is a significant difference	Post-test	61	20.72	5.07	Craftsmanship	Pre-test	61	22.89	6.85	5.984	5.87	< .001	There is a significant difference	Post-test	61	28.87	7.93	Suitability	Pre-test	61	6.21	1.38	0.705	3.14	0.001
Design	Pre-test	61	17.80	4.32	2.918	4.39	< .001	There is a significant difference																																		
	Post-test	61	20.72	5.07					Craftsmanship	Pre-test	61	22.89	6.85	5.984	5.87	< .001	There is a significant difference	Post-test	61	28.87	7.93	Suitability	Pre-test	61	6.21	1.38	0.705	3.14	0.001	There is a significant difference	Post-test	61	6.92	1.42								
Craftsmanship	Pre-test	61	22.89	6.85	5.984	5.87	< .001	There is a significant difference																																		
	Post-test	61	28.87	7.93					Suitability	Pre-test	61	6.21	1.38	0.705	3.14	0.001	There is a significant difference	Post-test	61	6.92	1.42																					
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\*=Not significant;  $P > 0.05$  \*\*=Significant;  $P < 0.05$

The implementation of the pedagogical agent persona led to noteworthy improvements in drawing competencies compared to the traditional classroom setting. The paired samples t-tests conducted in the study illustrate substantial improvements in student performance when a pedagogical agent persona was incorporated into a project-based learning environment. The statistically significant increases in scores from the pretest to the post-test for creativity, design, craftsmanship and suitability suggest that the agent persona had a positive impact on drawing competencies (all  $p < .001$ ).

### Creativity (Comparison between Pre-Test Scores and Post-Test Scores)

Creativity scores increased by 5.96 points ( $t(60) = -5.96$ ,  $p < .001$ ). The integration of pedagogical agents notably enhances creativity. This is supported by the study "Effective Pedagogical Agent Behaviour," which found that certain behaviours of

pedagogical agents, specifically those that perform relevant gestures, significantly aid in learning by providing a more engaging and interactive experience (Zha & Bourguet, 2016). Additionally, the increase in creativity scores aligns with the findings of Ryu & Ke. (2018) on "Increasing Persona Effects," where it was demonstrated that the voice and appearance of an animated pedagogical agent can positively influence students' engagement and perception of the agent, thereby enhancing their creative outputs (Ryu & Ke, 2018).

### Design (comparison between Pre-Test Scores and Post-Test Scores)

Design scores increased by 4.39 points ( $t(60) = -4.39$ ,  $p < .001$ ). The scores obtained for design also indicated an improvement, demonstrating the agent's ability to improve comprehension and application of design elements. Alfaro et al. (2020), in "New Trends in Pedagogical Agents in Education", examine various pedagogical agents' implementations and find

that they are highly effective in cognitive areas such as design because they are adaptable and offer realistic simulations. The outcomes of the research by Schroeder et al., (2017) on “Measuring Pedagogical Agent Persona” also bolster the effectiveness of pedagogical agents in improving design capabilities by increasing informational utility and interactive learning.

### **Craftsmanship (comparison between Pre-Test Scores and Post-Test Scores)**

Craftsmanship scores increased by 5.87 points ( $t(60) = -5.87, p < .001$ ). Craftsmanship experienced a notable increase following the intervention, which can be attributed to the comprehensive feedback and personalised interaction delivered by the pedagogical agent. The study “Measuring Pedagogical Agent Persona” underscores the substantial impact of affective interaction with agents on the perceived usefulness of information, thus leading to enhanced craftsmanship and skill development (Schroeder et al., 2017). Additionally, the research by Stahl (2023) on “Using Pedagogical Agents to Support Collaborative Distance Learning” emphasises how collaborative efforts, backed by pedagogical agents, can enhance craftsmanship by providing timely feedback and fostering a cooperative learning environment. Similarly, the review article “New Trends in Pedagogical Agents in Education” by Alfaro et al. (2020) supports this notion by demonstrating that pedagogical agents can improve various aspects of learning, including craftsmanship, through personalised and adaptive interactions.

### **Suitability (comparison between Pre-Test Scores and Post-Test Scores)**

Suitability scores increased by 3.14 points ( $t(60) = -3.14, p = 0.001$ ). The increase in the suitability scores suggests that the pedagogical agent persona guided learners to successfully align their work with the project criteria. Buddemeyer et al. (2021) in the study “Agentic Engagement with a Programmable Dialogue System” highlight the significance of educational agents in promoting student expression of preferences and opinions, allowing work to be customised to better match stated criteria. Furthermore, the study by Alfaro et al. (2020) on “New Trends in Pedagogical Agents in Education” investigates how pedagogical agents might adapt to socio-cultural needs and project requirements, resulting in more appropriate student outcomes. The cumulative scores also exhibited a significant increase from pretest to post-test, with a total increase of 5.84 points ( $t(60) = -5.84, p < .001$ ). These findings highlight the effectiveness of incorporating a pedagogical agent persona to enhance students’ project-based learning competencies by providing valuable support and guidance. This leads to improved performance and skill development in various dimensions.

### **Analysis of Post-Test Results Across Different Pacing Conditions.**

A one-way ANOVA was conducted to analyse the post-test results across different pacing conditions: System-paced (SP), Learner-paced (LP), and Learner-attenuated System-paced (LASP). These conditions represent variations in the ability of learners to control the pace of learning materials. The results, including group descriptives, means, standard deviations, and standard errors, are presented below:

**Table 4.2 Analysis of Post-Test Results Across Different Pacing Conditions****Group Descriptives:**

	Post test	N	Mean	SD	SE
Creativity	SP	20	10.50	2.21	0.495
	LP	21	15.10	3.18	0.693
	LASP	20	16.30	3.05	0.681
Design	SP	20	16.85	4.45	0.995
	LP	21	21.90	4.83	1.053
	LASP	20	23.35	3.51	0.786
Craftsmanship	SP	20	21.85	7.57	1.693
	LP	21	31.38	6.31	1.377
	LASP	20	33.25	4.51	1.008
Suitability	SP	20	6.00	1.34	0.299
	LP	21	7.14	1.20	0.261
	LASP	20	7.60	1.27	0.285
SUM	SP	20	55.20	12.55	2.807
	LP	21	75.52	14.95	3.262
	LASP	20	79.75	12.76	2.854

The one-way ANOVA revealed statistically significant differences among the pacing conditions for creativity,  $F(2, 58) = 93.22$ ,  $p < .001$ ; design,  $F(2, 58) = 64.95$ ,  $p < .001$ ; craftsmanship,  $F(2, 58) = 203.77$ ,  $p < .001$ ; suitability,  $F(2, 58) = 45.03$ ,  $p < .001$ ; and the sum of post-test scores,  $F(2, 58) = 213.15$ ,  $p < .001$ .

**Creativity Across Different Pacing Conditions**

The results indicated that learners in the LASP condition achieved the highest average scores in creativity ( $M = 16.3$ ), followed by the LP ( $M = 15.1$ ) and SP ( $M = 10.5$ ) groups. This significant difference ( $F(2, 58) = 93.22$ ,  $p < .001$ ) highlights the importance of learner control in fostering creativity. Studies such as Stiller et al., (2009) on "How pacing of multimedia instructions can influence modality effects" support this finding, suggesting that learner-paced instructions enhance cognitive performance and reduce mental effort. According to Anurugwo(2020), Self-paced learning allows learners to progress through the educational material at their own speed to improve retention and comprehension of complex

information. Moreover, research by Patel et al. (2018) on "Curriculum Pacing: A New Approach to Discover Instructional Practices in Classrooms" suggests that varying pacing can be an effective instructional strategy that enhances creativity.

**Craftsmanship Across Different Pacing Conditions**

The LASP group had significantly higher scores in craftsmanship ( $M = 33.25$ ) compared to the LP ( $M = 31.38$ ) and SP ( $M = 21.85$ ) groups ( $F(2, 58) = 203.77$ ,  $p < .001$ ). This suggests that pacing conditions that allow for more learner control contribute to better craftsmanship. Research by Guimarães et al. (2016) on "Investigating Instructional Pacing Supports" supports these findings, showing that balanced pacing strategies can enhance both autonomy and skill development in learners.

**Suitability Across Different Pacing Conditions**

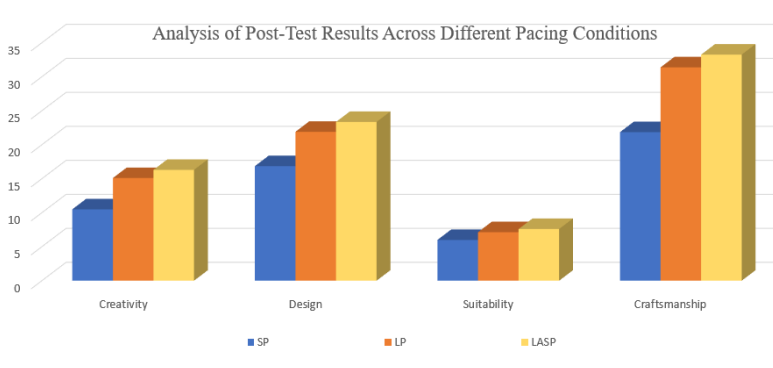
The suitability scores followed a similar pattern, with the LASP group scoring the highest ( $M = 7.6$ ), followed by the LP ( $M = 7.14$ ) and SP ( $M = 6$ ) groups ( $F(2, 58) = 45.03$ ,

$p < .001$ ). This suggests that learner control in pacing enhances the ability to meet project requirements. The “Meta-Analysis of Single-Case Research Design Studies on Instructional Pacing” found that varying pacing parameters significantly influence learning outcomes, with brisker pacing improving correct responses and reducing challenging behaviours (Tincani & De Mers, 2016). More recent studies by Patel et al. (2018) on “Curriculum Pacing: A New Approach to Discover Instructional Practices in Classrooms” further support the effectiveness of customised pacing strategies in improving the suitability of student outputs.

**Design Scores Across Pacing Conditions**

The design scores across the three pacing conditions reveal notable differences. The learner-adapted system-paced (LASP) condition yielded the highest mean score of 23.35 (SD = 3.51, SE = 0.786, N = 21), followed

by the learner-paced (LP) condition with a mean of 21.9 (SD = 4.83, SE = 1.053, N = 20), while the self-paced (SP) condition scored lowest with a mean of 16.85 (SD = 4.45, SE = 0.995, N = 20). The standard deviation was highest for the LP condition and lowest for the LASP condition, suggesting more consistent performance in the LASP group. These results indicate that both learner-paced and learner-adapted system-paced conditions may enhance design performance compared to self-paced conditions, with LASP showing a slight advantage. These findings suggest that providing learners with the ability to pause or rewind learning materials in short videos (LP) or providing learners with the ability to pause or rewind learning materials in full videos (LASP) significantly enhances drawing competencies compared to a purely system-paced approach (SP). The histogram below shows an analysis of the findings.



**Figure 4.** Analysis of Post-Test Results Across Different Pacing Conditions

**Themes Emerged from Responses to Semi-Structured Interview**

Qualitative feedback regarding the effectiveness of the pacing of the PAP module was gathered through semi-structured interviews from 15 students; 5 from each pacing condition. The data was analysed thematically, with a focus on identifying recurring patterns and themes.

The analysis revealed several themes across different pacing conditions, which are included in the table below:

**Table 4.2 Summary of Qualitative Themes in All Three Pacing Condition**

Questions	Themes	Pacing Condition	Responses
How has the pedagogical agent persona influenced your creative process in the project-based learning tasks?	Enhanced Creativity	Learner-paced	"The pedagogical agent persona served as a catalyst for my creativity by providing prompts that inspired me to think innovatively."
		LASP	"The agent encouraged me to experiment with different artistic techniques and approaches."
		System-paced	"Though the time was limited, the pedagogical agent persona fuelled my creativity and motivated me to explore various artistic techniques and approaches."
Can you explain how the pacing of the pedagogical agent persona influenced the design aspect of your project outcomes?	Improved Design	Learner-paced	"With the agent's support, I had the freedom to structure my designs creatively."
		LASP	"The agent's guidance helped me to refine and improve the design of my work."
		System-paced	"The agent provided me with a structured framework for my designs."
In terms of suitability, how did the persona of the pedagogical agent contribute to ensuring that your project outcomes met the required standards?	Alignment with Standards for Suitability	Learner-paced	"The learner-paced environment enabled me to align my creative ideas with the project objectives effectively".
		LASP	"The instructions helped me to meet the project requirements accurately."
		System-paced	"The system allowed me to create a somewhat work on my project as expected, however, it ended very fast without my ability to pause it and gradually work"
In what ways did working with the pedagogical agent persona enhance your craftsmanship skills in the project-based learning environment?.	Enhanced Craftsmanship	Learner-paced	"I noticed a significant improvement in my craftsmanship skills."
		LASP	"The pedagogical agent persona improved my craftsmanship by helping me focus on precision and attention to detail."

## Enhanced Creativity

In the learner-paced condition, students' creativity was significantly enhanced by the ability to control the pacing of short videos. They found that the prompts provided by the pedagogical agent inspired innovative thinking and allowed them to pause and reflect when needed. In the Learner-attenuated System-paced condition, where students could pause and rewind full videos, the agent encouraged experimentation with different artistic techniques, fostering creativity. Although the System-paced condition had time constraints, it still motivated students to explore various creative approaches, albeit with less flexibility. The effect of pacing in educational environments on creativity has been well-documented in the literature. The results of this study align with the literature on the impact of pacing on creativity in educational environments. Mayer & Moreno (2003) found that giving learners control over the pace of multimedia instruction significantly improved learning outcomes, including creativity and problem-solving skills. This aligns with our findings as the Learner-paced condition enhanced creativity by providing prompts that inspired innovative thinking. Learners were able to pause and reflect, which is consistent with the idea of "cognitive offloading" described by Sweller et al. (2011). Learners in the Learner-attenuated System-paced condition also showed increased creativity, which is in line with Park & Lim's (2007) findings that some degree of control in multimedia learning environments can foster deeper engagement and creativity. Even in the System-paced condition, where there was less flexibility, creativity was still motivated due to the structured prompts provided by the agent, as discussed by Kirschner et al. (2006).

## Improved Design

The learner-paced condition offered students the freedom to structure their designs creatively while receiving support from the pedagogical agent. This freedom allowed for more thoughtful and iterative design processes. In the Learner-attenuated System-paced condition, students reported that the agent's guidance was instrumental in refining and improving their designs. Even with less control over pacing, the System-paced condition provided a structured framework for designs, helping students follow a systematic approach, but the inability to pause or rewind limited their ability to make iterative improvements. In the learner-paced condition, students were able to structure their designs creatively with the support of the pedagogical agent. This is consistent with Clarke & Mayer's (2011) study, which found that learner control over pacing enhances the design process. The guidance provided by the agent in the Learner-attenuated System-paced condition helped students improve their designs, which is supported by Azevedo & Cromley's (2004) research on the importance of scaffolding in self-regulated learning environments. However, the System-paced condition limited students' ability to make iterative improvements, which is in line with findings from Moreno & Mayer (2007) that overly rigid pacing hinders the iterative design process crucial for high-quality outcomes.

## Alignment with Standards for Suitability

To meet project standards, it is important to ensure that instructional guidance aligns clearly with learning objectives. In the Learner-paced condition, Zimmerman's work (2002) highlights the role of self-regulation and feedback in helping students effectively align

their creative ideas with project objectives. The flexible pacing in this condition allows for continuous alignment and adjustment. Similarly, in the Learner-attenuated System-paced condition, Belland et al. (2013) findings emphasise the importance of effective scaffolding in guiding learners to meet learning objectives. Here, the agent’s instructions play a crucial role in helping students meet project requirements accurately. However, the System-paced condition, although somewhat effective, faces challenges due to the lack of control over pacing. This limitation is consistent with Garrison & Kanuka’s research (2004), which emphasises the need for learner control to effectively meet complex learning objectives.

### **Enhanced Craftsmanship**

In terms of craftsmanship, the learner-paced condition led to significant improvements as students were able to focus on precision and make iterative refinements. The Learner-attenuated System-paced condition also enhanced craftsmanship, with the agent helping students pay attention to detail. In the System-paced condition, the pedagogical agent taught students specific techniques, such as positioning angles for perspective drawing, but the lack of pacing control limited the depth of craftsmanship skills development. Craftsmanship skills can be improved through focused practice and attention to detail.

In the learner-paced condition, learners had the opportunity to pause and rewind, allowing them to focus on precision and make significant improvements in craftsmanship. This aligns with Adeoye (2024), who posits that students who have the freedom to pace the learning environment tend to demonstrate better retention of information. In the Learner-attenuated System-paced condition, the pedagogical agent assists students in focusing on precision and attention to detail, in line with the principles of formative assessment described by Black & Wiliam (2009). These principles emphasise ongoing feedback and reflection to enhance craftsmanship. On the other hand, in the System-paced condition, although the agent provides useful techniques for specific skills like perspective drawing, the lack of pacing control limits the development of deeper craftsmanship. This limitation is discussed by Mayer (2001) in the context of cognitive load theory, which highlights how excessive load can hinder skill acquisition.

### **Experiences of Learners with the PAP Module Across Pacing Conditions**

The semi-structured interview further went on to find learners’ experiences with the PAP module. The themes gathered are stated below, which provide a summary of the qualitative themes that emerged from the semi-structured interview.

**Table 4.3: Summary of Qualitative Themes in all three pacing conditions**

Questions	Themes	Pacing Condition	Responses
Did you understand what the agent taught you?	Understanding what was taught	Learner-paced	“I like the way the agent was speaking. He was able to explain the point well to my understanding.”
		LASP	“I realised that the class was more effective. If we are to continue this way, we would do better in our practical lessons.”
		System-paced	“The steps in the video helped me to understand the content taught.”

Were you able to focus?	Focusing on learning content	Learner-paced	“Yes, it helped me focus. It was better than every other class we have had in the semester”
		LASP	“Yes, because everyone had their headsets on, we were able to stay focused and concentrate”
		System-paced	“Yes, I was able to stay focused throughout the lesson”
Comparing the PAP module to the traditional teaching method, which one was more effective?	Effectiveness of PAP module in different Pacing Conditions?	Learner-paced	“I would always choose this module over a traditional class. I was able to take my time to follow the steps and complete my project work. I didn’t feel that I needed to rush through to get a complete work.”
		LASP	“The PAP module helped me better understand the content than the traditional class. The segmented structure of this module helped me pause, reflect and think about the content.”
		System-paced	“The module clearly explained the steps for me but it was too fast. ”
		Learner-paced	“Yes, I was able to complete my work; I like that I was able to work at my own pace.”
Were you able to finish working on the project?	Completing project work	LASP	“Yes, I like that it was segmented and I had the chance to pause, reflect and work at my own pace to complete the project.”
		System-paced	“No, the module was too fast for me. I couldn’t finish before it ended”
		Learner-paced	“The voice of the agent did not match the movement of the mouth. Even though I understood everything and I was able to finish my project, I wished the movement of the mouth aligned with the voice”
What did you like least about the module?	Movement of the agent	LASP	“The agent’s movement was not enough. Even at a point, the voice of the agent was too slow”
		System-paced	“The movement of the mouth did not match the voice. I wished I could rewind it and control the pacing but I could not. I didn’t really enjoy the module”

**Understanding what was Taught**

In general, participants expressed positive feedback about their understanding of the content presented in the PAP module. Learner-paced participants appreciated the clarity of explanations provided by the

agent. LASP (Learner-attenuated System-paced) participants acknowledged the effectiveness of the module in enhancing learning outcomes. System-paced participants found the step-by-step instructions helpful in understanding the content. The ability to understand instructional content is crucial

for effective learning. In the learner-paced condition, students appreciated the agent's clear explanations and the ability to control the pace, which enhanced comprehension. This aligns with Mayer & Moreno's (2003) finding that learner control over multimedia instruction improves understanding. In the Learner-attenuated System-paced (LASP) condition, students found the class effective and beneficial for practical lessons, supporting Azevedo & Cromley's (2004) findings on the importance of scaffolding in understanding complex content. In the System-paced condition, students understood the steps taught but found the pace too fast, indicating the need for pacing control to optimise comprehension (Moreno & Mayer, 2007).

### **Focusing on Learning Content**

Participants in all pacing conditions reported improved focus during the PAP module sessions. Learner-paced participants highlighted the module's comparative effectiveness in maintaining attention compared to traditional classes. LASP participants attributed their focus to the use of headsets, which minimised distractions. System-paced participants indicated sustained focus throughout the lesson. Maintaining focus is crucial for effective learning. Students in the Learner-paced condition reported that the pacing helped them focus better than in the traditional class. This is supported by Sweller et al. (2011), who emphasised the importance of reducing cognitive load to improve focus. The LASP condition also helped maintain focus, aligning with research by Park & Lim (2007) on the benefits of controlled multimedia environments for concentration. In the System-paced condition, although students could stay focused throughout the lesson, the lack of pacing control was a potential drawback, as highlighted by Kirschner et al. (2006).

### **Effectiveness of PAP Module**

The effectiveness of the PAP module compared to traditional teaching methods varied among participants. Learner-paced participants appreciated the module's flexibility and the opportunity it provided for thorough understanding. LASP participants valued the segmented structure of the module as it allowed for reflection. However, some System-paced participants found the pace of the module to be too fast, which affected their comprehension. The effectiveness of the PAP module compared to traditional teaching methods varied by pacing condition. In the learner-paced condition, students preferred the module as it allowed them to work at their own pace, reducing the pressure to rush and improving project outcomes, consistent with Clarke & Mayer (2011) on the benefits of learner-controlled pacing. The LASP condition was also favoured for its segmented structure, which enabled pausing and reflection, enhancing understanding (Azevedo & Cromley, 2004). However, in the System-paced condition, although the module was clear, the fast pace hindered its effectiveness, as described by Mayer (2005) in the context of cognitive load theory.

### **Completing the Project Work**

The ability to complete project work is a key indicator of the effectiveness of pacing conditions. In the learner-paced condition, students successfully completed their projects at their own pace, echoing findings on the benefits of deliberate practice. Learner-paced participants appreciated the freedom to work at their own pace, which facilitated project completion. LASP participants found that the segmented structure helped them complete their project with the flexibility to pause and reflect and successfully complete tasks. This is further supported by Liu (2021), who found that system pauses, especially those determined by the complexity of the

material, can enhance test performance and instructional efficiency. While many participants reported successfully completing project work, challenges were observed in certain pacing conditions. In contrast to the LP and LASP conditions, the System-Paced condition's fast pace prevented some students from finishing their work, highlighting the limitations of rigid pacing. Stiller (2011) cautions that the speed of system-paced presentations can impact learning success, with learner-paced instructions often resulting in better performance. Therefore, while the Learner-attenuated System-paced condition may allow for project completion with the flexibility to pause and reflect, the effectiveness of this approach may depend on the specific design and implementation of the system. Research suggests that rigid pacing can lead to decreased performance and increased discomfort. This is further supported by Miller (2019), who found that rigid deadlines can detract from student participation. In contrast, self-paced learning, such as the learner-paced and learner-attenuated system-paced conditions has been shown to improve performance (Tullis, 2011), echoing the positive outcomes of the learner-paced and learner-attenuated system-paced conditions in project work completion. These findings highlight the importance of flexible pacing conditions in promoting successful project completion.

### **Dislikes about the PAP Module**

Feedback regarding dislikes about the PAP module indicated that the movement of the agent within the PAP module was rigid. Learner-paced participants noticed discrepancies between the agent's voice and mouth movement, which affected their overall enjoyment. LASP participants desired more dynamic agent movement to enhance engagement. System-paced participants found the movement to be slow and wished for the ability to pause during practical sections.

### **Movement of the Agent**

The movement of the pedagogical agent is crucial for maintaining student engagement. In the Learner-paced condition, students noticed discrepancies between the agent's voice and mouth movements. Although this discrepancy did not affect understanding, it caused frustration. This finding supports Mayer's (2005) emphasis on coherence in multimedia learning, highlighting the necessity for pedagogically sound instructional design. Fenesi (2016) further emphasised the importance of coherence in multimedia instruction, especially for learners with lower working memory capacity. Similarly, in the LASP condition, students found the agent's movements inadequate and occasionally found the voice too slow. In the System-paced condition, the inability to control pacing exacerbated these issues, reducing enjoyment and engagement. Issues such as a mismatch between the agent's voice and mouth movements can lead to frustration (Wang, 2022). Expressive auditory gestures, particularly interjections, can enhance emotional rapport and motivation in learners (Ceha, 2022). However, the impact of gestures on learning outcomes is mixed (Davis, 2021).

### **Implications for Teaching and Learning**

The implications for teaching and learning based on the research findings are as follows:

**Student-Centred Instruction:** The research highlights the importance of adopting student-centred instructional approaches that allow learners to control the pacing of their learning. Teachers can design lessons that cater to individual learning styles and preferences, promoting greater student engagement and autonomy.

**Personalised Learning:** By incorporating pedagogical agent personas in different pacing conditions, teachers can personalise the learning experience for students. This approach can help address diverse learning needs and preferences, leading to improved learning

outcomes in areas such as creativity, design, suitability and craftsmanship skills.

**Enhanced Creativity and Critical Thinking:** The study suggests that learner-controlled pacing conditions can enhance students' creativity and critical thinking skills. Teachers can encourage students to explore various artistic techniques and approaches at their own pace, fostering a deeper understanding of the subject matter and promoting innovative thinking.

**Professional Development for Teachers:** The research underscores the importance of providing professional development opportunities for educators to enhance their understanding of pacing strategies and the effective use of pedagogical agent personas. Training programs can empower teachers to create supportive learning environments that optimise student outcomes in project-based settings.

**Policy Considerations:** Educational policymakers can consider the implications of the research findings when designing policies related to technology integration and personalised learning approaches. By promoting learner-centred instructional practices and supporting the use of pedagogical agents, policymakers can create an environment that fosters student success and engagement in high school education.

### **Limitations and Future Research**

The limitations of this study include potential challenges in generalising findings beyond the specific context of project-based learning in High School education. The short duration of the study may overlook long-term effects. Technology constraints in schools with limited access to technology. The study's reliance on technology-mediated pedagogical agents may pose challenges in schools with limited access to technology or technical support.

Future research could look into conducting longitudinal studies to assess the sustained

impacts of different pacing conditions and pedagogical agent personas on student learning outcomes over an extended period. Also, further studies could explore cross-cultural variations in the effectiveness of pacing conditions and pedagogical agents on special education applications of these methods. The sample showed a gender imbalance (50 males, 11 females), mirroring actual Visual Arts enrolment. Although gender was not a key focus, a two-way ANOVA showed no significant interaction effects ( $p > .05$ ). Future research should employ a more gender-balanced sample to examine whether gender-based differences in learning preferences may have influenced the observed outcomes, as gender continues to play a significant role in shaping learning experiences and outcomes (Li & Wong, 2021; Voyer & Voyer, 2014).

## **CONCLUSIONS**

This study underscores the pivotal role of pacing conditions in shaping student performance. The results of the study revealed that learners in the learner-paced and learner-attenuated self-paced conditions performed better than learners in a system-paced condition, resulting in heightened creativity, design, suitability and craftsmanship processes. These conditions empowered students to refine their work with precision, iterate on improvements and align their projects with set standards effectively. The study underscores the significance of tailored learning methods to accommodate diverse learning preferences and deepen student engagement. The conclusions drawn from the research emphasise the critical alignment of instructional guidance with learning objectives and the promotion of self-regulated learning in high school environments. Students learn better and complete projects more successfully when they can control the pace of their learning. This insight can help teachers improve their methods, support students' self-

regulation skills, and create a better learning environment for students in high school.

### **Declaration of Conflict of Interest**

The authors report of no conflict of interest.

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