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Enhancing Student Engagement in a Networking Course Through Object Detection Projects: An Interrupted Time Series Design

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Abstract

Student engagement in technical courses remains a persistent challenge, particularly in balancing theoretical instruction with hands-on, applied learning and abstract conceptualization. This study investigated the impact of introducing object detection projects on student engagement – behavioral, cognitive, and emotional – in a Networking course for the Bachelor of Technology and Livelihood Education (BTLED) students (n=30). This seven-week interrupted time series study, which addressed gaps in technology-enhanced vocational education, employed validated surveys (α=0.89) analyzed via segmented regression and non-parametric tests. Wilcoxon Signed-Rank Tests demonstrated significant post-intervention engagement improvements ($W = 465$, $p < .001$, significant effect size $r = .87$). Segmented regression confirmed significant shifts in engagement levels and slopes. The study validates that integrating object detection projects in technical courses significantly enhances student engagement, supporting the inclusion of hands-on applications in curriculum design. Future research should explore the longitudinal effects of this technology across technical disciplines.

Keywords: interrupted time series design, object detection, Pictoblox, student engagement, technical-vocational education

INTRODUCTION

Student engagement is fundamental in fostering academic success and enriching the learning experience, especially in Technical-Vocational (Tech-Voc) courses (Fredricks et al., 2004; Kearney & Maakrun, 2020). Moreover, research has shown how difficult it is to maintain engagement through the behavioral, cognitive, and emotional dimensions in such courses as Networking (Lee & Reeve, 2012; Smith & Hu, 2013; Villa et al., 2023). The general causes of low student engagement include the technical nature of the content, hands-on learning activities, and the perceived disconnect between academic knowledge and application in real life (Heilporn et al., 2022). The challenges mentioned above become especially potent in networking courses, where the intricacy of concepts and the hands-on practical nature of the learning environment hinder student engagement. It is imperative to address this issue: student engagement is not only a hallmark of a high-quality educational experience but also a key contributor to the success of any learning intervention (Wang et al., 2021).

The technical nature of networking courses often leads to challenges in maintaining student engagement. However, emerging technologies like object detection, particularly through tools such as Pictoblox, offer innovative solutions that have shown the potential to enrich educational experiences across various disciplines (Cruz et al., 2021). Object detection can provide a unique method for visualizing and interpreting complex network components, which may increase student interaction and engagement with course content (Liu et al., 2022). By incorporating object detection through Pictoblox into networking courses, students can experience theoretical network concepts in a hands-on, practical way, bridging the gap between abstract knowledge and real-world application. For instance, students could interact with physical representations of routers or servers, enhancing their understanding of networking concept. Pictoblox, a visual programming environment built on object detection technology, has been successfully utilized in various educational settings. Case studies have shown that this tool significantly enhances student engagement through interactive, immersive learning experiences (Lee et al., 2020; Tan & Ganapathy, 2021).

Despite the promising applications of emerging technologies, researchers have conducted limited studies on integrating object detection to enhance student engagement in networking courses. Existing studies on student engagement have primarily focused on general higher education settings, with limited attention given to the unique challenges faced in Tech-Voc courses (Edwards et al., 2020; Tualaulelei et al., 2021). Moreover, systematic reviews have identified gaps in the literature regarding the use of specific technologies in enhancing engagement in technical education (Nazamud-din, 2020; Shah & Raza, 2022). Notably, there is a lack of research on how object detection, primarily through tools like Pictoblox, can address the unique challenges of student engagement in Tech-Voc disciplines, which are often perceived as challenging and prone to low student engagement (Malayas et al., 2022).

Addressing this gap is essential for educational practitioners and policymakers, especially in the context of the Bachelor of Technology and Livelihood Education major in Information and Communication Technology (BTLED - ICT). This program, offered by a few universities in Mindanao, aims to equip students with practical, real-world skills (Dela Cruz & Santos, 2023). Research on the impact of emerging technologies like object detection in these programs is crucial for informing pedagogical strategies and resource allocation. Furthermore, an Interrupted Time Series (ITS) research design can provide valuable evidence to guide policy decisions to enhance student engagement in technical-vocational education (Simonsen et al., 2021).

Ultimately, this study aims to explore the potential of Pictoblox in improving student engagement in the Networking course of the BTLED program. Specifically, it seeks to provide empirical evidence on how object detection can enhance behavioral, cognitive, and emotional engagement in Tech-Voc education. To evaluate the effectiveness of the object detection project in enhancing student engagement, this study will employ an Interrupted Time Series (ITS) research design, which allows for the evaluation of engagement before and after the intervention, providing robust evidence of its impact. By doing so, it aims to contribute to the growing body of literature on educational technologies and their role in improving student engagement in technical education. The findings of this research could provide actionable insights into enhancing students' learning experiences in Tech-Voc courses, ultimately supporting the development of more effective, real-world-oriented educational interventions.

OBJECTIVE OF THE STUDY

This study addresses this gap by investigating the potential of object detection projects using PictoBlox, to enhance student engagement in the Networking Course. Specifically, this study aims to answer the following questions:

1. What are the levels of student engagement (behavioral, cognitive, and emotional) observed in the Networking Course of the BTLED students before the intervention?
2. What are the levels of student engagement (behavioral, cognitive, and emotional) observed in the Networking Course of the BTLED students after the intervention?
3. Is there a statistically significant difference in the levels of student engagement (behavioral, cognitive, and emotional) in the Networking Course of the BTLED students before and after the intervention?
4. Does the intervention significantly alter the level and slope of student engagement levels (behavioral, cognitive, and emotional) in the Networking course?

METHODOLOGY

This study utilized an interrupted time-series design, a quasi-experimental approach particularly well-suited for evaluating the impact of interventions over time. This allows for analysing trends and changes in engagement levels, providing a stronger basis for causal inference (Mccleary, 2023; Schnell, 2023). The study involved a baseline data collection to measure student engagement before the intervention which would then be followed by the implementation of the intervention consisting of introducing object detection projects using PictoBlox into the Networking Course. After the intervention, student engagement was measured again over several weeks to observe changes in engagement levels and slope using the same data collection methods employed during the baseline phase. This study employed a purposive sampling to select a sample of thirty (n = 30) students. Specifically, the study took place within the context of the Networking Course. This course provided students with a basic introduction to computer networking, covering essential networking components, protocols, and technologies for data transfer between connected systems (Achdiyah et al., 2023; Shernof et al., 2017).

This study utilized an adopted instrument, the Student Engagement Scale (SES), as the primary research instrument to measure changes in student engagement before and after implementing the object detection technology. The Student Engagement Scale was a well-validated instrument that consisted of 33 items (Henrie et al., 2015; Sarhandi et al., 2017). The SES assessed various dimensions of student engagement, including behavioral, emotional, and cognitive aspects (Gupta & Nagpal, 2021). Its strong psychometric properties, including demonstrated reliability and validity, made it a suitable tool for capturing nuanced changes in student engagement within the context of educational technology research. The SES employed a five-point Likert scale for data collection. For behavioral engagement and emotional engagement items, the response options were: (1) Strongly Disagree, (2) Disagree, (3) Neutral, (4) Agree, and (5) Strongly Agree. For the cognitive engagement items, the response options range from (1) Never to (5) Always, with intermediate options of (2) Rarely, (3) Sometimes, and (4) Often. The computed mean score will be used to assess student engagement levels, accompanied by a qualitative interpretation of the mean score based on established criteria, aligning with methodologies employed in prior studies such as Hartono et al. (2019).

Table 1: Interpretation of Mean Score

No.	Range of Mean	Level
1	1.00 – 2.32	Low
2	2.33 – 3.67	Intermediate
3	3.68 – 5.00	High

Since the data violates normality assumption, the Shapiro-Wilk test is applied.

Before data collection, the researcher sought written permission from the school administrators to conduct the study involving the student participants on campus and thoroughly explained the study's purpose and procedures to all participants. Ethical considerations were paramount throughout the study. The researcher ensured that all participants provided informed consent and were aware of their right to withdraw from the study at any time without penalty. Strict measures were taken to protect the confidentiality of participant information, including the secure storage of all data and the use of anonymized identifiers for each participant. (Adawiyah, 2021; Hernández et al., 2020; Miller et al., 2012; Reuter et al., 2020).

RESULTS AND DISCUSSION

The levels of student engagement (behavioral, cognitive, and emotional) observed in the Networking Course of the BTLED students before the intervention.

Table 2: Pre-intervention Levels of Student Engagement

Dimension	Mean	SD	Interpretation
Week 1			
Behavioral	2.43	0.17	Intermediate
Cognitive	2.52	0.29	Intermediate
Emotional	2.74	0.12	Intermediate
Week 2			
Behavioral	2.43	0.17	Intermediate
Cognitive	2.52	0.16	Intermediate
Emotional	2.75	0.48	Intermediate
Week 3			
Behavioral	2.43	0.56	Intermediate
Cognitive	2.53	0.17	Intermediate
Emotional	2.75	0.47	Intermediate
Total			
Behavioral	2.43	0.30	Intermediate
Cognitive	2.52	0.21	Intermediate
Emotional	2.75	0.36	Intermediate
Overall	**2.57**	**0.29**	**Intermediate**

The pre-intervention data revealed that students displayed intermediate levels of engagement across all three dimensions: behavioral ($M = 2.43$, $SD = 0.30$), cognitive ($M = 2.52$, $SD = 0.21$), and emotional ($M = 2.75$, $SD = 0.36$). Behavioral engagement fluctuated slightly over the three weeks, while cognitive engagement showed the least variability, suggesting consistent intellectual involvement. Emotional engagement had the highest mean but still remained at an intermediate level, reflecting a moderate emotional connection to the course material. The data established a baseline of engagement, showing that without specific interventions, engagement levels remained relatively stable. This confirms that active strategies are necessary to enhance student participation and involvement, especially in technical course like Networking.

The levels of student engagement (behavioral, cognitive, and emotional) observed in the Networking Course of the BTLED students after the intervention.

Table 3: Post-intervention Levels of Student Engagement

Dimension	Mean	SD	Interpretation
Week 5			
Behavioral	4.00	0.47	High
Cognitive	4.21	0.54	High
Emotional	4.43	0.46	High
Week 6			
Behavioral	4.34	0.57	High
Cognitive	4.53	0.41	High
Emotional	4.66	0.33	High
Week 7			
Behavioral	4.77	0.41	High
Cognitive	4.77	0.38	High
Emotional	4.91	0.20	High
Total			
Behavioral	4.37	0.48	High
Cognitive	4.50	0.44	High
Emotional	4.67	0.33	High
Overall	**4.51**	**0.42**	**High**

Post-intervention, all engagement dimensions showed a significant increase, indicating a high level of involvement across behavioral (M = 4.37, SD = 0.48), cognitive (M = 4.50, SD = 0.44), and emotional (M = 4.67, SD = 0.33) engagement. The data demonstrated a steady rise in behavioral engagement from Week 5 to Week 7, suggesting increased participation in class activities. Cognitive engagement also showed improvement, reflecting deeper thinking and critical analysis. Emotional engagement reached the highest mean, highlighting a stronger personal connection to the course material. This increase in engagement aligns with the theory that active, hands-on learning strategies enhance student involvement, suggesting that interventions like object detection technology can significantly boost student engagement in technical courses.

Comparison of the levels of student engagement (behavioral, cognitive, and emotional) in the Networking Course of the BTLED students before and after the intervention.

Table 4: Pre- and Post-intervention Levels of Student Engagement

	Pre-intervention		Post-intervention	
Dimension	**M (SD)**	**Mdn (IQR)**	**M (SD)**	**Mdn (IQR)**
Behavioral	2.43 (0.30)	2.42 (2.23–2.67)	4.37 (0.48)	4.36 (4.27–4.47)
Cognitive	2.52 (0.21)	2.51 (2.00–3.00)	4.50 (0.44)	4.54 (4.38–4.63)
Emotional	2.75 (0.36)	2.78 (2.67–2.89)	4.67 (0.33)	4.71 (4.59–4.80)
Overall	**2.57 (0.29)**	**2.50 (2.33–2.78)**	**4.51 (0.14)**	**4.52 (4.40–4.61)**

Note. IQR = Interquartile Range (Q3–Q1)

In comparing the pre-and post-intervention engagement levels, there is a clear increase in engagement across all three dimensions—behavioral, cognitive, and emotional. Pre-intervention, students demonstrated intermediate engagement levels, with moderate participation, intellectual involvement, and emotional connection to the course material, as indicated by the mean, median, and IQR values. However, after the intervention, the engagement levels in all three dimensions shifted to high levels, with a marked increase in both the mean and median scores. The IQR post-intervention further suggests that the engagement levels became more consistent among the students, indicating that more students were equally involved across all aspects of the course. These changes highlight that the intervention was effective in enhancing engagement, fostering increased involvement and deeper connection with the course material.

Table 4: Wilcoxon Signed-Rank Test Results for Engagement Measures

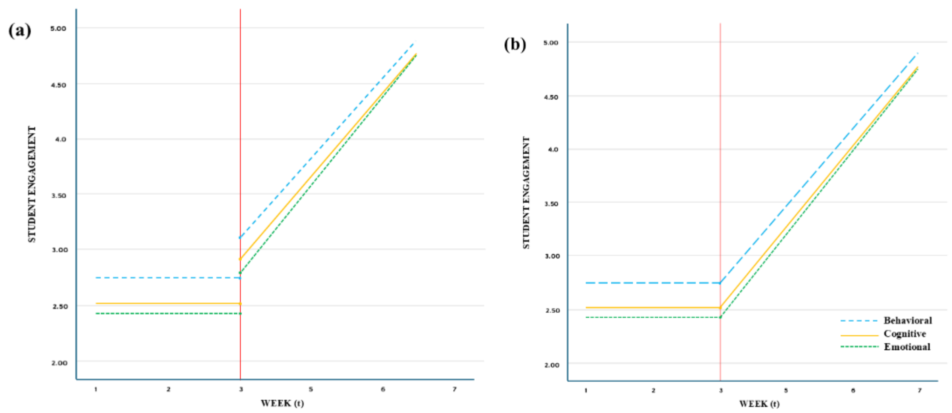
	W	***z***	***p***	***r***	***Decision***
Behavioral (Pre) – Behavioral (Post)	465	-4.784	< .001	-0.873	**Reject H_0**
Cognitive (Pre) – Cognitive (Post)	465	-4.783	< .001	-0.873	
Emotional (Pre) – Emotional (Post)	465	-4.783	< .001	-0.873	
Overall (Pre) – Overall (Post)	**465**	**-4.782**	**< .001**	**-0.873**	

α = 0.05 level of significance

The results of the Wilcoxon Signed-Rank Test showed that all comparisons—behavioral (W = 465, z = -4.784, p < .001, r = -.873), cognitive (W = 465, z = -4.783, p < .001, r = -.873), and emotional engagement (W = 465, z = -4.783, p < .001, r = -.873)—yielded significant results with large effect sizes. This significant improvement across all engagement dimensions demonstrates that the intervention was effective in enhancing student participation and connection to the course material, providing strong evidence of the intervention's success in increasing student engagement. The rejection of the null hypothesis supports the alternative hypothesis, confirming the positive impact of the object detection intervention on student engagement.

Evaluation of changes in the level and slope of student engagement levels (behavioral, cognitive, and emotional) in the Networking course.

Figure 1: Trends in Student Engagement Dimensions



Note. The vertical red line indicates the point at which the PictoBlox object detection intervention was implemented.

Figure 1 illustrates the trends in student engagement over the course of the study. The graph is divided into two panels. Panel (a) highlights the level change, showing the shifts in engagement scores across three dimensions—behavioral, cognitive, and emotional—before and after the intervention. Panel (b) depicts the slope change, representing how the rate of engagement evolved over time following the intervention. The x-axis spans the seven-week duration of the study, excluding the fourth week, which served as the baseline period. The subsequent intervention phase occurred during Weeks 5–7. The y-axis reflects the mean engagement scores for each dimension.

As shown in Figure 1, it shows significant changes in both the level and slope of student engagement following the intervention. Panel (a) highlights that the introduction of the object detection intervention led to an immediate level change across all three engagement dimensions, with a noticeable rise in student participation. Panel (b) illustrates the significant acceleration in engagement following the intervention, particularly in emotional engagement, which showed the steepest increase.

Table 5: Segmented Regression Analysis of Behavioral, Cognitive, and Emotional Engagement

Parameter	b (SE)	*t*	*p*	95% CI
		Behavioral		
β_0	2.43 (0.04)	61.23	< .001**	[2.35, 2.51]
β_1	-0.00 (0.02)	0.00	1.000	[-0.04, 0.04]
β_2	1.17 (0.05)	25.31	.002*	[1.07, 1.27]
β_3	0.39 (0.03)	14.82	.005**	[0.33, 0.45]
		Cognitive		
β_0	2.51 (0.04)	70.70	< .001**	[2.44, 2.58]
β_1	0.01 (0.02)	0.30	.790	[-0.03, 0.04]
β_2	1.42 (0.04)	34.17	< .001**	[1.34, 1.50]
β_3	0.28 (0.02)	11.82	< .007*	[0.23, 0.33]
		Emotional		
β_0	2.74 (0.01)	277.55	< .001**	[2.72, 2.76]
β_1	0.01 (0.00)	1.10	.388	[-0.00, 0.01]
β_2	1.44 (0.01)	124.93	< .001**	[1.41, 1.46]
β_3	0.24 (0.01)	36.41	< .001**	[0.22, 0.25]

Note. β_0 – Baseline Level; β_1 – Pre-Intervention Trend; β_2 – Level Change; β_3 – Slope Change
***p < .001, *p < .01.*

The segmented regression analysis confirmed these findings, with statistically significant level changes (b = 1.17, p = .002 for behavioral; b = 1.42, p < .001 for cognitive; b = 1.44, p < .001 for emotional) and slope changes (b = 0.39, p = .005 for behavioral; b = 0.28, p = .007 for cognitive; b = 0.24, p < .001 for emotional). These results indicate that the intervention not only increased engagement immediately but also accelerated the rate of improvement over time, especially in emotional engagement. This sustained improvement underscores the efficacy of interactive technologies in fostering student engagement and suggests that the intervention had a profound and lasting influence on students' emotional connection to the course. The findings further highlight the importance of incorporating interactive and technology-driven strategies to enhance student engagement in technical subjects.

CONCLUSIONS

The results of this study confirm that the introduction of the object detection intervention had a significant and positive impact on student engagement across all three dimensions: behavioral, cognitive, and emotional. Prior to the intervention, students demonstrated intermediate engagement levels, suggesting a need for active strategies to enhance participation and involvement. Post-intervention, a marked increase in engagement was observed in all areas, indicating the effectiveness of the intervention in fostering higher levels of involvement and connection to the course material.

The analysis also revealed a statistically significant improvement in engagement levels, supported by strong statistical evidence, confirming the effectiveness of the intervention in enhancing student engagement. The immediate increase in engagement following the intervention, coupled with a sustained rate of improvement, particularly in emotional engagement, underscores the potential of interactive technologies in transforming the learning experience. Furthermore, the rejection of the null hypothesis confirms that the intervention led to measurable improvements in engagement across all dimensions.

These results suggest that integrating hands-on, technology-driven approaches can play a critical role in enhancing student engagement in technical courses, ensuring that students are not only present but actively participating, thinking critically, and forming deeper connections with the material. The study highlights the importance of adopting such strategies in educational settings, particularly in technical disciplines, to foster a more dynamic and engaging learning environment.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are proposed:

1. **For Curriculum Enhancement and Practical Application**, given the significant improvement in student engagement following the intervention, it is recommended to integrate object detection projects using PictoBlox into the Networking Course curriculum. The development of curriculum guidelines should encourage the incorporation of technology-enhanced projects to increase engagement and foster deeper learning experiences. These guidelines should be adaptable to allow instructors to tailor strategies to specific courses and student populations, addressing the need for personalized engagement.
2. **For Educational Institutions**, they should focus on providing adequate training and support for instructors to effectively integrate technology-enhanced learning strategies. The study revealed that students experienced significant increases in engagement when interactive technologies, such as PictoBlox, were used. Therefore, institutions must ensure that instructors have the necessary resources and training to implement such technologies. Additionally, institutions should consider broadening the implementation of object detection projects and similar interventions to other technical courses, thereby enhancing student engagement in a range of subjects.
3. **For Professional Development Programs**, to further improve the quality of student engagement, educators should enhance their skills in designing and implementing technology-driven learning experiences. As demonstrated in this study, interactive learning projects can significantly improve student involvement. Professional development programs should emphasize the use of innovative educational technologies and pedagogical strategies to promote active student participation. With technological advances continuing to shape education, it is essential for educators to remain informed and proficient in the latest tools and methods to create high-quality learning experiences.
4. **For Policy Recommendations**, based on the positive impact observed in this study, it is crucial for educational policymakers and administrators to allocate resources for the integration of technology-

enhanced learning strategies into curricula. This includes funding for the required infrastructure, software, and professional development for instructors. The study's findings indicate that technology-driven interventions can have a sustained impact on student engagement. Ensuring sustainable access to such technologies will enable continuous improvements in student participation and overall academic success.

5. **For Collaboration**, a collaboration between educational institutions, technology developers, and industry stakeholders should be fostered to create and disseminate innovative learning tools and resources. The study's positive results suggest that hands-on, interactive learning technologies can enhance student engagement, not just in one course, but across technical disciplines. Partnerships can help ensure that educational tools are relevant, effective, and aligned with industry needs, preparing students with the practical skills necessary for the workforce. This collaboration could lead to new, engaging tools that continuously improve educational experiences and better meet the needs of both students and the industries they will serve.
6. **For Future Researchers:** Future research could expand the scope of this study by increasing the sample size and including students from different academic programs or institutions, which could provide more generalized insights into the effectiveness of object detection projects across diverse student populations. Future researchers may also consider using a control group to strengthen the study's internal validity and enhance the generalizability of the results. Finally, exploring different types of technology-enhanced learning tools and comparing their effects on various dimensions of engagement would help identify the most effective strategies for fostering student involvement in technical education.

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