Preliminary Analysis: Development of the TSABIT (Technology Supported Augmented Reality to Build Interactive Teaching) Learning Model to Improve Student Competence in Invertebrate Zoology Courses

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Abstract. This study presents a preliminary analysis aimed at developing the TSABIT (Augmented Reality-Based Technology for Interactive Learning) learning model to improve student competence in the Invertebrate Zoology course. This preliminary analysis uses descriptive statistical techniques, including measures of central tendency, range, and variability. The results show that students' initial academic performance was in the moderate category, with an average score of 63.96 and a standard deviation of 14.19, indicating considerable variation in learning outcomes. The analysis highlights the potential of augmented reality (AR)-based learning in supporting better visualization of abstract concepts, increasing student engagement, and encouraging active participation in the learning process. Therefore, the development of the TSABIT model is considered relevant as an innovative instructional approach. This study provides an important empirical basis for designing effective, innovative, technology-based learning models that meet the demands of 21st-century higher education.

Keywords: Augmented Reality Media, Interactive model, Invertebrate Zoology, Student Competence, TSABIT Model

1 Introduction

The learning process must follow interests and developments of the times so that educational goals can be optimally achieved. The teaching and learning process is a complex system that involves interaction between various components to achieve learning objectives. [1] in his book quotes Piaget's theory of assimilation, which states that the process of responding to the environment is an adjustment between cognitive structures and the physical environment. Good learning is learning that is in line with the characteristics of the learners and the optimal utilization of the learning environment [2]. Thus, learning methods must also be adapted to the learners' environment, which is currently greatly influenced by the rapid development of technology.

The five main components in the learning process include educators as communicators, teaching materials, learning media, learners, and learning objectives [3]. Learning models must be adapted to the characteristics of today's learners, where the learning models used are expected

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to increase interest, motivation, active involvement, and significantly improve student learning outcomes. Learning models will continue to be updated. Gardner and cognitive science researchers believe that a person's intelligence is not genetically fixed but can be significantly improved through an attentive, stimulating, and challenging learning environment. One of Dara's [4] studies shows that Gardner's theory of multiple intelligences can be used to accommodate the learning preferences of each individual learner in a computer-assisted learning environment.

Vygotsky's theory also claims that learning will be most effective when individuals learn and are placed in a supportive learning environment and when they receive appropriate guidance mediated by “tools.” These instructional tools can be cognitive strategies, teachers, peers, teaching materials, or other media and instruments organized to provide information to learners [5]. The development of modern learning theory places students as active subjects in the learning process. One learning model that emphasizes this is the interactive learning model, which is based on constructivism theory and emphasizes the active involvement of students in the learning process.

According to Vygotsky, effective learning occurs through social interaction, collaboration, and support from the surrounding environment (scaffolding) within the student's zone of proximal development [6]. Learning should encourage active student engagement through direct experience. Interactive learning is also in line with the concept of active learning, which is a learning strategy that involves students in higher-order thinking activities such as analyzing, evaluating, and creating. According to Johnson [7], interaction in learning can take many forms, ranging from interaction between students and lecturers, students and students, to students and learning media.

In the context of digital learning, the theory of connectivism introduced by Siemens and Downes is becoming increasingly relevant. This theory emphasizes that learning in the information age takes place through connections between communities, digital media, and global information networks [8]. For this reason, the author conducted preliminary observations to identify accurate problems so that the development of learning models and media could be tailored to the needs of students. Preliminary observations also served to identify real facts and problems that could be solved and to reflect on issues that were currently being discussed in the world of education. According to Rusdi [9] problems originating in the workplace are essentially real everyday problems faced by educational institutions and can help practitioners improve their performance.

Current developments in educational technology have led to the emergence of various learning innovations aimed at improving the quality of the teaching and learning process. One promising approach is the use of Augmented Reality (AR), which can present abstract objects in a more concrete and interactive way. In the context of Invertebrate Zoology learning, the use of AR is very relevant because the material presented is often complex, detailed, and requires three-dimensional visualization to be easily understood by students. To address these needs, the TSABIT (Technology Supported Augmented Reality To Build Interactive Teaching) learning model was developed, designed to improve student competence through visual, interactive, and exploration-oriented learning experiences. Before this model is implemented further, a preliminary analysis is needed to identify students' initial conditions, academic performance, and potential problems that can be overcome through the TSABIT model.

This article presents a preliminary analysis based on student scores in the Invertebrate Zoology course, as a basis for developing the TSABIT model in a more focused and needs-oriented manner.

2 Method

The data utilized in this study were derived from students' academic performance in the *Invertebrate Zoology* course. As an initial stage, a preliminary analysis was conducted using a descriptive statistical approach to obtain a comprehensive overview of students' baseline competence prior to the implementation of the TSABIT (Technology Supported Augmented Reality to Build Interactive Teaching) learning model.

The descriptive statistical measures employed in this analysis include the mean, median, minimum and maximum values, as well as the standard deviation. These statistical indicators are used to examine the distribution patterns of student scores, identify variations in learning achievement, and evaluate the overall level of students' mastery of course content. This preliminary analysis serves as a foundational step in determining the urgency and relevance of developing the TSABIT learning model to enhance student competence.

Population and Sample

The population of this study comprises all students enrolled in the *Invertebrate Zoology* course during the semester in which the research was conducted. The sampling technique applied in this study is total sampling, whereby all members of the population are included as research participants. However, in cases where the population size is relatively large, a stratified random sampling technique may be employed to ensure adequate representation across different levels of student ability.

Descriptive Statistics

1. Mean

For a sample of size nnn with observations

$$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i \tag{1}$$

2. Median

Sort the data. If nnn is odd, the median = the middle value; if even, the median = the average of the two middle values.

3. Sample variance (s2)

$$s^2 = \frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})^2 \tag{2}$$

4. Standard Deviation)s)

$$s = \sqrt{s^2} = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(x_i - \bar{x})^2} \tag{3}$$

5. Range

$$\text{Range} = x_{max} - x_{min} \tag{4}$$

6.Percentage (%) for the frequency of a class

$$\% = \frac{f}{N} \times 100\% \tag{5}$$

3 Results and Discussion

Based on the data presented in Table 1 and Table 2, it can be seen that the level of effectiveness of program implementation is influenced by several key factors, namely the quality of committee communication, the intensity of promotion, and institutional collaboration with other campuses. The relationship between these three variables shows that the better the internal coordination and the stronger the promotional strategy used, the higher the overall program performance. This confirms that program failure cannot be viewed solely as a technical error, but rather as the result of systemic failure in the program management process.

Table 1. Frequency distribution of student scores (based on range of values)

Range of values	Category	Frequency	Percentage (%)
90–100	Very good	3	6%
80–89	Good	6	12%
70–79	Fairly good	10	20%
60–69	Fair	14	28%
50–59	Poor	9	18%
30–49	Very poor	8	16%
Total	—	50	100%

Table 2. Summary of distribution and interpretation

Aspect	Result
Dominant value range	60–69 (adequate category)
Higest score group	90–100 (excellent), only a small number of students
Lowest score group	30–49 (very poor), indicating students who are still struggling
Distribution pattern	Relatively balanced, but with significant variation
Learning indication	Students have diverse abilities → need an adaptive model such as TSABIT

The average score of 63.96 indicates that, in general, students are in the adequate category in terms of mastery of the material. This indicates that the basic learning level has been achieved, but has not yet shown optimal results. The median of 60, which is close to the average score, indicates that the distribution of scores is relatively balanced. Most students have scores in the range of 60–70, which shows a tendency for achievement in the middle range. The standard deviation of 14.19 indicates that there is considerable variation in performance among students. This means that students' abilities are not homogeneous. There is a group of students who are able to achieve very good scores (even reaching the maximum score of 100), However, there were also groups that scored as low as 30.

When compared to Stakeholder Theory, particularly in the implementation of educational programs, each party involved must understand their roles, responsibilities, and contributions to the program's achievements [10]. The lack of communication between stakeholders, especially between the committee and the partner campus, shows that the principle of coordination is not working as it should. This ultimately creates a misalignment between the program's objectives and operational actions in the field.

In addition, Organizational Communication theory [11] emphasizes that unclear communication channels can hinder teamwork, reduce the quality of collaboration, and cause information distortion. In this case, weak communication flows resulted in ineffective promotion and failure to optimally reach the target audience. This is in line with the table data showing that promotion was one of the lowest indices.

From an educational marketing perspective, promotion is part of the marketing mix (Educational Marketing Mix) that influences public perception and participation decisions [12]. When the intensity of promotion is low and not well segmented, the level of community participation will also decline. This data confirms this relationship because the lack of promotional activities is a direct cause of the low number of participants. Furthermore, the low level of institutional collaboration can be explained by the Collaborative Governance theory, which states that the success of inter-institutional cooperation is highly dependent on trust, intensive communication, and a clear coordination structure [13]. The failure of the international seminar program was caused by the collapse of these cooperation mechanisms, resulting in the collaborative objectives not being achieved.

Several empirical studies have also shown the positive impact of implementing interactive learning models. A study at a university showed that this model increased student learning activity from 56.55% to 81.55% and raised the average post-test score from 70 to 81.43 [14]. Another study on elementary school students revealed that interactive learning can increase students' motivation to learn, creativity, and attention to subject matter [15]. Similar findings were also found in the context of history learning at the high school level, where social interaction between students in discussions significantly strengthened cognitive learning outcomes [16]. Even at the elementary education level, the use of thematic-based interactive models has been proven to improve students' conceptual mastery and rational thinking skills [17]. On the other hand, the application of interactive multimedia in the Quantum Learning model has succeeded in improving the logical thinking skills of vocational high school students [18]. Through this theoretical and empirical evidence, it can be concluded that interactive learning models not only enrich the learning experience but also significantly improve the quality of student learning outcomes. Therefore, the development and application of interactive learning models based on strong theories and relevant to the needs of the times are important to improve the effectiveness of education at various levels.

Research conducted by Siti Anisyah et al. [19] found that AR media significantly improved student learning outcomes. In research by Sriadhi [20] on the effectiveness of Augmented Reality, the results showed that Augmented Reality-based learning media improved student learning outcomes. Furthermore, the study found that cognitive abilities have a positive influence on learning outcomes, and that students with high cognitive abilities achieve better learning outcomes than students with low cognitive abilities. In addition, Augmented Reality-based learning media developed using an exploratory tutorial model proved to be effective for all students.

Based on these conditions, the development of an AR based learning model (TSABIT) is empirically and pedagogically justified. AR supports three-dimensional visualization, enables interactive exploration of invertebrate anatomical structures, and provides space for differential learning through features such as step-by-step modules, real-time feedback, and adaptive quizzes. Thus, TSABIT is designed not merely as a technological gimmick, but as an intervention that targets two core problems revealed by the data: (1) improving conceptual understanding for students who have visual-spatial difficulties, and (2) providing adaptable learning paths so that low-range students can systematically improve their competence. Furthermore, the findings on value variation open up a clear evaluative agenda: every TSABIT design must be accompanied by a continuous formative assessment mechanism to monitor the reduction in variability (reducing SD) and the increase in average achievement. The evaluative target is not only to increase the mean but also to narrow the gap between the lower and upper quartiles so that learning outcomes are more evenly distributed. In summary, this preliminary data provides strong justification for TSABIT development research: there is a real need, not just a hypothetical one, for a multimodal, adaptive, and technology-integrated learning approach. Given the complex and visual characteristics of Invertebrate Zoology material, TSABIT has the potential to be a practical solution to reduce performance disparities, increase engagement, and encourage more equitable competency achievement among students.

4 Conclusion

Preliminary analysis of student data shows that students' initial competency is in the adequate category, with an average score of 63.96 and a median of 60. Although the distribution of scores is relatively balanced, the high standard deviation (14.19) indicates significant variation in learning abilities among students. This condition confirms that learning needs to be designed adaptively in order to accommodate differences in the characteristics and abilities of learners [21].

The development of the TSABIT (Technology Supported Augmented Reality to Build Interactive Teaching) learning model is relevant as an innovative solution to address these challenges. Various studies show that the application of Augmented Reality in learning can improve conceptual understanding, especially in abstract and complex material, through three-dimensional visualization and direct interaction with learning objects [23,24]. This is highly relevant to the characteristics of the Invertebrate Zoology course, which requires a deep understanding of morphological structures and biological concepts.

In addition, the use of AR has also been proven to increase student motivation, active engagement, and participation in the learning process, thereby having a positive impact on learning outcomes and competency mastery [24,25]. Thus, the development of the TSABIT model not only has a strong empirical basis but is also in line with the demands of 21st-century learning, which emphasizes the use of digital technology to create interactive, contextual, and student-centered learning.

Overall, the results of this initial analysis provide a strong foundation for designing the TSABIT model to be more focused and effective in improving student competencies, as well as having the potential to make a significant contribution to the development of technology-based learning models in higher education.

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