Al-Jahiz: Journal of Biology Education Research
ISSN 2722-5070 (Print) ISSN 2722-5275 (Online)
Vol. 7 No. 2 July-December 2026
Available online at:
http://e-journal.metrouniv.ac.id/index.php/Al-Jahiz

# The IMUNOPOLI Board Game: Effects on Students' Self-Efficacy and Emotional Intelligence in Learning the Immune System

**Karina Nur Aliyah[1], Adi Rahmat[2*], Yanti Hamdiyati[3], Dewi Susanti[4], Muhamad Wafda Jamil[5]**
[1, 2, 3, 4] Indonesia University of Education
Jalan Dr. Setiabudi No. 229, Isola, Kec. Sukasari, Kota Bandung, Jawa Barat, Indonesia
[5]Seoul National University
Gwanak-ro, Gwanak-gu, Seoul, South Korea
*Corresponding author: adirahmat@upi.edu

**Article Information**

**Article History:**
Received: May 13, 2026
Revised: October 29, 2026
Published: November 08, 2026

**Keywords:**
Board game, Self-efficacy, Emotional intelligence

**ABSTRACT**

This study aimed to examine the effect of the IMUNOPOLI board game on students' self-efficacy and emotional intelligence in immune system learning, with concept mastery included as a supporting variable to contextualize learning outcomes. A quasi-experimental method with a Non-equivalent Control Group Design was used, involving 60 students, at a state senior high school in Bandung City, divided into an experimental and a control group (each with 30 students). Data were collected using a self-efficacy questionnaire (15 items), an emotional intelligence questionnaire (33 items), and a concept mastery multiple-choice test (25 items). Data were analyzed using the Mann-Whitney test, score categorization, effect size via rank biserial correlation, and Spearman correlation to explore the relationships among the variables. Descriptively, the experimental group showed a greater shift toward high self-efficacy than the control group, though this difference did not reach statistical significance. Emotional intelligence in the experimental group remained stable due to a baseline ceiling effect, whereas the control group showed a more noticeable increase, resulting in no statistically significant post-test differences between groups. Furthermore, no statistically significant correlations were found among self-efficacy, emotional intelligence, and concept mastery. These findings indicate that while IMUNOPOLI descriptively supported self-efficacy and maintained high emotional intelligence levels, it did not demonstrate statistically significant superiority over conventional instruction, highlighting the importance of initial student conditions in game-based learning interventions.

How to Cite
Aliyah, K. N., Rahmat, A., Hamdiyati, Y., Susanti, D., Jamil, M. W. (2026). The IMUNOPOLI Board Game: Effects on Students' Self-Efficacy and Emotional Intelligence in Learning the Immune System. *Al Jahiz: Journal of Biology Education Research* 7(2), 415–434. DOI: https://doi.org/10.32332/al-jahiz.v7i1.13596.

Published by
Al-Jahiz: Journal of Biology Education Research
Website
https://e-journal.metrouniv.ac.id/index.php/Al-Jahiz/index
This is an open access article under the CC BY SA license
https://creativecommons.org/licenses/by-sa/4.0/

## INTRODUCTION

Modern education demands that students not only master knowledge but also develop skills such as communication, collaboration, critical thinking, and problem-solving (Szabo et al., 2020). However, these skills cannot develop optimally without support from socio-emotional factors, particularly self-efficacy and emotional intelligence. Self-efficacy determines students' confidence in facing challenges and completing tasks, while emotional intelligence helps students manage their emotions, build social relationships, and maintain their motivation to learn (Dewi et al., 2023; Quílez-Robres et al., 2023). Emotional intelligence has been shown to facilitate the accumulation of positive emotional experiences and the reduction of negative emotional experiences, thereby mitigating the occurrence of emotional exhaustion. Consequently, emotional intelligence can enhance an individual's ability to overcome adversity, gradually accumulate positive psychological resources, and increase confidence in their learning and work. This contributes to the formation of self-efficacy (Gharetepeh et al., 2015; Tang & He, 2023). These two aspects are closely related, as individuals with high emotional intelligence tend to maintain their self-confidence under academic pressure, thereby sustaining their self-efficacy (Chang & Tsai, 2022).

The importance of emotional intelligence and self-efficacy becomes particularly evident when students are confronted with complex and abstract topics, such as the immune system in biology. As an interdisciplinary subject, the immune system requires students to integrate prior knowledge from various fields, including cell biology, biochemistry, anatomy, and genetics. Its conceptual complexity, extensive use of technical terminology, and the need to apply knowledge across different contexts often make it challenging for students to understand, retain, and actively engage with the material (Cahyani et al., 2024; Stranford et al., 2020; Teng et al., 2021). Moreover, learning about the immune system is essential not only for developing scientific understanding but also for fostering students' awareness of their own health and well-being (Rahmawati et al., 2024; Siani et al., 2024). When teaching strategies are not innovative, this can further hinder the development of both aspects while also weakening students' cognitive framework (Novallyan et al., 2023).

One approach considered effective in building self-efficacy and emotional intelligence is Game-Based Learning (GBL), particularly through interactive board games that promote student-centered learning (Tsai et al., 2021). The use of board games can create a positive collaborative environment where students work in teams to overcome challenges and develop communication skills, problem-solving abilities, and self-confidence (Hosseinpour & Keshmiri, 2025; Meccawy et al., 2023). The experience of success during gameplay directly contributes to the formation of self-

efficacy through mastery experience (Bandura, 1997), while the dynamics of interaction among team members implicitly train components of emotional intelligence, such as emotional regulation and empathy (Schutte et al., 1998).

Although many studies have demonstrated the potential of game-based learning (GBL), several important gaps remain in the literature. Previous findings on the effects of GBL on self-efficacy have been inconsistent, and many studies have examined GBL broadly or focused primarily on digital games rather than on non-digital board games within specific subject areas (Clark et al., 2016; Sailer & Homner, 2020). In the context of educational board games, most existing research has concentrated on short-term cognitive outcomes, leaving the effects on emotional and motivational factors, such as self-efficacy and emotional intelligence relatively underexplored (Cardinot & Fairfield, 2019; Mostowfi et al., 2016). Moreover, the absence of a standardized framework for designing educational board games means that each game is typically developed for a particular learning objective (Videnovik et al., 2023), which limits the comparability of findings across studies and educational contexts. Of particular concern is the scarcity of research that simultaneously examines the relationship between board game-based learning, self-efficacy, and emotional intelligence within the domain of biology education. To address these gaps, this study investigates the role of IMUNOPOLI, an innovative board game specifically designed for biology learning, in fostering students' self-efficacy and emotional intelligence during the study of the immune system. Unlike prior board games that generally focus on a single learning objective without an explicit mechanism linking gameplay to socio-emotional constructs, IMUNOPOLI was specifically designed with a collaborative, turn-based challenge structure. This structure creates repeated mastery and vicarious-learning experiences that directly target self-efficacy and emotional intelligence, rather than treating these constructs as incidental by-products of play. Furthermore, because self-efficacy and emotional intelligence are difficult to interpret in isolation from actual comprehension, concept mastery was incorporated to provide a concrete cognitive backdrop. This allows the study to distinguish genuine, knowledge-grounded confidence from confidence lacking conceptual understanding.

In addition to self-efficacy and emotional intelligence as the primary variables, concept mastery is included as a complementary variable. This inclusion is grounded in the understanding that self-efficacy and emotional intelligence represent psychological (affective) factors that shape the learning process, including motivation, confidence, and emotional regulation. However, to ensure that these psychological factors translate into meaningful learning outcomes, a cognitive indicator is needed to capture the depth of students' conceptual understanding rather than mere

rote memorization. Therefore, concept mastery serves as a cognitive baseline to confirm whether improvements in self-efficacy and emotional intelligence are accompanied by actual subject matter comprehension. Ultimately, integrating these variables provides a more holistic assessment of student learning outcomes across both the affective and cognitive dimensions.

## RESEARCH METHODS

This study employed a quasi-experimental method with a Non-equivalent Control Group Design (Figure 1). This design was chosen because it is appropriate when full randomization is not feasible in real educational settings, yet researchers seek to evaluate the causal effect of an intervention by comparing groups that differ primarily in the treatment received (L. Cohen et al., 2018). In addition, the quasi-experimental approach is widely adopted in educational research conducted under natural classroom conditions, where pre-existing class groups serve as intact units of analysis (Sugiyono, 2007).

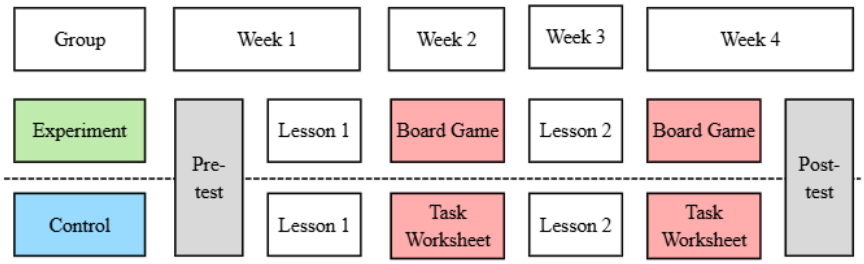



**Figure 1. Research Design for the Application of a Board Game in Immune System Learning**

As illustrated in Figure 1, the instructional intervention was structured across four weeks into two core lesson blocks (Lesson 1 and Lesson 2), each followed by a designated reinforcement session in Week 2 and Week 4. Lesson 1 focused on non-specific (innate) immune defense mechanisms, while Lesson 2 covered specific (adaptive) immune defense mechanisms and immune system disorders, aligning directly with the main conceptual categories assessed in the concept mastery test (Table 4). In both sessions, direct instruction was delivered first, after which the experimental group played the IMUNOPOLI board game while the control group completed equivalent task worksheets covering identical subject matter. The board games functioned specifically as scaffolded, retrieval-practice activities designed to reinforce newly acquired knowledge rather than deliver new content. Although Board Game 1 and Board Game 2 shared identical game rules, boards, and mechanical structures, they differed in their content coverage, pedagogical objectives, and challenge card sets. Specifically, Board Game 1 (implemented in Week 2) aimed to consolidate foundational knowledge of innate immunity, with its challenge cards strictly limited to non-specific defense mechanisms such as physical barriers, inflammatory

responses, and phagocytosis. In contrast, Board Game 2 (implemented in Week 4) aimed to extend conceptual understanding to complex adaptive responses and systemic disorders, utilizing challenge cards that emphasized specific immunity and immune disorders while integrating review items from Lesson 1 to maintain conceptual continuity across the entire unit.

This study was conducted from January 19–30, 2026, at a state senior high school in Bandung City, involving 60 eleventh-grade students divided into an experimental group and a control group, with 30 students in each group. The participants were aged 16 to 17 years and were enrolled in the natural science track. The sample consisted of 38 male students (63.3%) and 22 female students (36,7%), with similar gender distributions across the experimental (13 males, 17 females) and control groups (25 males, 5 females). All participants had completed identical prerequisite biology coursework under the same national curriculum framework, ensuring comparable academic backgrounds prior to the intervention. Both groups were selected through convenience sampling because the intervention required intact, pre-existing classes that could be taught within their regular weekly schedule without disrupting the school's academic calendar. Additionally, this sampling technique was adopted due to the accessibility of the participating teacher and classes within the study's timeframe, aligning with the intact-group logic of the non-equivalent control group design (Cohen et al., 2018). The research instruments consisted of three types, as presented in Table 1.

**Table 1. Research Instrument**

| Data | Instrument Type | Instrument Form | Number | Data Source |
|---|---|---|---|---|
| Self-efficacy | Non-Tes | Questionnaire | 15 items | Students |
| Emotional Intelligence | Non-Tes | Questionnaire | 33 items | Students |
| Concept Mastery | Tes | Multiple Choice | 25 items | Students |

The self-efficacy and emotional intelligence questionnaires served as the primary instruments, while the concept mastery test functioned as a supporting instrument. All three instruments were administered during both the pre-test and post-test. The concept mastery test was included to provide cognitive context on students' conceptual understanding throughout the intervention, and its results were statistically analyzed alongside the self-efficacy and emotional intelligence data to examine the relationship between students' psychological development and their conceptual learning outcomes. The self-efficacy questionnaire demonstrated high internal consistency (Cronbach's $\alpha = 0.94$), while the emotional intelligence scale yielded $\alpha = 0.90$.

Students' self-efficacy was measured using a 15-item questionnaire with a nine-point scale, adapted from Frankenstein et al. (2022), covering students' confidence in explaining, classifying, identifying, analyzing, and applying immune system concepts (Table 2).

**Table 2. The Framework of Self-efficacy Questionnaire in Immune System Learning**

| Framework | Item Number | Total Item |
|---|---|---|
| Belief in their ability to explain concepts in immune system material | 1, 2, 3, 5 | 4 |
| Belief in their ability to classify concepts in immune system material | 4, 9 | 2 |
| Belief in their ability to identify concepts in immune system material | 6, 7, 8, 13 | 4 |
| Belief in their ability to analyze concepts in immune system material | 10, 11 | 2 |
| Belief in their ability to apply concepts in the immune system material | 12, 14, 15 | 3 |
| **Total** | | 15 |

Students' emotional intelligence was measured using a 33-item questionnaire with a nine-point scale, adapted from the Schutte Emotional Intelligence Scale (SEIS) by Schutte et al. (1998), encompassing appraisal and expression of emotion, regulation of emotion, and utilization of emotion (Table 3).

**Table 3. The Framework of Emotional Intelligence Questionnaire in Immune System Learning**

| Aspect | Indicator | Item Number | Total Item |
|---|---|---|---|
| Appraisal and expression of emotion | Regulation and utilization of emotion in problem-solving | 3,7,8,9,10,15,16, 19,21,24,22,25, 26 | 13 |
| Regulation of emotion | Ability to cope with and control one's own and others' emotions | 33*,32,29,18,11,5*, 4,1,2,6 | 10 |
| Utilization of emotion | Ability to plan, think, pay attention, and motivate oneself and one's social surroundings | 31,30,28*,27,20,17, 14,13,12,23 | 10 |
| **Total** | | | 33 |

Unlike the questionnaire-based variables, students' concept mastery of the immune system was measured using an objective test administered in two stages: a pre-test before the intervention and a post-test after its completion. The test consisted of 25 multiple-choice items with five answer options (Table 4), developed according to The New Taxonomy framework by Marzano & Kendall (2007).

**Table 4. Pre-test and Post-test Grids based on The New Taxonomy (Marzano & Kendall, 2007)**

| Cognitive Level | Cognitive Process | Indicator | Number of Items |
|---|---|---|---|
| Level 1 (Retrieval) | Recognizing | Identifying the main criteria for classifying a cell as part of the specific immune defense system. | 1 |

| Cognitive Level | Cognitive Process | Indicator | Number of Items |
|---|---|---|---|
| | | Identifying components of the specific immune system based on given characteristics. | 2 |
| | Recalling | Recalling the definition of the non-specific immune system. | 1 |
| | | Providing examples of non-specific immune defense components. | 1 |
| | | Recalling specific information about the type of protein that inhibits viral replication. | 1 |
| Level 2 (Comprehension) | Integrating | Analyzing the relationship between histamine release and the mechanism of inflammation symptoms. | 1 |
| | | Explaining the mechanism of interferon as a non-specific immune response to viral infection. | 1 |
| | | Distinguishing the characteristics of humoral and cellular immune mechanisms. | 1 |
| | | Explaining the basic mechanism of active artificial immunity formation in vaccination. | 1 |
| | Symbolizing | Sequencing the stages of the immune response mechanism in allergy patients. | 1 |
| Level 3 (Analysis) | Classifying | Grouping components that are part of the non-specific and specific immune systems. | 2 |
| | | Classifying examples of immunity acquisition into specific immunity types. | 1 |
| | | Classifying specific processes that occur during humoral and cellular immune responses. | 1 |
| | Analyzing Errors | Analyzing potential errors in blood transfusion procedures based on antigen-antibody compatibility concepts. | 1 |
| | | Analyzing errors in a given statement. | 1 |
| | Generalizing | Formulating generalizations about the differences in working principles between humoral and cellular immunity in handling pathogens. | 1 |
| | | Connecting specific clinical symptoms to the underlying general concepts. | 1 |
| | | Drawing general conclusions about the impact of nervous system | 1 |

| Cognitive Level | Cognitive Process | Indicator | Number of Items |
|---|---|---|---|
| | | disorders based on the analysis of several specific cases. | |
| Level 4 (Knowledge Utilization) | Decision Making | Determining the appropriate decision to prevent and/or overcome immune system disorders. | 3 |
| | Problem Solving | Determining the appropriate solution to address immune system disorders. | 2 |
| **Total** | | | 25 |

Prior to statistical analysis, assumption tests for normality were performed using the Shapiro-Wilk test. The results indicated that the data for self-efficacy, emotional intelligence, and concept mastery significantly departed from a normal distribution ($p < 0.05$). Consequently, non-parametric tests were employed. The self-efficacy and emotional intelligence data were analyzed using the Mann-Whitney test, categorized based on (Cassady & Johnson, 2002) as shown in Table 5. Effect size calculations were performed using the rank biserial correlation ($r_{rb}$), which is a rank-based effect size measure that does not require the assumption of a normal distribution. Therefore, it is more appropriate for use with the Mann-Whitney test than parametric measures such as Cohen's d (Glass, 1966; Kerby, 2014), interpreted according to (Cohen, 1988) as shown in Table 6. Concept mastery data were analyzed using the Mann-Whitney test and N-Gain (Hake, 1998) as shown in Table 7.

**Table 5. Grouping and Categorization of Students' Self-Efficacy and Emotional Intelligence (Cassady & Johnson, 2002)**

| Score Range | Category |
|---|---|
| 0-33% | Low |
| 34-66% | Medium |
| 67-100% | High |

**Table 6. Effect Size Categories (Cohen, 1988)**

| Effect Size Value | Interpretation |
|---|---|
| <0.10 | Negligible |
| 0.10-0.30 | Small |
| 0.31-0.50 | Medium |
| >0.50 | Large |

**Table 7. N-Gain Categorization (Hake, 1998)**

| Score Range | Interpretation |
|---|---|
| g<0.3 | Low |
| 0.3<g<0.7 | Medium |
| g>0.7 | High |

The relationships among the three variables were analyzed using the Spearman correlation coefficient, as the data did not meet the assumptions of parametric tests.

## RESEARCH RESULT

### Normality Assumption Test Results

The outcome of the Shapiro-Wilk test confirmed that all pre-test and post-test scores for self-efficacy, emotional intelligence, and concept mastery significantly deviated from a normal distribution ($p < 0.05$). These test outputs established the empirical basis for applying non-parametric procedures specifically the Mann-Whitney test and rank biserial correlation ($r_{rb}$) in presenting the subsequent findings.

### Self-efficacy Outcomes

Self-efficacy was measured using a 15-item questionnaire administered to both groups before and after four weeks of instruction. Data on students' self-efficacy in both research groups in learning the immune system are presented in Table 8. Results from the Mann-Whitney test showed no significant difference between the two groups at pre-test (p = 0.403) or post-test (p = 0.178).

**Table 8. Data on Students' Self-efficacy in Both Research Groups**

| Test | Research Group | Mean & SD | Sig. |
|---|---|---|---|
| Pre-test | Experiment | 79.70±26.85 | 0.403 |
| | Control | 85.17±29.53 | |
| Post-test | Experiment | 107.63±13.14 | 0.178 |
| | Control | 97.63±22.84 | |

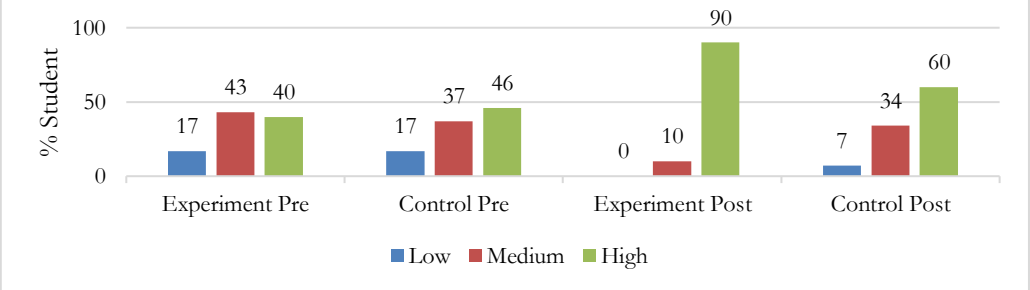



**Figure 2. Percentage of Students in Both Research Group Based on Self- Efficacy Category**

In the experimental class, the pre-test distribution showed 17% of students in the low category, 43% in the medium category, and 40% in the high category. After instruction (post-test), a substantial change occurred: the high category rose to 90%, while the medium category dropped to 10%, and the low category reached 0%. This indicates that the majority of students in the experimental class increased their self-efficacy after participating in the learning activities.

Meanwhile, in the control class, the pre-test showed 37% of students in the medium category, 46% in the high category, and 17% in the low category. After instruction (post-test), the

high category increased to 60%, the medium category increased to 34%, and the low category decreased to 7%. However, it is important to distinguish between these descriptive trends and the inferential statistical results. Despite the larger magnitude of change observed in the experimental group, the Mann-Whitney test revealed no statistically significant difference between the two groups at post-test ($p = 0.178$), indicating that the descriptive improvement did not reach the threshold of statistical significance.

The effect size calculated using rank biserial correlation on the post-test self-efficacy scores yielded $r_{rb} = 0.202$, categorized as small according to Cohen (1988). Although this result did not reach statistical significance, a small effect size in the context of educational intervention research should not be overlooked. Kraft (2020) argues that small effect sizes in field-based educational studies frequently carry practical relevance, as they reflect real differences in students' outcomes that can be meaningful in classroom settings. In other words, even though the difference between the experimental and control groups was not large enough to be detected statistically, the board game IMUNOPOLI still produced a noticeable, real-world difference in students' self-efficacy levels. This limited effect size may be attributed to the relatively short duration of the intervention, given that self-efficacy is a stable psychological construct that requires repeated and sustained mastery experiences to change meaningfully (Bandura, 1997). This is further supported by a systematic review by Noda et al. (2019), which found that board game interventions across various educational outcomes produced effect sizes ranging from 0.04 to 2.60, indicating that a small effect size in a short-term quasi-experimental study falls within a reasonable and expected range.

The observed increase in self-efficacy across both groups, with a comparable descriptive gain in the control group, can be understood through Bandura's (1997) social cognitive theory, which posits that mastery experience is the primary driver of self-efficacy development. In the experimental group, the IMUNOPOLI board game provided a collaborative learning environment where students faced conceptual challenges and achieved success collectively through gameplay (Hosseinpour & Keshmiri, 2025; Meccawy et al., 2023). Meanwhile, the control group likely gained mastery experiences through conventional classroom instruction and routine learning tasks over the same period. The lack of a statistically significant difference between the two groups suggests that both instructional approaches effectively fostered mastery experiences, while extraneous factors such as variations in individual game difficulty and differences in baseline task familiarity may have also influenced students' self-efficacy gains (Assapun & Thummaphan, 2023).

## Emotional Intelligence Outcomes

Students' emotional intelligence was measured using a 33-item questionnaire administered to both groups before and after instruction. Data on students' emotional intelligence in both research groups in learning the immune system are presented in Table 9. Results from the Mann-Whitney test showed no significant difference between the two groups at pre-test ($p = 0.258$) or post-test ($p = 0.790$).

**Table 9. Data on Students' Emotional Intelligence in Both Research Groups**

| Test | Research Group | Mean & SD | Sig. |
|---|---|---|---|
| Pre-test | Experiment | 231.27±28.19 | 0.258 |
| | Control | 211.27±52.96 | |
| Post-test | Experiment | 237.5±32.85 | 0.790 |
| | Control | 237±37.99 | |

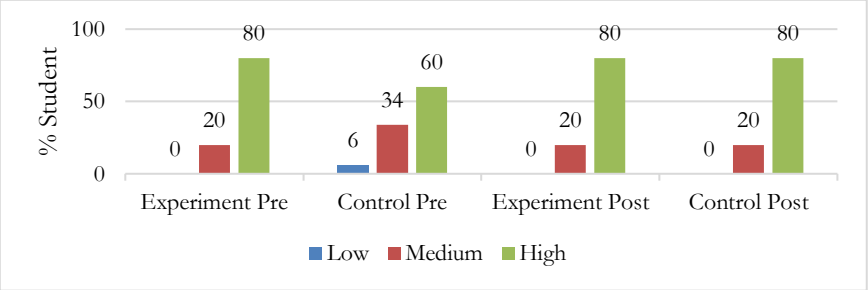



**Figure 3. Percentage of Students in Both Research Groups Based on Emotional Intelligence Category**

In the experimental group, the pre-test distribution was already dominated by the high category (80%), with 20% in the medium category and 0% in the low category. After instruction, this distribution did not change, indicating that the experimental students' emotional intelligence was already at a high level from the outset. In contrast, the control group, which at pre-test still had 6% of students in the low category and 34% in the medium category, showed more noticeable improvement at post-test, with the high category increasing to 80% and no students remaining in the low category. At the post-test stage, both groups reached an equivalent distribution of 80% high and 20% medium.

The effect size calculation using rank biserial correlation on the post-test emotional intelligence scores yielded $r_{rb} = 0.04$, which is considered negligible according to Cohen (1988), indicating that there was virtually no practical difference in emotional intelligence outcomes between the experimental and control groups.

The stable emotional intelligence in the experimental class indicates the occurrence of a ceiling effect, where the already-high initial condition limits the detectable scope for further

improvement (Staus et al., 2021). Even so, this condition shows that the IMUNOPOLI board game maintained students' emotional intelligence at a high level throughout the learning process. The more noticeable improvement in the control group indicates that the general learning process contributes to the development of emotional intelligence, particularly through students' active engagement in interaction and discussion (Sánchez-moreno et al., 2026).

**Concept Mastery and N-Gain Analysis**

Concept mastery directly reflects students' cognitive learning outcomes by demonstrating their capacity to comprehend, retain, and apply complex biological concepts regarding the immune system following the intervention. Higher post-test scores and N-gain values in concept mastery indicate that students successfully progressed from basic recall to higher-level conceptual understanding. Furthermore, evaluating concept mastery alongside psychological measures allows for a comprehensive assessment of how game-based instruction influences both cognitive achievement and affective development.

Data on students' concept mastery across both research groups are presented in Table 10. The pre-test results revealed a statistically significant difference in average scores between the experimental and control groups ($p = 0.000$). This baseline difference indicates that students in the two groups possessed significantly different levels of prior knowledge regarding immune system concepts before the intervention was administered.

**Table 10. Data on Students' Concept Mastery in Both Research Groups**

| Test | Research Group | Mean & SD | Sig. |
|---|---|---|---|
| Pre-test | Experiment | 75.87±22.90 | 0.000 |
| | Control | 37.20±20.96 | |
| Post-test | Experiment | 89.33±19.09 | 0.000 |
| | Control | 56.53±23.38 | |

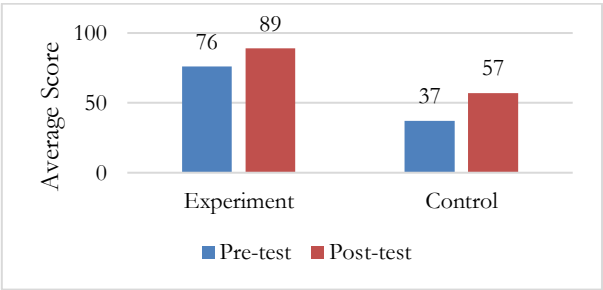



**Figure 4. Average Student Scores in Both Groups**

Based on the figure, the average pre-test score of the experimental class (76) was substantially higher than that of the control class (37), with a statistically significant difference ($p = 0.000$), indicating an initial ability difference between the two groups prior to the intervention.

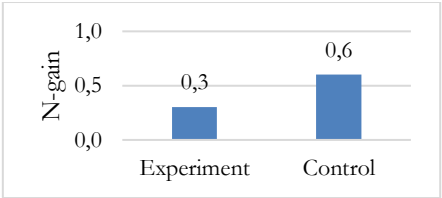



**Figure 5. Comparison of Concept Mastery Improvement (N-Gain)**

Based on N-Gain calculations, the control class showed an N-Gain improvement of 0.6 (medium category), while the experimental class achieved only 0.3 (low category). The effect size calculation using rank biserial correlation on the concept mastery N-Gain produced rrb = 0.486, which falls in the medium category according to Cohen (1988).

These findings do not indicate the ineffectiveness of board games for cognitive learning. Rather, they reflect the strong influence of a ceiling effect, compounded by the limitations of the convenience sampling technique employed without pre-established inclusion and exclusion criteria to balance prior knowledge across groups. Consequently, students in the experimental class entered the study with substantially higher initial mastery, leaving limited room for measurable N-Gain improvement (Staus et al., 2021).

Importantly, this study was primarily designed to optimize self-efficacy and emotional intelligence outcomes, not to maximize cognitive gains. The post-test scores of the experimental class (89) remained significantly higher than those of the control class (57; p = 0.000), confirming that IMUNOPOLI students retained superior conceptual knowledge. The contextual dependency of board game effectiveness in cognitive domains is well-documented (Wang et al., 2022), and games with short-term novelty effects may be insufficient for deep conceptual change when students already possess high prior knowledge (Othman et al., 2025).

**Correlation Analysis Among Variables**

The data from all three variables were analyzed using the Spearman correlation coefficient based on post-test data, as presented in Table 11.

**Table 11. Inter-Variable Correlation Data**

| Variable 1 | Variable 2 | Sig. (2-tailed) | Correlation Coefficient |
|---|---|---|---|
| Concept Mastery | Self-efficacy | 0.279 | 0.204 |
| Concept Mastery | Emotional Intelligence | 0.564 | -0.110 |
| Emotional Intelligence | Self-efficacy | 0.330 | 0.184 |

Based on the table above, no statistically significant correlations were found among the three variables. The correlation between emotional intelligence and self-efficacy showed a weak positive direction (r = 0.184; p = 0.330), which aligns with theoretical expectations that individuals with higher emotional intelligence better regulate their emotions, thereby supporting self-efficacy

maintenance (Chang & Tsai, 2022; Shengyao et al., 2024). This non-significant result was primarily attributable to the limited score variance caused by a strong ceiling effect, as most students recorded high baseline scores from the pre-test stage, restricting the statistical power to detect inter-variable relationships (Staus et al., 2021). Similarly, the post-test correlations between concept mastery and self-efficacy ($r = 0.204$; $p = 0.279$) as well as emotional intelligence ($r = -0.110$; $p = 0.564$) were non-significant, indicating that cognitive achievement operated independently of these psychological constructs within the specific context of this intervention.

## DISCUSSION

The findings of this study suggest that game-based learning through the IMUNOPOLI board game functioned primarily as a contextual instruction tool rather than a superior method producing uniform cognitive or socio-emotional advantages. Rather than functioning as a singular instructional tool with uniform effects across all outcome variables, the board game appeared to exert differential influences depending on students' initial conditions and the nature of each learning construct being measured. This pattern is consistent with broader evidence indicating that the effectiveness of game-based learning is inherently contextual, as no single optimal learning environment exists instead, its impact depends on learners, instructional goals, and implementation context (Vandercruysse & Elen, as cited in Wouters & Oostendorp, 2017, p. 18). Moreover, design decisions and students' individual interpretations may lead to different learning processes and outcomes (Vandercruysse & Elen, as cited in Wouters & Oostendorp, 2017, p. 19–20).

Regarding self-efficacy, the descriptive gains observed in the experimental group were consistent with Bandura's (1997) mastery experience framework, as collaborative problem-solving provides opportunities to face conceptual challenges in teams (Hosseinpour & Keshmiri, 2025; Meccawy et al., 2023). However, because comparable descriptive trends were also present in the control group, these changes may also have been supported by collaborative learning experiences, as group discussions and peer interactions can provide opportunities to receive help, discuss solutions, and receive encouraging feedback that contribute to self-efficacy (Aikens & Kulacki, 2023). Therefore, because between-group differences lacked statistical significance, these self-efficacy outcomes cannot be exclusively attributed to the IMUNOPOLI intervention.

Beyond self-efficacy, a similar nuance applies to the affective domain, particularly emotional intelligence. The absence of a significant improvement in emotional intelligence in the experimental group is most plausibly explained by a ceiling effect, as 80% of students already entered the intervention at a high level of functioning, inherently limiting the statistical space for measurable improvement (Staus et al., 2021). Notably, the control group also demonstrated a

descriptive improvements, suggesting that conventional classroom activities involving peer discussion and collaborative worksheet completion provide sufficient opportunities for emotional skill development (Sánchez-moreno et al., 2026).

Turning to the cognitive dimension, the concept mastery data offer additional context for interpreting the study results, though these patterns must be viewed cautiously due to the lack of statistically significant differences between groups. The lower relative N-Gain score in the experimental group does not necessarily indicate inferior instructional impact. Rather, it likely reflects a cognitive ceiling effect among students entering with higher prior knowledge (Staus et al., 2021). Although the post-test mean scores were descriptively higher in the experimental class, this non-significant trend suggests conceptual retention rather than proving the game was superior. While game-based learning is often recognized as a good medium to reinforce and apply existing knowledge (Cardinot & Fairfield, 2019; Othman et al., 2025), the empirical data here indicate that IMUNOPOLI performed on par with conventional instruction in helping students master the concepts.

When evaluating these outcomes collectively, the non-significant correlations among concept mastery, self-efficacy, and emotional intelligence may be partly attributable to the study's reliance on convenience sampling of two intact classes rather than random assignment. This sampling design limited control over confounding variables and may have obscured genuine associations between the constructs.

Beyond this methodological constraint, the results highlight an important theoretical consideration, as these constructs may not interact in straightforward ways within the timeframe of a short-term intervention. Bandura (1997) acknowledged that the relationship between academic performance and self-efficacy is mediated by motivational and contextual variables, such as task value and engagement quality. The current study did not measure these mediating variables, which likely accounts for the non-significant correlations observed. This gap is consistent with Miao et al. (2025), who demonstrated that the relationships among academic achievement, self-efficacy, and related psychological factors are not purely direct, but are mediated by learning engagement, reflecting the complex interplay of personal, behavioral, and environmental influences in educational contexts. Future research would benefit from incorporating measures of learning motivation and student engagement as mediating variables, which could reveal more nuanced pathways through which game-based learning simultaneously influences cognitive and socio-emotional outcomes.

## CONCLUSION

This study examined the effect of the IMUNOPOLI board game on students' self-efficacy, emotional intelligence, and concept mastery in immune system learning through a quasi-experimental design involving 60 students at a state senior high school in Bandung City. Descriptively, self-efficacy in the experimental group showed a more substantial improvement than the control group with 90% of students reaching the high category at post-test compared to 60% in the control group yet this difference was not statistically significant ($p = 0.178$), and the effect size was small ($r_{rb} = 0.202$). Similarly, emotional intelligence showed no statistically significant difference between groups at either pre-test or post-test ($p = 0.790$), with a negligible effect size ($r_{rb} = 0.04$). Consequently, the stability of emotional intelligence scores cannot be directly attributed to the IMUNOPOLI intervention. Rather, this lack of significant change across both groups is primarily explained by a baseline ceiling effect, as 80% of students had already scored within the high category at the pre-test stage. This high initial standing left minimal room for measurable improvement and indicates that emotional intelligence remained stable independently of the game-based instruction. Regarding concept mastery, the experimental group's N-Gain (0.3, low category) was lower than the control group's (0.6, medium category), also reflecting a ceiling effect due to substantially higher initial scores, although the experimental group's post-test scores remained significantly higher ($p = 0.000$). While no statistically significant correlations were found among self-efficacy, emotional intelligence, and concept mastery, suggesting that these constructs are mediated by unmeasured variables such as learning motivation and engagement. These findings indicate that the IMUNOPOLI board game produced descriptively larger gains in self-efficacy but did not demonstrate statistically significant superiority over conventional instruction in any of the three variables measured, highlighting the need for longer implementation periods and more controlled designs in future research.

## ACKNOWLEDGMENTS

We would like to express our gratitude to the biology teachers for their willingness to allow their classes to be used as research sites, and to the Principal for the opportunity to conduct this study. This research was supported by a research grant from the Faculty of Mathematics and Natural Sciences Education, Universitas Pendidikan Indonesia. We extend our deepest appreciation to the Rector of UPI and the Dean of FPMIPA for their invaluable support.

## FUNDING STATEMENT

This research was funded by 2026 Annual Work Plan and Budget (Rencana Kerja dan Anggaran Tahunan RKAT) of Universitas Pendidikan Indonesia under Rector's Decree No. 490/UN40/PT.01.01/2026 and Contract No. 69/UN40.F7/ADD – PT.01.01/2026.

## CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest regarding the publication of this paper.

## CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

**K. N. Aliyah:** conceptualization, methodology, formal analysis, resources, investigation, data curasion, funding acquisition, visualization, writing – original draft, and writing – review & editing. **A. Rahmat:** validation, resources, formal analysis, visualization, supervision, writing – review & editing, and project administration**. Y. Hamdiyati:** validation, resources, formal analysis, visualization, writing – review & editing, and supervision. **D. Susanti:** conceptualization, resources, writing – review & editing, supervision, and project administration. **M. W. Jamil:** conceptualization, validation, writing – review & editing, supervision, and project administration.

## DECLARATION OF THE USE OF AI

During the preparation of this work, the authors used Claude and Consensus to search academic literature, and Gemini for language editing and proofreading. Following the use of these tools, the authors reviewed and edited the content as necessary and take full responsibility for the final publication.

## DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author.

## REFERENCE

Aikens, M. L., & Kulacki, A. R. (2023). That Increase Students ' Self-Efficacy for Quantitative Biology Tasks. *CBE Life Sciences Education*, *22*(2). https://doi.org/10.1187/cbe.22-04-0076

Assapun, S., & Thummaphan, P. (2023). *Assessing the Effectiveness of Board Game-based Learning for Enhancing Problem-Solving Competency of Lower Secondary Students*. *16*(2), 511–532.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. W H Freeman/Times Books/ Henry Holt & Co.

Cahyani, R. P., Rahmat, A., & Suwandi, T. (2024). Implementation of Retrieval Practice After Learning the Immune System in High School: Students' Perceptions and Self-Efficacy. *Jurnal Penelitian Dan Pembelajaran IPA JPPI*, *10*(1), 78–97. https://doi.org/10.30870/jppi.v10i1.24269

Cardinot, A., & Fairfield, J. A. (2019). Game-Based Learning to Engage Students with Physics and Astronomy Using a Board Game. *International Journal of Game-Based Learning*, *9*(1), 42–57. https://doi.org/10.4018/IJGBL.2019010104

Cassady, J. C., & Johnson, R. E. (2002). Cognitive test anxiety and academic performance. *Contemporary Educational Psychology*, *27*(2), 270–295. https://doi.org/10.1006/ceps.2001.1094

Chang, Y. C., & Tsai, Y. T. (2022). The Effect of University Students' Emotional Intelligence, Learning Motivation and Self-Efficacy on Their Academic Achievement—Online English Courses. *Frontiers in Psychology*, *13*(February), 1–11. https://doi.org/10.3389/fpsyg.2022.818929

Clark, D. B., Tanner-smith, E. E., & Killingsworth, S. S. (2016). Digital Games , Design , and Learning : A Systematic Review and Meta-Analysis. *Review of Educational Research*, *86*(1), 79–122. https://doi.org/10.3102/0034654315582065

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences (2nd ed.)*.

Cohen, L., Manion, L., & Morrison, K. (2018). *Research Methods in Education (8th ed.)*. Routledge.

Dewi, A. K., Lestari, S. M. P., & Sandayanti, V. (2023). Can self-efficacy have a role in learning interest. *Psikostudia Jurnal Psikologi*, *12*(2), 302–308. http://dx.doi.org/10.30872/psikostudia.v12i2.10829

Frankenstein, A. N., Udeogu, O. J., Mccurdy, M. P., Sklenar, A. M., & Leshikar, E. D. (2022). Exploring the relationship between retrieval practice , self - efficacy , and memory. *Memory & Cognition*, 1299–1318. https://doi.org/10.3758/s13421-022-01324-z

Gharetepeh, A., Safari, Y., Pashaei, T., Razaei, M., & Kajbaf, M. B. (2015). Emotional intelligence as a predictor of self-efficacy among students with different levels of academic achievement at Kermanshah University of Medical Sciences. *Journal of Advances in Medical Education & Professionalism*, *3*(2).

Glass, G. V. (1966). Note on rank biserial correlation. *Educational and Psychological Measurement*, *26*, 623–631.

Hake, R. R. (1998). Interactive-engagement versus traditional methods : A six-thousand-student survey of mechanics test data for introductory physics courses Interactive-engagement versus traditional methods : A six-thousand-student survey of mechanics test data for introduc. *American Journal of Physics*, *64*(1). https://doi.org/10.1119/1.18809

Hosseinpour, A., & Keshmiri, F. (2025). The effect of interprofessional game-based learning on perceived cognitive load and self-efficacy in interprofessional communication and collaboration in patient safety incidents. *PLoS ONE*, *20*(4 April), 1–14. https://doi.org/10.1371/journal.pone.0321346

Kerby, D. S. (2014). The simple difference formula: an approach to teaching nonparametric correlation. *Comprehensive Psychology*, *3*. https://doi.org/10.2466/11.IT.3.1

Kraft, M. A. (2020). Interpreting Effect Sizes of Education Interventions. *Educational Researcher*, *49*(4), 241–253. https://doi.org/10.3102/0013189X20912798

Marzano, R. J., & Kendall, J. S. (2007). The New Taxonomy of Educational Objectives. In *Corwin Press*.

Meccawy, M., Alzahrani, A., Mattar, Z., Almohammadi, R., Alzahrani, S., Aljizani, G., & Meccawy, Z. (2023). Assessing EFL Students' Performance and Self-Efficacy Using a Game-Based

Learning Approach. *Education Sciences*, *13*(12). https://doi.org/10.3390/educsci13121228

Miao, H., Guo, R., & Li, M. (2025). The influence of research self-efficacy and learning engagement on Ed . D students ' academic achievement. *Frontiers in Psychology*, *16*(June), 1–13. https://doi.org/10.3389/fpsyg.2025.1562354

Mostowfi, S., Koleini, N., & Khorramar, M. (2016). Designing Playful Learning by Using Educational Board Game for Children In The Age Range of 7-12 : ( A Case Study : Recycling and Waste Separation Education Board Game ). *International Journal of Environmental & Science Education*, *11*(12), 5453–5476.

Noda, S., Shirotsuki, K., & Nakao, M. (2019). The effectiveness of intervention with board games : a systematic review. *BioPsychoSocial Med*, *13*. https://doi.org/10.1186/s13030-019-0164-1

Novallyan, D., Gusfarenie, D., & Safita, R. (2023). Analysis of Students ' Conceptual Understanding of Biology Material Based on STEM Learning. *Biodik: Jurnal Ilmiah Pendidikan Biologi*, *09*, 47–55.

Othman, M. K., Mat, R., & Sim, K. C. (2025). A systematic review of paper- - based and digital board games for collaborative science learning. *Review of Education*, *13*(3), 1–53. https://doi.org/10.1002/rev3.70107

Quílez-Robres, A., Usán, P., Lozano-Blasco, R., & Salavera, C. (2023). Emotional intelligence and academic performance: A systematic review and meta-analysis. *Thinking Skills and Creativity*, *49*(July). https://doi.org/10.1016/j.tsc.2023.101355

Rahmawati, M., Ridlo, S., Widiyaningrum, P., & Irsadi, A. (2024). The Using of Padlet on Students ' Communication and Collaboration Skill in Immune System Material. *Unnes Science Education Journal*, *13*(2), 69–75.

Sailer, M., & Homner, L. (2020). The Gamification of Learning : a Meta-analysis. *Educational Psychology Review*, *33*(1), 77–112. https://doi.org/10.1007/s10648-019-09498-w

Sánchez-moreno, J. A., Serrano-marugán, I., March-llanes, J., & Guzmán, N. (2026). Emotional and behavioral benefits of a standardized program with modern board games. *International Journal of Serious Games*, *13*(2), 79–93. https://doi.org/10.17083/fxnmkg53

Schutte, N. S., Malouff, J. M., Hall, L. E., Haggerty, D. J., Cooper, J. T., Golden, C. J., & Dornheim, L. (1998). *Development and validation of a measure of emotional intelligence*. *25*, 167–177.

Shengyao, Y., Xuefen, L., Jenatabadi, H. S., Samsudin, N., Chunchun, K., & Ishak, Z. (2024). Emotional intelligence impact on academic achievement and psychological well-being among university students : the mediating role of positive psychological characteristics. *BMC Psychology*, *12*, 389. https://doi.org/10.1186/s40359-024-01886-4

Siani, M., Dubovi, I., Borushko, A., Haskel-ittah, M., & Borushko, A. (2024). Teaching immunology in the 21st century : a scoping review of emerging challenges and strategies. *International Journal of Science Education*, *46*(17), 1826–1847. https://doi.org/10.1080/09500693.2023.2300380

Staus, N. L., Connell, K. O., & Storksdieck, M. (2021). *Addressing the Ceiling Effect when Assessing STEM Out-Of-School Time Experiences*. *6*(July), 1–9. https://doi.org/10.3389/feduc.2021.690431

Stranford, S. A., Owen, J. A., Mercer, F., & Pollock, R. R. (2020). Active Learning and Technology Approaches for Teaching Immunology to Undergraduate Students. *Frontiers in Public Health*,

*8*(May). https://doi.org/10.3389/fpubh.2020.00114

Sugiyono. (2007). *Metode Penelitian Kuantitatif, Kualitatif dan R&D*. Bandung: CV. Alfabeta.

Szabo, Z. K., Körtesi, P., Guncaga, J., Szabo, D., & Neag, R. (2020). Examples of problem-solving strategies in mathematics education supporting the sustainability of 21st-century skills. *Sustainability (Switzerland)*, *12*(23), 1–28. https://doi.org/10.3390/su122310113

Tang, Y., & He, W. (2023). Relationship between emotional intelligence and learning motivation among college students during the COVID-19 pandemic : A serial mediation model. *Frontiers in Psychology*, *14*(March). https://doi.org/10.3389/fpsyg.2023.1109569

Teng, Y., Chou, W.-C., & Cheng, M.-T. (2021). Learning immunology in a game : Learning outcomes , the use of player characters , immersion experiences and visual attention distributions. *Journal of Computer Assisted Learning*, *37*(2), 275–486. https://doi.org/10.1111/jcal.12501

Tsai, J. C., Liu, S. Y., Chang, C. Y., & Chen, S. Y. (2021). Using a board game to teach about sustainable development. *Sustainability (Switzerland)*, *13*(9), 1–19. https://doi.org/10.3390/su13094942

Videnovik, M., Vold, T., Kiønig, L., Bogdanova, A. M., & Trajkovik, V. (2023). Game - based learning in computer science education : a scoping literature review. *International Journal of STEM Education*, *10*, 54. https://doi.org/10.1186/s40594-023-00447-2

Wang, L. H., Chen, B., Hwang, G. J., Guan, J. Q., & Wang, Y. Q. (2022). Effects of digital game - based STEM education on students ' learning achievement : a meta - analysis. *International Journal of STEM Education*. https://doi.org/10.1186/s40594-022-00344-0

Wouters, P., & Oostendorp, H. van. (2017). *Instructional Techniques to Facilitate Learning and Motivation of Serious Games*. Springer Cham. https://doi.org/10.1007/978-3-319-39298-1

**Copyright Holder:**
© Aliyah, K. N., et al. (2026)

**First Publication Right:**
© Al-Jahiz: Journal of Biology Education Research

**This article is under:**
CC BY SA