

## Neuroscience-Based Board Games Education Potentially Trains Student Adaptability and Emotional Engagement

Bevo Wahono<sup>1\*</sup>, Tsamara Ghinah Salsabilah Wijaya<sup>2</sup>, Iwan Wicaksono<sup>3</sup>, Astrino Purmanna<sup>4</sup>  
<sup>1,2,3,4</sup> Faculty of Teacher Training and Education, University of Jember, Indonesia

### Article Info

#### Article history:

Received August 1, 2024

Revised October 9, 2024

Accepted October 12, 2024

#### Keywords: (A-Z)

Adaptability

Board game education,

Emotional Engagement,

Neuroscience

### ABSTRACT

This study seeks to analyze how neuroscience-based board games can enhance students' adaptability skills and emotional engagement in science learning. While board games have been utilized as educational tools, the specific application of neuroscience-based board games to foster 21st-century skills has not been extensively researched. This study was conducted using a quasi-experimental method using a single-group interrupted time-series design, involving 202 seventh-grade science students who completed adaptability and emotional engagement questionnaire instruments before and after the intervention. Data were analyzed using paired t-test and Cohen's d-effect size to determine the effectiveness of learning interventions using neuroscience-based board games. The results showed that neuroscience-based board games significantly increased students' adaptability ( $t = 31,72$ ;  $p < 0,001$ ;  $d = 2,64$ ). The most significant increase was in affective adaptability ( $d = 6,65$ ), followed by behavioral ( $d = 2,10$ ) and cognitive ( $d = 0,19$ ). Students' emotional engagement also significantly increased ( $t = 18,94$ ;  $p < 0,001$ ;  $d = 1,77$ ). This study also revealed that gender differences significantly influence adaptability ( $p = 0,015$ ;  $t = -2,47$ ) but do not significantly influence student emotional engagement ( $p = 0,329$ ;  $t = 0,98$ ). In addition, differences in socio-economic status have no significant effect on adaptability ( $p = 0,419$ ;  $t = 0,81$ ), but there is a significant effect on students' emotional engagement ( $p = 0,010$ ;  $t = -2,63$ ). Neuroscience-based board games play a crucial role in science education, particularly in fostering adaptability and emotional engagement.

*This is an open access article under the [CC BY-SA](#) license.*



### Corresponding Author:

Bevo Wahono

Biology Education, University of Jember

Jalan Kalimantan 37 Sumbersari, Jember 68121, Indonesia

Email: [bevo.fkip@unej.ac.id](mailto:bevo.fkip@unej.ac.id)

## 1. INTRODUCTION

Board games serve as a valuable medium that can be seamlessly integrated into the science learning process. They have gained popularity as an engaging educational tool, as they effectively connect contextual material with real-world scenarios (Parekh et al., 2021; Robinson et al., 2021). The distinctive design of board games captures children's attention and fosters interest in various topics. Additionally, the inherent complexity of systems within board games contributes to the development of critical thinking skills among children (Parekh et al., 2021). This complexity not only enhances cognitive abilities but also nurtures the development of essential soft skills (Radzi et al., 2020; Viviers et al., 2016). Given the significant potential of board games, it is crucial to integrate them into science learning at school, particularly for fostering the development of soft skills.

The effectiveness of board games in enhancing soft skills is holistic, focusing on a broad range of skills rather than targeting one or two specific areas for development. Generally, the soft skills cultivated through the learning process with board games encompass communication, teamwork, problem-solving, and decision-making (Chen et al., 2021; Radzi et al., 2017). Furthermore, board games can be tailored to specifically foster the development of soft skills that align with the objectives of board game design (Kushairi, 2023). In this study, the

board games are intentionally crafted to support the growth of adaptability skills while simultaneously increasing students' emotional engagement with their learning environment. This customization emphasizes both practical design and the particular soft skills intended for enhancement.

Adaptability skills are increasingly recognized as essential for development today. Traditional teacher-centered learning often leads students to encounter monotonous situations with clearly defined and predictable problem parameters. Consequently, when faced with change, students may struggle to think critically in order to devise solutions (Sirotiak & Sharma, 2019). Developing adaptability in the current educational landscape is crucial due to the numerous changes affecting the learning environment, which can disrupt the effectiveness of the learning process (Peng et al., 2019). Moreover, adaptability is closely linked to emotional regulation, which significantly impacts student satisfaction in the learning experience and contributes to achieving optimal learning outcomes (Feraco et al., 2022). To ensure the stability and effectiveness of the learning process, it is imperative to begin fostering students' adaptability.

Students' adaptability is defined as their capacity to mentally and emotionally accept change and failure. This adaptability is closely tied to emotional independence, enabling students to organize themselves despite various challenges (Feraco et al., 2022; Zhang et al., 2021). To be effective, the development of adaptability skills must be accompanied by a focus on emotional skills, as these two aspects are interrelated. Improving adaptability without considering emotional variables will diminish its effectiveness (Feraco et al., 2022; Zhang et al., 2021). Therefore, enhancing both adaptability and emotional engagement is crucial, particularly in science learning, which requires independent thinking. When adaptability is paired with emotional independence, it leads to more effective science learning.

To enhance adaptability and emotional engagement among students using board games and media, an appropriate approach is essential. Various strategies can optimize the effectiveness of board games, such as cooperative learning, which fosters collaboration among students while also encouraging healthy competition (de Almeida et al., 2021). Another effective method is game-based learning, where board games form the basis of the educational experience and the teacher acts as a facilitator (Santos, 2023). This research utilizes a neuroscience-based approach to enhance the use of board games to improve adaptability and emotional engagement. Neuroscience in education emphasizes learning processes that support brain development (Chang et al., 2022). In this study, neuroscience principles are applied to board games, taking into account that each child's brain develops at different stages. By prioritizing brain development, we aim to enhance each child's adaptability skills.

The aim of this research is to analyze changes in students' adaptability skills and emotional engagement, as well as to explore the impact of gender differences and socio-economic status on these changes during science learning with neuroscience-based board games. The study will focus on three specific research questions as follows.

- 1) In what ways does student adaptability evolve in science learning through the use of neuroscience-based board game media?
- 2) How does student emotional engagement shift in science learning when utilizing neuroscience-based board game media?
- 3) What impact do gender and socio-economic status have on students' adaptability and emotional engagement in science learning through neuroscience-based board game media?

## Literature Review

### Adaptability Skill Theories

Adaptability skills encompass a broad definition, but within the context of 21st-century skills, their meaning becomes more specific. According to Trilling & Fadel (2009), adaptability refers to an individual's ability to reassess problems and transform them into opportunities that yield unique solutions and innovations. In the 21st century, the necessary adaptability includes the capacity to handle criticism, setbacks, and even failures. Owen (2020) emphasized that adaptability is crucial for responding effectively to environmental changes. When individuals can adjust to rapidly changing situations, their behavioral responses evolve, leading to effective changes and nuanced managerial responses to those changes.

For students, adaptability skills are essential for swiftly adjusting to rapidly evolving circumstances. Dorzheeva (2020) noted that adaptability is a complex process that involves varying levels of self-adjustment including biological, physiological, psychological, and social changes as well as different aspects such as socio-psychological and socio-pedagogical elements. Adaptability is shaped by an individual's needs and motivations when faced with specific situations. More specifically, adaptability in students focuses on psychological and social dimensions, encompassing their perceptions of themselves and their environment in any given context. A study by Holliman et al. (2022) revealed that middle school students with strong adaptability skills demonstrated favorable psychological conditions, effectively mediating their personalities to align with the situations they encountered. The findings indicate that this personality mediation fosters students' social well-being, resulting in a positive relationship between extroversion and psychological well-being.

Adaptability in students is measured using indicators divided into cognitive, affective, and behavioral domains. Cognitively, adaptability is considered successful when a person's logical way of thinking can change to adapt to changing situations and is able to find solutions to the changes that occur. Effective adaptability occurs when someone can emotionally accept change and remain calm when facing change. Finally, the results of the combination of cognitive and affective will be seen in behavioral adaptability, where a person's behavior shows changes that adapt to the changed conditions of the situation. Adaptability in students will be considered successful when students can balance adaptability in each indicator (van Dam & Meulders, 2021).

Regarding academics, adaptability plays an important role for students. In the learning process of middle school students, adaptability plays a role in the emergence of learning motivation, mediation of independent and cumulative learning, and positive self-management. The positive adaptability process fosters strong motivation for learning and self-management, encouraging students to engage in independent learning that suits their needs. The result of learning personalized to one's needs is improved academic results (She et al., 2023; Suratno et al., 2020). A study conducted by Stockinger et al. (2021) provides an overview of how differences in adaptability capacity in uncertain situations result in different reactions. The crisis experience will control the structural equations of decision-making, positively influencing decision-making in the learning process. The positive emotions from this hope will then be connected to the atmosphere in the learning process, influencing the final semester grades.

### **Emotional Engagement Theories**

The implementation of adaptability skills within the school environment encompasses the emotional responses of students affected by situational changes. These emotional shifts significantly influence how students connect with the dynamic aspects of their school setting. According to Neuharth-Pritchett and Bub (2022), emotional engagement is characterized by students' positive or negative reactions to their learning environment, which subsequently affects their motivation to engage in the learning process. Wolters and Taylor (2022) further elaborated that emotional engagement stems from the affective experiences students encounter while participating in school activities. Such experiences often yield positive responses, including interest, joy, and a sense of enjoyment within the school environment.

Emotional engagement is considered to be perfectly formed when the emotional engagement indicators are achieved. In general, students will be emotionally attached to teachers, peers, and the learning environment; these three aspects are indicators of emotional engagement. In the peer context, emotional bonds form when friends' emotional presence shapes their responses. For example, such as the existence of oneself who feels accepted or rejected by a peer play group. Then, an emotional relationship between teacher and student is formed if the student emotionally needs the teacher. In this case, the presence of a teacher, if it makes students feel comfortable, is considered to have positively led to emotional engagement. The last is the emotional bond of students towards school, which is the result of the emotional bond of students with friends and fellow students and with teachers. The result of the emotional bond that is formed is a form of student ownership of the school so that there will always be a desire to be involved in school activities (Gunuc & Kuzu, 2015).

One aspect of student involvement in learning is proven through emotional engagement. According to Gladisia et al. (2022), student involvement in the learning process can be seen from their participation in behavioral, cognitive, and emotional aspects, which show how students face academic challenges. Wolters & Taylor (2022), stated that student engagement is highly dependent on emotional and affective aspects, which are important dimensions in the academic process. Emotional engagement is related to how students' emotions remain positive, such as maintaining interest and attention to learning (Kumtepe & Ucar, 2021).

Emotional skills between students and the learning environment significantly impact learning outcomes. Research by Liu et al. (2022) on emotional and cognitive involvement in predicting learning outcomes shows a relationship between emotional and cognitive aspects and learning outcomes. Deng (2021) found that emotional engagement, as measured by learning satisfaction, significantly impacts student learning outcomes. Learning satisfaction also has a positive influence on cognitive engagement and behavioral engagement. Emotions are involved in learning. Positive emotions are more dominant than negative emotions because they influence students' learning motivation. Similar research by Estévez et al. (2021) also found that students with high levels of engagement in emotional, behavioral, and cognitive dimensions showed better learning outcomes than other students. This is because they are able to manage the learning environment better, choose effective learning strategies, and do not exhibit deviant behavior during the learning process. This difference is also caused by low emotional and behavioral engagement, which results in poor management of contextual conditions and learning environments.

### **Neuroscience Theories in Education**

Neuroscience is a branch of science that studies the nervous system and brain function. In the educational context, neuroscience examines neurophysiology related to learning behavior, memory ability, focus in learning, and motivation (Chang et al., 2022). The brain plays an important role in neuroscience learning and is the center of the learning process (see figure 1). Neuroplasticity, the brain's ability to change, is a major aspect influencing learning. This aspect involves changes in the brain by creating connections between nerves to complete tasks.

This relationship becomes effective when it is used consistently, and this process continues throughout learning. The brain needs to be given time to reflect to speed up information processing. One way to speed up the connections between nerves is to provide more information about old and new information. This impact creates repetitive connections between neurons, strengthening learning (Bajaj et al., 2016).

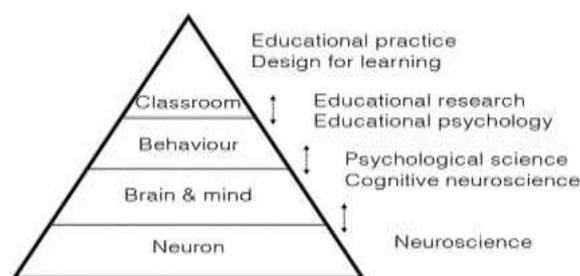


Figure 1. Liner Translation Representation in Neuroscience Learning (Lodge et al., 2017)

Each part of the brain has a function that can be optimized in learning using specific methods. Research by Greipl et al. (2021) discusses the relationship between emotions and learning using games. The results show that learning using games can activate neural activity related to emotions. Brain responses, especially in the amygdala, are more active when learning is done through games. According to Goleman (1995), the amygdala is a part of the brain located close to the limbic ring and adjacent to the brainstem. The amygdala regulates emotions, and because it is close to the hippocampus, it also plays a role in memory and learning processes. Melvin (2019) stated that the brain is designed to store information that is considered valuable. When feelings of pleasure or stress accompany information, the brain produces hormones that bind to those memories. Therefore, in learning, it is important to prioritize emotions that trigger certain hormones that help information bind better in the brain.

Game media can accommodate brain development while providing emotional development. Research by Kober et al. (2020) shows that a game-based learning environment makes the frontal brain more active due to the reward system positively associated with individual motivation. Game-based learning also involves a strong emotional aspect that improves brain performance. Another study by Greipl et al. (2021) found similar results, where brain and neural activity increased during gaming due to the reward, emotional, and motivational aspects it offered. Based on these studies, games have a neuroscience basis in learning because they can improve brain performance.

Neuroscience in this research is the basis for compiling the board games. Board games are designed to evolve with the brain's learning needs. Attractive and colorful design is a principle of the neuroscience approach that is useful for making it easier for the brain to remember and form learning and understanding. Then, in the concept of neuroscience, learning occurs when neuron connections are formed. These neuronal connections are formed through repetitive activities, whereas in board games, the game steps are repetitive. This repetitive activity will trigger understanding due to the formation of neuronal connections. For these neurosynapses to become stronger, they must be formed in broader relationships through contextual play. So, this board game uses scientific concepts that are adapted to how scientific concepts are applied in the real world, and the result will be the formation of an interconnected understanding. The final and most important neuroscience concept is strengthening understanding through the rewarding process while also building emotional relationships through the competency process.

## 2. RESEARCH METHOD

### Participants

Table 1. Gender Distribution and Socio-Economic Status of Participants

Participants	Gender		Socio-Economic Status	
	Female (%)	Male (%)	High Class (%)	Lower Class (%)
Public school	40 (47,05)	45 (52,95)	29 (34,11)	56 (65,89)
Private school	62 (53)	55 (47)	92 (78,63)	25 (21,37)
Total	102 (50,50)	100 (49,50)	121 (59,90)	81 (40,10)

The participants in this study comprised 202 junior high school students, specifically seventh-graders enrolled in science lessons focused on Newton's Laws. The students were drawn from two institutions: a public school and a religious-based private school located in East Java province, Indonesia. Two classes from the public school and three from the private school took part in the study. At the time of the study, the students were aged between 13 and 15 years.

Additionally, the participants came from a range of socio-economic backgrounds and were grouped by gender. The distribution of these student groups is detailed in Table 1. Students' backgrounds were classified according to their socio-economic status, which took into account factors such as the number of dependents in the family, monthly income, and the stability of their parents' employment. The classification was divided into two categories: the lower class, which included families with more than five dependents, a monthly income below the minimum wage, and unstable employment; and the higher class, which encompassed families with three or four dependents, an income at or above the minimum wage, and stable jobs. Participation in this research was voluntary, with all participants providing informed consent without any coercion.

### Research Design

This research employs a quantitative approach to assess the effectiveness of board games on adaptability and emotional engagement. A single-group interrupted time-series design, a type of quasi-experimental model, was utilized, as illustrated in Table 2. The quasi-experimental model is suitable for this study because student learning can occur naturally, which enhances the validity of the results. The single-group interrupted time-series design allows for the comparison of pre-test results taken before the treatment with post-test results obtained after the treatment over a specified period. The pre-test results and the post-test results after treatment were given for a certain period of time.

Table 2. Single-Group Interrupted Time-Series Design

Single-Group Interrupted Time-Series Design				
Experimental Class	X	O	O	X
	Time			

X = Adaptability and Emotional Engagement Measurement

O = Game Treatment Rails and Ruin: Journey Through The New World

This study included one public school and one private school. In public schools, two classes participated in this research. In private schools, the total number of classes participating in this research was three classes. The selection for this class is based on the following criteria: the average science score of students is above 70, the distribution of student scores is even, and at least 20% of the students in the class have played board games. In addition to class criteria, teachers who act as game facilitators in this study must also meet specific criteria. The criteria for teachers in this study were graduates with a bachelor's degree in science education (Physics, Biology, or Chemistry), who had taught for at least 3 years, and who had or knew about board games. The criteria for the class and teacher are adjusted to the needs, where both students and teachers must have at least a basic knowledge of science and a basic knowledge of board games, which is sufficient to understand the basics of the board games that will be used.

This research method begins with taking a pre-test in the first week of learning. After the pre-test was taken, the next two weeks were spent learning using board games for 360 minutes, divided into four meetings over 2 weeks. In each meeting for 2 weeks, students learn science using neuroscience-based board games. Finally, in the fourth week of learning, participants took a post-test. Students were not informed in advance about the post-test. The results between the pre-test and post-test were then compared to see if there was any improvement after the treatment.

### Instrument and Data Collection

In this study, one independent instrument and two dependent instruments were utilized. The first dependent instrument is an adaptability questionnaire derived from Martin's Adaptability Scale (van Dam & Meulders, 2021). This questionnaire comprises 10 questions that are categorized into three primary aspects: cognitive, behavioral, and affective. For instance, a statement reflecting cognitive adaptability is, "I am confident that I can tackle various challenges." For behavioral adaptability, an example statement is, "I am capable of handling new and unfamiliar situations," while a statement representing affective adaptability is, "I enjoy situations that involve change." The research findings were gathered using a Likert scale ranging from 1 to 5, where a score of 1 indicates "Strongly Disagree" and a score of 5 signifies "Strongly Agree."

The following dependent instrument is the emotional engagement questionnaire, adapted from the OELE instrument Analysis (Ningsih, 2022) and the Student Emotional Engagement Scale (Gunuc & Kuzu, 2015). This questionnaire consists of 22 questions that express students' emotional ties to peers, teachers, and school. One of the statements in this questionnaire reads: "I feel happy when studying science." This questionnaire also uses a 5-point Likert scale.

Board games in this study are an independent instrument. The board game used in this study is Ruin and Rails: Journey Through The New World, an adventure-themed board game about taking over the world through the railroad business, as shown in Figure 2, students' use of the Rails & Ruins board games. Ruin and Rails is a self-custom board game designed to help learn science, especially Newton's laws. In the game, a hexagon puzzle can be put together to form islands. Players are free to determine the number and size of islands, and then each

island is connected by railroad tracks. Railway tracks are the sections on which trains run. During the game, the number of islands and railways can change depending on the game conditions, so the player must always be prepared for all possibilities.



Figure 2. Board Games Ruin & Rails – Its Use by Students

Neuroscience-based board games Ruin and Rails, meaning it maximizes the performance of groups of neurons in the brain. Through attractive and colorful designs, players will be more interested and then produce certain hormone compounds that improve brain performance. Designs with striking colors and images also help the brain to remember better. In addition, through the competition and reward system, the adaptation process will be forced, increasing critical thinking skills to find solutions in the game. This entire process occurs throughout the game, continuously and repeatedly. This process builds connections between neurons in the brain, which in turn increases brain neuroplasticity.

#### Data Analysis

In this study, data were collected from 202 participants who engaged in science learning through board games over a four-week period. To analyze the pre-test and post-test data, we employed paired t-test statistical analysis. The paired t-test is appropriate in this context, as the research subjects received identical treatment, allowing us to compare the pre-test and post-test means to determine significant differences between the two (Reinard, 2006). Additionally, Cohen's *d* effect size was utilized to assess the magnitude of the effect observed in the research. Cohen's *d* is calculated by taking the difference between the average pre-test and post-test scores and dividing it by the standard deviation. The interpretation of Cohen's *d* results follows the criteria outlined by Privitera (2017), as presented in Table 3.

Table 3. Cohen's *d* Effect Size Criteria

Cohen's <i>d</i> Effect Size	Interpretation	Differences in SD
$d = .0-.19$	Trivial effect	$<1/5$ from <i>s</i> SD
$d = .20$	Small effect	$1/5$ from a SD
$d = .50$	Medium effect	$1/2$ from a SD
$d = .80$ or higher	Large effect	$8/10$ from a SD

### 3. RESULT AND DISCUSSION

#### Result

##### Adaptability Improvement

The board game used is a well-customized board game to accommodate students' adaptability. Changes in game situations are considered to train adaptability skills, as shown in Table 4. This table will answer the first problem formulation: "How does student adaptability change in science learning using neuroscience-based board games media?". Table 4 shows that the statistical analysis increases pre-test to post-test scores. In this study, the affective adaptability aspect shows the greatest increase, which is related to students' emotional and mental states during the playing process. Meanwhile, the aspect with the lowest change is the cognitive aspect related to rational ability.

Table 4. The Effectiveness of Board Games on Students' Adaptability

Aspect of Adaptability	Pretest		Posttest		t-value	Effect size (Cohen's <i>d</i> )	p-value
	Mean	SD	Mean	SD			
Cognitive	8,42	1,98	11,7	1,37	-21,85	0,19	<0,001
Affective	10,78	2,50	15,88	1,80	-24,77	6,65	<0,001
Behaviorial	8,59	1,89	12,06	1,29	-25,91	2,10	<0,001
Total	27,79	5,59	39,71	3,05	-31,72	2,64	<0,001

The findings presented in Table 4 indicate that board games can significantly enhance adaptability. The average adaptability score during the pre-test was 27.79, while the post-test score rose to 39.71, with a t-value of 31.72 and a p-value of less than 0.001. This demonstrates a significant difference between the pre-test and post-

test results. Additionally, Cohen's d effect size value of 2.64 reflects the considerable impact of board games on students' adaptability skills, as evidenced by the average scores before and after the intervention.

The analysis reveals that affective adaptability yielded the highest adaptability effect, with a t-value of 24.77, a p-value of less than 0.001, and a d value of 6.65. In contrast, cognitive adaptability exhibited the lowest adaptability effect, reflected by a t-value of 21.85, a p-value of less than 0.001, and a d value of 0.19. Meanwhile, behavioral adaptability falls within the medium effect category, with a t-value of 25.91, a p-value of less than 0.001, and a d value of 2.10.

### Emotional Engagement Improvement

Based on the results of the affective aspect of adaptability, the study assumes that emotional improvement will occur significantly. Thus, this will answer the second problem: "How does student emotional engagement change in science learning using neuroscience-based board games media?". In terms of adaptability, students' affective aspects have the greatest effect among the other three. Table 5 shows consistent results, namely a rapid increase in emotional engagement before and after learning using board games.

Table 5. The Effectiveness of Board Games on Students' Emotional Engagement

Emotional Engagement	Pretest		Posttest		t-value	Effect size (Cohen's d)	p-value
	Mean	SD	Mean	SD			
	67,41	15,21	90,30	9,99	-18,942	1,77	<0,001

In Table 5, the results of the emotional engagement analysis show a significant increase, as seen from the pretest and posttest results. The pretest results were found to be 67,41, and the posttest results were 90,30 with the value of t 18,98, p-value <0,001. This value shows a significant difference between the pretest conditions before learning treatment using board games and the posttest conditions after learning treatment using board games.

In this study, neuroscience-based board games significantly affected students' emotional engagement. This is proven by Cohen's d analysis, which shows a large difference effect with a value of 1.77. This value is included in the large category, so neuroscience-based board games have a significant influence on increasing students' emotional engagement.

### Gender and Socio-Economic Status on Adaptability and Emotional Engagement

Student adaptability is the ability to adjust to changes psychologically. In general, the psychology of male and female students differs, so they will have different levels of adaptability. Emotions are at their peak during adolescence, which will have a significant influence. Different emotional conditions in each category will result in different student adaptability and emotional engagement results. The influence of gender on adaptability and emotional engagement was analyzed using paired t-test statistical analysis. Table 6 and Figure 4 present the results of students' adaptability and emotional engagement based on gender. These results will answer the third problem: "How do gender and socio-economic status influence students' adaptability and emotional engagement in science learning using neuroscience-based board games media?"

Table 6. Adaptability and Emotional Engagement Based on Gender

Assessment Aspects		Mean	N	Std. Deviasi	t	df	d	$\alpha$
Adaptability	Female	39,23	100	±2,85	-2,47	99	13,7	0,015
	Male	40,22		±3,19			12,6	
Emotional Engagement	Female	90,74		±8,55	-0,98		10,6	0,329
	Male	89,69		±11,2	8,0			

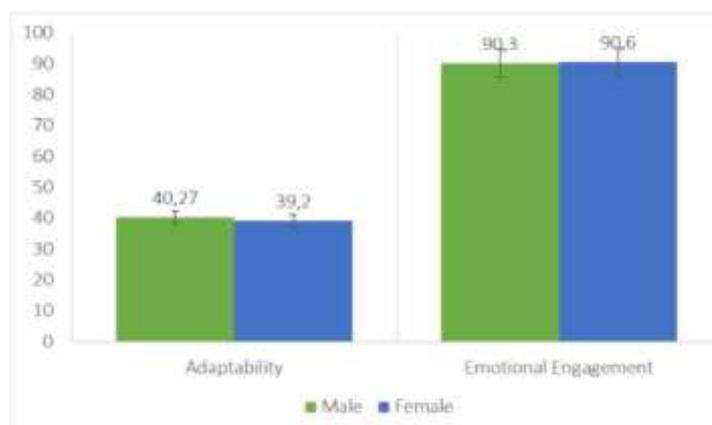


Figure 3. Comparison of Adaptability and Emotional Engagement Based on Gender

The role of gender in adaptability, as indicated by the statistical analysis, has a significance value of 0.015, which is less than 0.05. This suggests that gender does have an impact on students' adaptability. In contrast, the analysis of gender's influence on emotional engagement yielded a significance value of 0.329, which is greater than 0.05, leading to the conclusion that there is no significant difference in this area. It's important to note that statistical analysis results should not be the sole basis for conclusions, as other factors, such as the student's learning environment, may also play a crucial role.

Furthermore, adaptability and emotional engagement were examined in relation to socio-economic status, categorized into lower and higher classes. Table 7 and Figure 5 illustrate the findings regarding adaptability and emotional engagement based on students' socio-economic class. The impact of socio-economic status on these factors was assessed using a paired t-test analysis.

Table 7. Adaptability and Emotional Engagement Based on Socio-Economic Status

Assesment Aspects		Mean	N	Std. Deviasi	t	df	d	$\alpha$
Adaptability	Higher Class	39,25	80	$\pm 2,607$	-0,81	79	15,0	0,419
	Lower Class	38,91		$\pm 3,102$			12,5	
Emotional Engagement	Higher Class	91,28	80	$\pm 9,533$	-2,63	79	9,5	0,010
	Lower Class	87,4		$\pm 10,753$			8,1	

Based on a review of the socio-economic status class of students, it can be seen that the adaptability assessment aspect has a significance value of  $0,419 > 0,05$ , and the emotional engagement aspect has a significance value of  $0,010 < 0,05$ , so it is stated as significant.

## Discussion

### Adaptability Improvement Using Neuroscience Board Games

This research examines the effectiveness of using board games to enhance three dimensions of adaptability: cognitive, affective, and behavioral. Adaptability is an individual's willingness to change and adjust to the tasks or challenges encountered in social contexts (Kodden, 2020). The study revealed that affective adaptability showed the greatest improvement among the three dimensions, while behavioral adaptability showed a moderate increase, and cognitive adaptability showed the least growth. These variations in adaptability levels are attributed to differences in self-adjustment in response to change. In cognitive adaptability, the response to change relates to shifts in thought processes. Behavioral adaptability involves changes in actions as a response, whereas affective adaptability pertains to how individuals emotionally respond to others during adjustment (Zhang et al., 2021).

Various factors cause differences in the level of adaptability in the three aspects of adaptability. In this study, students aged 13-15 years, in adolescence, played the game with peers. In adolescence, there is an increase in emotional responsiveness and initiative. The increased emotional responses that continue to occur while playing board games will bind the students' emotional relationships. While emotionally, students become more proactive and responsive, cognitively, their development is still immature. This results in a hasty, ineffective decision-making process (Somerville et al., 2010). This is reflected in the low cognitive adaptation results, where students still do not dare to make too risky decisions while playing board games. Although emotional adaptability affects cognitive aspects, successful emotional adaptability will be key in dynamic interpersonal relationships and the ability to share trust in achieving a goal (Oleszkiewicz et al., 2022). In this case, trust and interpersonal relationships are formed in the attitudes formed during the game. Emotions formed in a group will influence a person's attitude because, emotionally, the ability to make decisions will be focused on common goals (van Kleef et al., 2017). As a result, high emotionality forms an attitude of adaptability to complete the game together but also decreases cognitive abilities because emotional decisions are prioritized.

Although there are differences in each aspect of adaptability, in general, students' adaptability increases rapidly from before and after learning to use board games. Students' adaptability increased by 30% compared to before playing board games. Changes in game situations are thought to train adaptability, especially in providing responses related to decision-making (Moya-Higuera et al., 2023). During the gameplay, this customized board game provides many changing situations that occur due to decisions made by other players. As a result, students will be forced to continue adjusting to the changes.

### Emotional Engagement Improvement Using Board Games

Emotional engagement refers to the spectrum of positive and negative reactions individuals have towards various stimuli, including school, peers, and teachers in the context of this research. For students, emotional engagement encompasses several complex dimensions, such as enthusiasm, pride, interest, comfort at school, as well as feelings of boredom, fear, and dissatisfaction. Students experience emotional engagement when they feel a sense of belonging at school and derive enjoyment from that connection (Gladstone et al., 2022). This study investigates students' emotional attachment to school in the context of learning through board games. The use of board games as a learning medium has not been implemented in either school previously; thus, it can serve as a new source of motivation for students. Furthermore, incorporating board games into the classroom fosters a more

relaxed learning atmosphere, allowing students to experience joy and comfort, which encourages them to spend more time engaged in learning activities.

Increasing students' emotional engagement towards school, teachers, and peers cannot be separated from the learning experiences that students experience. Interactions between students and students, as well as students and teachers, result in a pleasant experience involving positive emotions. This active experience will then build psychological perceptions, which are interpreted as students' attachment to school, friends, and teachers. When students feel valued and supported in their learning environment, this increases their sense of ownership of the learning process and strengthens their social bonds (Marcus et al., 2021). Meaningful and positive interactions create an atmosphere conducive to collaborative learning and help build trust and mutual respect. As a result, students are more motivated to participate in school activities actively, increasing their overall engagement and enriching their educational experience (Prayogo et al., 2023).

During the learning process, the teacher actively accompanies students in playing, acting as a teacher and acting as a facilitator in the game so that the teacher plays an active role. This active role increases the interaction between students and teachers to a more positive and enjoyable level. From a teacher's perspective, using games allows students to construct their learning process, thereby reducing the teacher's burden and making them more flexible in teaching. Positive relationships from both parties build quality interactions (Ulmanen et al., 2016). High-quality classroom interactions are strongly associated with increased student emotional and behavioral engagement. A well-run class will provide positive interactions, so students tend to be more emotionally involved, feel more motivated, and show more positive learning behavior. Effective interactions between teachers and students create a supportive environment and encourage active participation, increasing student engagement in teaching and learning (Havik & Westergård, 2020). This process results in students' emotional ties to school, friends, and teachers increase and develop positively.

#### **Gender and Socio-Economic Status on Adaptability and Emotional Engagement**

The findings of this study suggest that male students exhibit greater adaptability compared to female students; however, there is no definitive theory regarding the impact of gender on adaptability. Various factors influence self-adjustment regulation, including psychological stability, self-esteem, communication skills, behavioral regulation, attitudes toward problem-solving, and group interaction skills. These factors contribute to an individual's capacity for self-regulation during the learning process (Tatianchenko, 2021). Male students typically adapt more swiftly to academic and social pressures, demonstrating higher self-confidence in confronting new challenges. In contrast, female students often encounter emotional barriers that may hinder their adaptability. They can be more vulnerable to anxiety and social pressure, which may diminish their capacity to adjust to change. Nonetheless, it is essential to acknowledge that every individual possesses the potential to enhance their adaptability through appropriate support and effective coping strategies.

Gender is not the main factor in students' adaptability, but several other studies mention the influence of gender on adaptability skills. Another study found that boys have better adaptability skills because they can assess the surrounding environment more holistically (Wahono et al., 2025). This assessment results in practical strategies for dealing with the surrounding environment (Gao et al., 2020). The low adaptability assessment of female students may be due to the short research time, so the game was over before students could find the right coping strategy. In contrast to male students who think more rationally when solving challenges, the result is that they become better at adapting.

Then, students' adaptability is also reviewed based on socio-economic level. Students with higher class socio-economic status showed better adaptability. Students from higher socio-economic classes often also benefit from a more stable and structured educational environment. They have better access to well-trained teachers, additional educational programs, and supportive learning environments. These factors can collectively help hone students' adaptability skills, as they have fewer economic challenges and more opportunities to focus on their personal and academic development. On the other hand, students from lower socio-economic classes often face more challenges, such as a lack of adequate educational resources and social support needed to overcome these obstacles. Therefore, the role of economic factors in influencing students' adaptability is important to understand in the context of inclusive and equitable education.

Furthermore, female students showed higher emotional engagement than male students in managing emotional engagement. This finding is related to how female students can express their emotions towards their environment compared to male students (Wahono et al., 2021). Female students tend to be more open and expressive and have better communication skills, which increases their involvement in school activities and social relationships. In contrast, male students tend to suppress or hide their emotions, which reduces their emotional engagement. Social and cultural factors also influence this difference, where males are usually forced to be strong and assertive. So, they will suppress their emotions more to show their strength. Previous research also indicates that females tend to perform better in interpersonal and emotional domains than males. This interpersonal and emotional dimension gives females a greater ability to interact with and understand others (Gao et al., 2020). Additionally, males are also lacking in traditional masculinity systems, where showing emotion and being

emotionally connected is considered unmanly. This is one of the reasons for low emotional attachment (Galay & Aizman, 2023).

Students with higher socio-economic status have better emotional engagement than those with lower class status. This result is due to various factors, such as better access to educational resources, a more supportive learning environment, and more excellent emotional support from family (Zhu, 2023). Students from higher socio-economic classes may also have more opportunities to engage in extracurricular activities and enriching learning experiences, all of which contribute to higher levels of emotional engagement (Wolters & Taylor, 2022). In neuroscience, emotional connections form when a psychological experience occurs.

The learning process in this study uses simulation as reinforcement. Simulations can effectively transfer procedural knowledge to real-world tasks and provide opportunities for developing students' higher-order thinking. Simulations conducted in games provide students with opportunities to practice skills in an environment, understand the basic concepts underlying the tasks, and engage in critical thinking and problem-solving. This helps them build the knowledge and skills needed to succeed in a variety of situations (Falloon, 2020). Applied simulations of science concepts, in addition to strengthening cognitive knowledge, also train students' emotions when faced with real problems, then build stored knowledge as part of the solution to solving problems. This knowledge will then become adaptive material in the future.

The analysis conducted on gender and socio-economic status variables provides new insights into how students' abilities develop not only from within the school but also from outside influences. Gender, in this case, does not really influence studies related to gender and adaptability, which needs to be studied further. Meanwhile, the relationship between gender and emotional engagement found a common ground: female students could connect emotionally better than male students. This finding is because women's emotional expression is more unrestrained, giving rise to active experiences that connect psychologically. The relationship between adaptability and emotional engagement with socio-economic status shows that students with higher class status tend to be better than others. This result is related to the relationship between parents and students, where parents who can provide full support to their children will produce children who value their worth and believe in their abilities so that they believe in the decisions they choose.

#### **4. CONCLUSION AND LIMITATION**

##### **Conclusion**

This study shows that neuroscience-based board games, such as Rails and Ruins: Journey Through the New World, effectively increase junior high school students' adaptability and emotional engagement in science learning. Students' adaptability increased significantly, especially in the affective aspect, which showed better emotional and mental responses during the playing process, although the cognitive aspect showed lower improvement. Then, students' emotional engagement also increased significantly, with greater emotional involvement towards teachers, peers, and the learning environment. This study also revealed differences in student adaptability based on gender, where male students tend to have better adaptability than female students. Male students may be more accustomed to cognitively challenging games and, therefore, more likely to adapt. In addition, emotional engagement did not show significant differences between the two genders.

Furthermore, socio-economic status has an influence, where students from higher socio-economic classes tend to have higher adaptability and emotional engagement than students from lower socio-economic classes. This finding is possible because students from higher socio-economic classes usually have better access to educational resources and supportive learning environments, so they are more emotionally and adaptively engaged in learning using neuroscience-based educational games. The research results in this paper confirm that the use of neuroscience-based board games can be an effective science learning medium for developing life skills, especially adaptability and emotional engagement skills.

##### **Limitation**

While this study possesses several strengths, it also has some limitations, particularly in its reliance on samples from public schools and religiously affiliated private schools. Nonetheless, this limitation does not detract from the research, as these samples effectively represent the conditions found in the field, encompassing both public and private educational settings. The study suggests that further research is needed to explore the relationship between high affective adaptability and students' critical thinking skills following the use of neuroscience-based board games. This research primarily focuses on the impact of board games on students' adaptability and emotional engagement, without examining their effects on cognitive aspects such as critical thinking skills. The development of high affective adaptability may reflect emotional independence, which signifies an individual's ability to autonomously regulate their learning, potentially linking it to cognitive abilities like critical thinking.

#### **5. ACKNOWLEDGEMENT**

Thank you to all parties who have supported the implementation of this research, especially to the institutions and schools that have given permission and facilitated research activities so that this research can be carried out properly.

## 6. REFERENSI

- Bajaj, N., Belloti, F., Berta, R., & Gloria, A. D. (2016). A Neuroscience Based Approach to Game Based Learning Design. In *Games and Learning Alliance*. Springer.
- Chang, Z., Schwartz, M. S., Hinesley, V., & Dubinsky, J. M. (2022). Neuroscience concepts changed teachers' views of pedagogy and students. *Frontiers in Psychology*, *12*(August), 1–9. <https://doi.org/10.3389/fpsyg.2021.685856>
- Chen, S. Y., Tsai, J. C., Liu, S. Y., & Chang, C. Y. (2021). The effect of a scientific board game on improving creative problem solving skills. *Thinking Skills and Creativity*, *41*((June)), 100921. Retrieved from <https://doi.org/10.1016/j.tsc.2021.100921>
- de Almeida, L. G., Taschner, N. P., & Lellis-Santos, C. (2021). Outbreak! an online board game that fosters collaborative learning of viral diseases. *Journal of Microbiology & Biology Education*, *22*(1), 1–4. <https://doi.org/10.1128/jmbe.v22i1.2539>
- Deng, R. (2021). Emotionally engaged learners are more satisfied with online courses. *Sustainability*, *13*(20). <https://doi.org/10.3390/su132011169>
- Dorzheeva, A. (2020). Content analysis of the adaptation phenomenon. *Scientific and Practical Journal*, *14*(3), 346–356.
- Estévez, I., Rodríguez-Llorente, C., Piñeiro, I., González-Suárez, R., & Valle, A. (2021). School engagement, academic achievement, and self-regulated learning. *Sustainability*, *13*(6). <https://doi.org/10.3390/su13063011>
- Falloon, G. (2020). From simulations to real: Investigating young students' learning and transfer from simulations to real tasks. *British Journal of Educational Technology*, *51*(3), 778–797. <https://doi.org/10.1111/bjet.12885>
- Feraco, T., Casali, N., Ganzit, E., & Meneghetti, C. (2022). Adaptability and emotional, behavioural and cognitive aspects of self-regulated learning: Direct and indirect relations with academic achievement and life satisfaction. *British Journal of Educational Psychology*, *93*(1), 353–367. <https://doi.org/10.1111/bjep.12560>
- Galay, I. A., & Aizman, R. I. (2023). Gender features of the psychosocial state of students in the period of adaptation to the educational environment of the pedagogical university. *Research and Advances in Education*, *2*(3), 23–27. <https://doi.org/10.56397/rae.2023.03.05>
- Gao, N., Shao, W., Rahaman, M. S., & Salim, F. D. (2020). Predicting in-class emotional, behavioural and cognitive engagement in the wild. *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies*, *4*(3), 1–26. <https://doi.org/10.1145/3411813>
- Gladisia, N., Laily, N., & Puspitaningrum, N. S. E. (2022). Gambaran student engagement dalam pembelajaran di era new normal. *Jurnal Psikologi: Jurnal Ilmiah Fakultas Psikologi Universitas Yudharta Pasuruan*, *9*(1), 26–46. <https://doi.org/10.35891/jip.v9i1.2763>
- Gladstone, J. R., Wigfield, A., Eccles, J., Reschly, A. L., & Christenson, S. L. (2022). Situated Expectancy-Value Theory, Dimensions of Engagement, and AcaMotivation and Engagement: Commentarydemic Outcomes. In *Handbook of Research on Student Engagement* (p. PP. 57-76). Springer International Publishing.
- Goleman, D. (1995). Emotional Intelligence. In *Gramedia Pustaka Utama*.
- Greipl, S., Klein, E., Lindstedt, A., Kiili, K., Moeller, K., Karnath, H. O., ... Ninaus, M. (2021). When the brain comes into play: Neurofunctional correlates of emotions and reward in game-based learning. *Computers in Human Behavior*, *125*(June), 106946. <https://doi.org/10.1016/j.chb.2021.106946>
- Gunuc, S., & Kuzu, A. (2015). Student engagement scale: vevelopment, reliability and validity. *Assessment and Evaluation in Higher Education*, *40*(4), 587–610. <https://doi.org/10.1080/02602938.2014.938019>
-

- 
- Havik, T., & Westergård, E. (2020). Do teachers matter? students' perceptions of classroom interactions and student engagement. *Scandinavian Journal of Educational Research*, 64(4), 488–507. <https://doi.org/10.1080/00313831.2019.1577754>
- Holliman, A., Cheng, F., & Waldeck, D. (2022). Adaptability, personality, and social support: Examining links with psychological wellbeing among chinese high school students. *International Journal of Educational Psychology*, 11(2), 125–152. <https://doi.org/10.17583/ijep.8880>
- Kober, S. E., Wood, G., Kiili, K., Moeller, K., & Ninaus, M. (2020). Game-based learning environments affect frontal brain activity. *PLoS ONE*.
- Kodden, B. (2020). The Ability to Adapt. In *The Art of Sustainable Performance* (pp. 25–30). [https://doi.org/10.1007/978-3-030-46463-9\\_4](https://doi.org/10.1007/978-3-030-46463-9_4)
- Kumtepe, A. T., & Ucar, H. (2021). Motivation, Volition, and Engagement in Online Distance Learning. In *IGI Global*.
- Kushairi, N. (2023). Mystery of a super ball: A personal account on a chemistry gamification in promoting soft skills amongst pre-service teachers. *Practitioner Research*, No.5(July), 1–34. <https://doi.org/10.32890/pr2023.5.1>
- Liu, S., Liu, S., Liu, Z., Peng, X., & Yang, Z. (2022). Automated detection of emotional and cognitive engagement in MOOC discussions to predict learning achievement. *Computers & Education*, 181, 104461.
- Lodge, J. M., Alhadad, S. S. J., Lewis, M. J., & Gašević, D. (2017). Inferring learning from big data: The importance of a transdisciplinary and multidimensional approach. *Technology, Knowledge and Learning*, 22(3), 385–400. <https://doi.org/10.1007/s10758-017-9330-3>
- Marcus, V. B., Atan, N. A., Salleh, S. M., Tahir, L. M., & Yusof, S. M. (2021). Exploring student emotional engagement in extreme e-service learning. *International Journal of Emerging Technologies in Learning*, 16(23), 43–55. <https://doi.org/10.3991/ijet.v16i23.27427>
- Melvin, M. C. (2019). *Memory Hack: How To Sharpen Your Mind And Improve Your Memory*. Bliibliomundi.
- Moya-Higueras, J., Solé-Puiggené, M., Vita-Barrull, N., Estrada-Plana, V., Guzmán, N., Arias, S., ... March-Llanes, J. (2023). Just play cognitive modern board and card games, it's going to be good for your executive functions: A randomized controlled trial with children at risk of social exclusion. *Children*, 10(9). <https://doi.org/10.3390/children10091492>
- Neuharth-Pritchett, S., & Bub, L. K. (2022). Early Childhood Engagement. In *Handbook of Research on Student Engagement*. <https://doi.org/10.1007/978-3-031-07853-8>
- Ningsih, R. S. (2022). *A Survey of University Students' Engagement in Online*. Islamic University of Indonesia.
- Oleszkiewicz, S., Weiher, L., & Mac Giolla, E. (2022). The adaptable law enforcement officer: Exploring adaptability in a covert police context. *Legal and Criminological Psychology*, 27(2), 265–282. <https://doi.org/10.1111/lcrp.12209>
- Owen, G. (2020). What makes climate change adaptation effective? A systematic review of the literature. *Global Environmental Change*, 62(January), 102071. <https://doi.org/10.1016/j.gloenvcha.2020.102071>
- Parekh, P., Gee, E., Tran, K., Aguilera, E., Pérez Cortés, L. E., Kessner, T., & Siyahhan, S. (2021). Board game design: an educational tool for understanding environmental issues. *International Journal of Science Education*, 43(13), 2148–2168. <https://doi.org/10.1080/09500693.2021.1956701>
- Peng, H., Ma, S., & Spector, J. M. (2019). Personalized adaptive learning: an emerging pedagogical approach enabled by a smart learning environment. *Smart Learning Environments*, 6(1). <https://doi.org/10.1186/s40561-019-0089-y>
-

- Prayogo, A., Khotimah, K., Istiqomah, L., & Maharsi, I. (2023). Students' emotional engagement in online classes: a conceptual framework. *International Journal of Information and Learning Technology*, 41(1). <https://doi.org/10.1108/IJILT-04-2023-0052>
- Privitera, G. J. (2017). *Statistics for the Behavioral Sciences*. <https://doi.org/10.2307/1268475>
- Radzi, S. H. B. M., Ying, T. Y., Abidin, M. Z. Z., & Ahmad, P. A. (2020). The effectiveness of board game towards soft skills development for higher education. *Elementary Education Online*, 19(2), 94–106. <https://doi.org/10.17051/ilkonline.2020.02.111>
- Radzi, S. H., Ying, T. Y., Abidin, M. Z. Z., Ahmad, P. A., & Zainol, A. Z. (2017). A board game architecture for soft skills development. *International Malaysia-Indonesia-Thailand Symposium on Innovation and Creativity (IMIT-SIC)*, 3(May), 867–873. Retrieved from [https://www.researchgate.net/profile/Shanizan\\_Herman\\_Mohd\\_Radzi/publication/327117684\\_A\\_board\\_game\\_architecture\\_for\\_soft\\_skills\\_development/links/5b7ac4e8a6fdcc5f8b56ab66/A-board-game-architecture-for-soft-skills-development.pdf](https://www.researchgate.net/profile/Shanizan_Herman_Mohd_Radzi/publication/327117684_A_board_game_architecture_for_soft_skills_development/links/5b7ac4e8a6fdcc5f8b56ab66/A-board-game-architecture-for-soft-skills-development.pdf)
- Reinard, J. C. (2006). *Communication research statistics*. Retrieved from <https://www.zora.uzh.ch/id/eprint/186794/%0Ahttps://ijoc.org/index.php/ijoc/article/view/10588>
- Robinson, G. M., Hardman, M., & Matley, R. J. (2021). Using games in geographical and planning-related teaching: Serious games, edutainment, board games and role-play. *Social Sciences & Humanities Open*, 4(1), 100208. <https://doi.org/10.1016/j.ssaho.2021.100208>
- Santos. (2023). Board Games as Part of Effective Game-Based Learning Strategies. In *In book: Learning, Design, and Technology*. [https://doi.org/10.1007/978-3-319-17727-4\\_142-2](https://doi.org/10.1007/978-3-319-17727-4_142-2)
- She, C., Liang, Q., Jiang, W., & Xing, Q. (2023). Learning adaptability facilitates self-regulated learning at school: The chain mediating roles of academic motivation and self-management. *Frontiers in Psychology*, 14(May), 1–9. <https://doi.org/10.3389/fpsyg.2023.1162072>
- Sirotiak, T., & Sharma, A. (2019). Problem-based learning for adaptability and management skills. *Journal of Professional Issues in Engineering Education and Practice*, 145(4). [https://doi.org/10.1061/\(ASCE\)EI.1943-5541.0000420](https://doi.org/10.1061/(ASCE)EI.1943-5541.0000420)
- Somerville, L. H., Jones, R. M., & Casey, B. J. (2010). A time of change: Behavioral and neural correlates of adolescent sensitivity to appetitive and aversive environmental cues. *Brain and Cognition*, 72(1), 124–133. <https://doi.org/10.1016/j.bandc.2009.07.003>
- Stockinger, K., Rinas, R., & Daumiller, M. (2021). Student adaptability, emotions, and achievement: Navigating new academic terrains in a global crisis. *Learning and Individual Differences*, 90(June), 102046. <https://doi.org/10.1016/j.lindif.2021.102046>
- Suratno, Wahono, B., Chang, C.-Y., Retnowati, A., & Yushardi. (2020). Exploring a direct relationship between students' problem-solving abilities and academic achievement: A STEM education at a coffee plantation area. *Journal of Turkish Science Education*, 17(2), 211–224. <https://doi.org/10.36681/tused.2020.22>
- Tatianchenko, N. P. (2021). Psychological conditions for the formation of adaptation potential of an individual in the learning process. *Психология и Психотехника*, 62–77.
- Trilling, B., & Fadel, C. (2009). *21st century skills: Learning for life in our times* (Jossey-Bass, Ed.). A Wiley Imprint.
- Ulmanen, S., Soini, T., Pietarinen, J., & Pyhältö, K. (2016). The anatomy of adolescents' emotional engagement in schoolwork. *Social Psychology of Education*, 19(3), 587–606. <https://doi.org/10.1007/s11218-016-9343-0>
- van Dam, K., & Meulders, M. (2021). The adaptability scale: development, internal consistency, and initial validity evidence. *European Journal of Psychological Assessment*, 37(2), 123–134. Retrieved from <https://doi.org/10.1027/1015-5759/a000591%0A>

- van Kleef, G. A., Heerdink, M. W., & Homan, A. C. (2017). Emotional influence in groups: the dynamic nexus of affect, cognition, and behavior. *Current Opinion in Psychology*, 17, 156–161. <https://doi.org/10.1016/j.copsyc.2017.07.017>
- Viviers, H. A., Fouché, J. P., & Reitsma, G. M. (2016). Developing soft skills (also known as pervasive skills): Usefulness of an educational game. *Meditari Accountancy Research*, 24(3), 368–389. <https://doi.org/10.1108/MEDAR-07-2015-0045>
- Wahono, B., Sholihah, I.M., Narulita, E. (2023). Visual Content Analysis of STEM-Related Content in Indonesian Vocational High Schools Biology Textbooks. *Journal of Science Learning*, 6(3). <https://doi.org/10.17509/jsl.v6i3.53772>
- Wahono, B., Narulita, E., Chang, C.-Y., Darmawan, E., & Irwanto, I. (2021). The Role of Students' Worldview on Decision-Making: An Indonesian Case Study by a Socio-Scientific Issue-Based Instruction Through Integrated STEM Education. *Eurasia Journal of Mathematics, Science and Technology Education*, 17(11), em2027.
- Wolters, C. A., & Taylor, D. J. (2022). A Self-regulated Learning Perspective on Student Engagement. In *Handbook of Research on Student Engagement*. <https://doi.org/10.15760/nwjte.2012.10.1.1>
- Zhang, K., Wu, S., Xu, Y., Cao, W., Goetz, T., & Parks-Stamm, E. J. (2021). Adaptability promotes student engagement under COVID-19: The multiple mediating effects of academic emotion. *Frontiers in Psychology*, 11(January), 1–8. <https://doi.org/10.3389/fpsyg.2020.633265>
- Zhu, H. (2023). Exploration and practice of the relationship between college students' learning adaptation and mental health under the information-based teaching environment of potential Profile Analysis. *Journal of Environmental and Public Health*, 1–13. <https://doi.org/10.1155/2023/2256741>