

Emotions and learning motivation of high school students in biotechnology learning under the Merdeka Curriculum

Rina Karwatisari *, Adi Rahmat, Sariwulan Diana

Master Program of Biology Education, Faculty of Mathematics and Natural Science Education, Universitas Pendidikan Indonesia, Bandung, West Java, Indonesia

* Corresponding Author Email: rinakarwatisari@upi.edu

Article Information	Abstract
Keyword: Emotions; Motivation; Biotechnology learning Kata Kunci: Emosi; Motivasi; Pembelajaran bioteknologi History: Received : 28/07/2025 Revised : 28/08/2025 Accepted : 08/09/2025 Published : 25/09/2025	Research on students' emotions and motivation in biotechnology learning is very important as key input for considering the development of appropriate learning strategies. This study aims to determine the emotions and motivations of high school students in biotechnology learning. Using a quantitative descriptive method, data on students' emotions and motivations collected from 69 respondents are presented in representative graphs. The student respondents were selected using cluster random sampling. The emotion questionnaire instrument used amounted to 20 items based on indicators from PANAS-GEN. Meanwhile, the motivation questionnaire instrument used amounted to 15 items based on indicators from SALES. Descriptive statistical analysis shows that students' emotions toward biotechnology learning are dominated by positive emotions with an average score of 60 points. The positive emotions among students are more prevalent in the moderate category, accounting for 44% of students. The highest positive emotional values are found in students' enthusiasm for biotechnology learning. Meanwhile, negative emotions among students are dominated by the moderate category, accounting for 34%. The highest negative emotion scores were found in the aspect of fear in biotechnology learning. On the other hand, the results of students' motivation in biotechnology learning mostly fall into the low and moderate categories. The highest motivation indicator value was found in the 'learning goal orientation' indicator. Of the three, positive and negative emotions toward motivation showed a significant relationship with moderate levels of relationship quality. These findings provide empirical evidence that positive emotions and motivation play a significant role in supporting the development of 21st-century skills in learning. <i>Abstrak. Penelitian mengenai emosi dan motivasi siswa dalam pembelajaran bioteknologi sangat penting sebagai masukan utama untuk mempertimbangkan pengembangan strategi belajar yang tepat. Penelitian ini bertujuan untuk mengetahui emosi dan motivasi siswa SMA dalam pembelajaran bioteknologi. Dengan menggunakan metode deskriptif kuantitatif, data hasil emosi dan motivasi siswa yang diambil dari 69 responden disajikan dalam bentuk grafik yang representatif. Responden siswa dipilih dengan teknik cluster random sampling. Instrumen kuesioner emosi yang digunakan terdiri dari 20 item berdasarkan indikator dari PANAS-GEN. Sementara itu, instrumen kuesioner motivasi yang digunakan terdiri dari 15 item berdasarkan indikator dari SALES. Analisis dengan statistik deskriptif menunjukkan bahwa emosi siswa terhadap pembelajaran bioteknologi didominasi oleh emosi positif dengan rata-rata nilai 60 poin. Emosi positif siswa lebih banyak pada kategori sedang sebanyak 44% siswa. Nilai emosi positif tertinggi ada pada aspek antusias siswa dalam pembelajaran bioteknologi. Kemudian, emosi negatif siswa didominasi kategori sedang sebanyak 34% dan kategori tinggi sebanyak 30%. Nilai emosi negatif tertinggi ada pada aspek takut dalam pembelajaran bioteknologi. Disisi lain, hasil motivasi siswa dalam pembelajaran bioteknologi paling banyak termasuk dalam kategori rendah dan sedang. Nilai indikator motivasi siswa tertinggi ada pada indikator 'learning goal orientation'. Dari ketiganya, antara emosi positif dan negatif terhadap motivasi menunjukkan adanya hubungan yang signifikan dengan taraf hubungan yang sedang. Temuan ini menjadi dasar empiris bahwa emosi positif dan motivasi berperan signifikan dalam mendukung pengembangan keterampilan abad 21 dalam pembelajaran.</i>

A. Introduction

Biotechnology is one of the fields of applied biology that currently plays an important role in the world of health, agriculture, and industry (Ma, 2021). In the Merdeka Curriculum, biotechnology material is taught to students in class X in a group of science lessons that were previously taught to students in class XI. In the Phase E Learning Outcomes document of the Merdeka Curriculum, it is stated that students must be able to understand the process and use of biotechnology in various areas of life (Badan Standar Kurikulum dan Asesmen Pendidikan, 2024). Students are required to be able to understand the mechanism of the formation of a biotechnology product and are also directed to understand its use in various fields in students' daily lives.

Biotechnology is defined as the science of applying knowledge or techniques to living organisms, cells, or other parts to produce a specific product (Gosal, 2021; Ma, 2021; Szyperski, 1998). Forms of biotechnology include fermentation, tissue culture, genetic engineering and the use of microorganism enzymes. Biotechnology has existed and been used for thousands of years, but its rapid progress occurred in the 1970s since the invention of genetic manipulation techniques (Gosal, 2021; Have & Neves, 2021). Biotechnology brings many changes to human life because it can be one of the alternative solutions to existing problems. Until now, the development of biotechnology continues to develop along with problems that are now increasingly complex.

Biotechnology materials are included in the curriculum and have been taught to students in high school (Harms, 2002; Zeller, 1994). Often learning in biotechnology materials always experiences less than optimal results. There are several extrinsic factors that make biology learning outcomes difficult to achieve. From the teacher's point of view, the difficulty in teaching biotechnology material lies in abstract and complex material (Agustina et al., 2017; Elladora et al., 2024; Steele & Aubusson, 2004). The complexity of biotechnology materials to be taught is compounded by time constraints and limited facilities (Agustina et al., 2017). On the other hand, students have difficulty understanding abstract processes or mechanisms because they are invisible and too complicated (Duda et al., 2020). In addition, biotechnology materials are difficult to visualize due to the lack of learning media (Qalbina & Ahda, 2019).

Apart from extrinsic factors, students' difficulties in learning can also be influenced by intrinsic factors such as emotions and motivation (Acosta-Gonzaga & Ramírez-Arellano, 2021). Emotions are defined differently, one of which is defined by Russell's (2003) as a neurophysiological state that is consciously accessible as simple, non-reflective feelings (Plass & Kalyuga, 2019). Emotions can affect the focus on learning and make it easier to

remember the material (Gow et al., 2020; Plass & Kalyuga, 2019). While motivation is the process that triggers and maintains goals (Schunk & DiBenedetto, 2020). Motivation is one of the factors that can improve a person's performance (Gurjar, 2022).

Students' emotions and motivations can affect student learning outcomes. Research results from Camacho-Morles et al. (2021) It shows that positive emotions such as enjoying learning affect learning performance, as well as negative emotions such as anger have a negative effect on learning performance. Other research from D'Mello et al. (2024) that students' emotions and negativity can predict the learning outcomes of those students. On the other hand, the results of the research on student motivation from Nugraha et al. (2021) shows that there is a positive relationship between motivation and student learning outcomes. Other research from Habibullah et al. (2022) It also shows that high learning motivation can improve student learning outcomes. Therefore, it is important to know the emotions and motivations of students in order to determine the appropriate learning models and methods (Lo, 2024; Wijnia et al., 2024).

Descriptive analysis was conducted to provide an overview using data obtained from the subjects (Suryanda et al., 2020). Descriptive analysis of emotions and motivations has been extensively done by previous research. Research by Fadilah et al. (2025) about descriptive analysis of student motivation using instruments SALES provide a description of students' learning motivation in science learning in each indicator. In the study, a comparative test was carried out on each indicator. On the other hand, research by Putri et al. (2024) about analyzing students' emotions using descriptive and comparative methods using achievement emotions questionnaire show the negative emotions of students in learning. The two previous research results describe the condition of the two variables in different conditions but not in biotechnology materials.

Based on this background, it is necessary to conduct a more in-depth analysis related to students' emotions and motivations in biotechnology learning. The novelty aspect of this study is to compare the results of students' emotions and motivation to biotechnology learning in one of the high schools in Sumedang Regency. It is hoped that this novelty can enrich the results of research and can be considered in implementing a learning model. Therefore, the research questions that must be answered in this study are: 1) How are the emotions of class X students in biotechnology learning? and 2) How is the motivation of class X students in biotechnology learning? 3) How do positive and negative emotions relate to student motivation in learning biotechnology?

B. Material and method

This study uses a correlational research method with explanation design. The aim is to see the extent to which the relationship between two or more variables correlates (Creswell & Guetterman, 2019). The phenomenon described is the emotions and motivation of class X students in biotechnology learning. In this study, we want to see how the emotions and motivations felt by students who are assessed and categorized differently in certain categories to be able to interpret real conditions in the field. In addition, a correlation analysis was conducted to determine the extent of the relationship between positive and negative emotions and student learning motivation.

This research was carried out on May 6 and 7, 2025 at Cimanggung State High School, Sumedang Regency. Cimanggung State High School uses two different curricula: the Merdeka Curriculum for X grade and the 2013 Curriculum for XI and XII grades. The sample in this study amounted to 69 students who were selected using the cluster random sampling. The sample was a class X student who had never studied biotechnology material in high school. The data taken from the sample is data on students' emotions and motivations which were collected using questionnaire instruments. The emotion questionnaire instrument used amounted to 20 items modified from the instrument PANAS-GEN (Positive and Negative Affect Schedule) Watson et al. (1988). Meanwhile, the motivation questionnaire instrument used amounted to 15 items adapted from the SALES (Students' Adaptive Learning Engagement in Science) Velayutham et al. (2011). Motivational instruments are tailored to the scope of biotechnology material so that the results obtained are more appropriate. Indicators of each instrument are presented in Table 1 and Table 2.

Based on Table 1, the indicators used for positive emotions consist of 10 indicators. These indicators include: interested, excited, confident, enthusiastic, proud, alert, inspired, diligent, attentive, active (Watson et al., 1988). In addition, there are 10 indicators for negative emotions. These indicators include: stress, upset, feeling guilty, fear, oppose/hostile, irritable, ashamed, nervous, restless, fear (Watson et al., 1988). However, based on Table 2, there are three indicators used, namely Learning Goal Orientation, Task Value, and Self-Efficacy.

Both instruments have been validated and tested so that they have been declared valid and reliable. The results of the validation of each item of the emotion and the motivation questionnaire instrument are shown in Table 3. The result of the reliability of the the motivation questionnaire instrument are shown in Table 4.

Table 1 Emotional questionnaire indicators

No.	Component	Indicators	Statement number
1	Positive emotions	Interested	1
		Excited	3
		Confident	5
		Enthusiastic	9
		Proud	10
		Alert	12
		Inspired	14
		Diligent	16
		Attentive	17
		Active	19
2	Negative emotions	Stress	2
		Upset	4
		Feeling guilty	6
		Fear	7
		Oppose/hostile	8
		Irritable	11
		Ashamed	13
		Nervous	15
		Restless	18
		Fear	20

Table 2 Motivation questionnaire indicators

No.	Component indicators	Statement number
1	Learning goal orientation	1, 2, 3, 4, 5, 6
2	Task value	7, 8, 9, 10
3	Self-efficacy	11, 12, 13, 14, 15

Table 3 Validation of instrument

Instrument	Statement number	R value	Category
Emotion questionnaire	1	0.559	Valid
	2	0.421	Valid
	3	0.581	Valid
	4	0.520	Valid
	5	0.419	Valid
	6	0.271	Valid
	7	0.635	Valid
	8	0.558	Valid
	9	0.454	Valid
	10	0.506	Valid
	11	0.396	Valid
	12	0.290	Valid
	13	0.264	Valid
	14	0.495	Valid
	15	0.353	Valid
	16	0.449	Valid
	17	0.309	Valid
	18	0.498	Valid
	19	0.379	Valid
	20	0.265	Valid
Motivation questionnaire	1	0.687	Valid
	2	0.638	Valid
	3	0.497	Valid
	4	0.581	Valid
	5	0.466	Valid
	6	0.624	Valid
	7	0.529	Valid
	8	0.645	Valid
	9	0.491	Valid

Instrument	Statement number	R value	Category
	10	0.635	Valid
	11	0.558	Valid
	12	0.447	Valid
	13	0.541	Valid
	14	0.624	Valid
	15	0.432	Valid

Description: $r_{Table} = 0,234$

Table 4 Reliability of instrument

Instrument	Cronbach's alpha	N of item	Category
Emotion	0.751	20	High
Motivation	0.843	15	Very high

The process of collecting emotional and motivation data is carried out during biology learning hours. The instruments were completed independently by the students. The instruments were completed after all chapters on biotechnology had been taught. The time used to answer the instrument is 60 minutes. Students are first given an explanation of the instructions for filling out the questionnaire. Then students were given two instrument questionnaires, namely an emotion questionnaire and a motivation questionnaire. Students first fill out an emotion questionnaire for 30 minutes, followed by filling out a motivational questionnaire for 30 minutes.

The results of filling out the questionnaire are collected and then scored and categorized based on categorization Azwar (2017). The results obtained from the students were emotional and motivational scores for each indicator statement. The emotional and motivational questionnaire scores were converted into values on a scale of 1–100. The categorization of values according to Azwar (2017) divided each category level based on the formula shown in Table 5.

Table 5 Emotion and motivation categorization

Equation	Category
$X \leq (\text{Mean} - 1.5 \text{ SD})$	Very low
$(\text{Mean} - 1.5 \text{ SD}) < X \leq (\text{Mean} - 0.5 \text{ SD})$	Low
$(\text{Mean} - 0.5 \text{ SD}) < X \leq (\text{Mean} + 0.5 \text{ SD})$	Moderate
$(\text{Mean} + 0.5 \text{ SD}) < X \leq (\text{Mean} + 1.5 \text{ SD})$	High
$X > (\text{Mean} + 1.5 \text{ SD})$	Very high

The results obtained are then analyzed and presented using descriptive statistics to provide an overview using data obtained from the subject (Suryanda et al., 2020). The analysis of student emotional and motivational data focused on the average score, and standard deviation for each indicator. The average results are displayed in graph form to facilitate data reading. Furthermore, to analyze the relationship between positive emotions and negative emotions on learning motivation, multiple correlation analysis was performed. The

results of the multiple correlation test will show the significance of the correlation and the degree of relationship between variables.

C. Results and discussion

Student emotion and motivation scores were obtained from students and converted into values on a scale of 1-100. The values obtained were used in descriptive and correlational analyses. The values used were the mean, standard deviation, highest value, and lowest value. The results of the processing of student emotion and motivation data are shown in Table 6.

Table 6 Data on students' emotional values and motivation in biotechnology learning

Data	Mean	Std. Dev	Max	Min
Positive emotion	60	12.579	84	22
Negative emotion	46	11.773	70	18
Motivation	73	7.797	91	60

Students' emotions in biotechnology learning

Data on students' emotional results on biotechnology learning were processed and presented in the form of graphs. The emotions discussed in this study are positive emotions and negative emotions of students towards biotechnology learning. The categorization of positive and negative emotional values was both netted with the PANAS GEN instrument and categorized using Azwar (2017). The results of the categorization of positive emotions are presented in Figure 1.

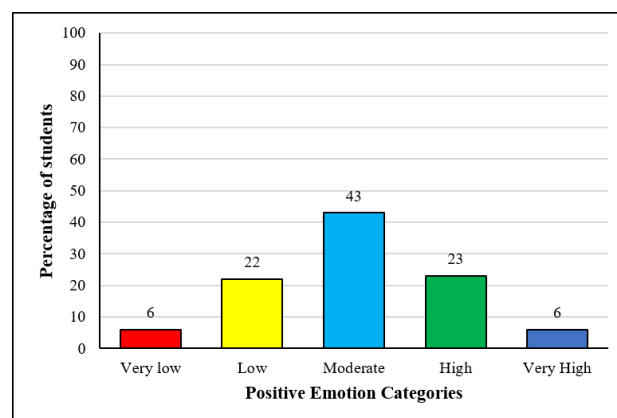


Figure 1 Categories of positive emotions of students in biotechnology learning

Based on Figure 1, the highest category of positive student emotions towards biotechnology learning is in the 'medium' category with a total of 43% or as many as 30 students. Meanwhile, the lowest number of positive emotions categories is in the 'very low' category and the 'very high' category with 6% each or as many as 4 students. These results show that the majority of students at SMA Negeri

Cimanggung have positive emotions who are learning biotechnology. To see the positive emotions that are most felt by students, it can be seen from the graph of the average value of positive emotions in each indicator. The average results of positive emotions values per indicator are presented in Figure 2.

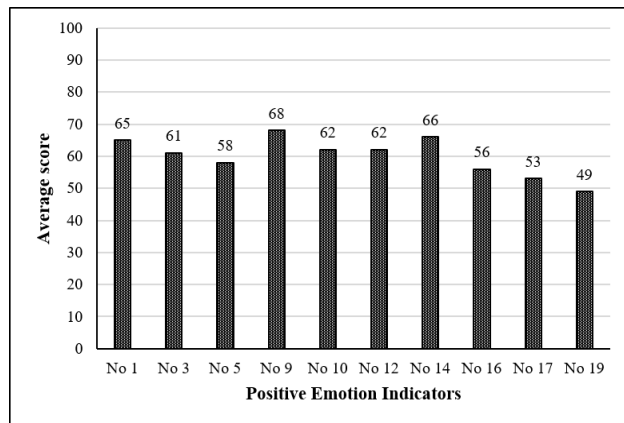


Figure 2 Average positive emotion values per indicator

The graph shows that the highest average value of positive emotions is in the 'enthusiasm' indicator in questionnaire number 9 with a value of 68 points. Cimanggung State High School students have the highest positive emotions in the enthusiastic aspect of biotechnology learning. Biotechnology learning materials are very related to the development of the times (Have & Neves, 2021) so that many people are more easily interested in the topic in it. Meanwhile, the lowest positive emotions were in the 'active' indicator in questionnaire no. 19 with a value of 49 points. Students lack positive emotions in terms of activeness in the biotechnology learning process. Some factors causing students to be less active in learning are low self-confidence (Aguillon et al., 2020) and the use of traditional methods that only require students to listen (Børte et al., 2020).

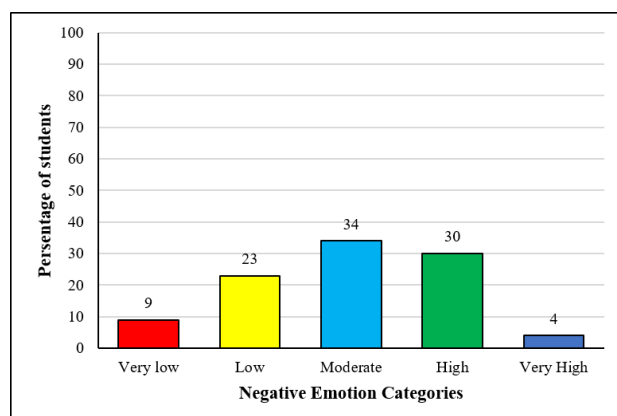


Figure 3

Categories of students' negative emotions in biotechnology learning

Next, the results of the categorization of negative emotions are shown in the graph in Figure 3. Based on the graph, the highest category of negative emotions of students in biotechnology learning is in the 'medium' category with a total of 34% or as many as 23 students. Meanwhile, the lowest category of negative emotions of students in biotechnology learning is in the 'very high' category with a total of 4% or as many as 3 students. These results show that the majority of students of SMA Negeri Cimanggung have negative emotions towards biotechnology learning. This is similar to the results of positive emotions that are equally in the 'moderate' category. To see the negative emotions that are most felt by students, it can be seen from the graph of each indicator. The average result of negative emotions values per indicator is presented in Figure 4.

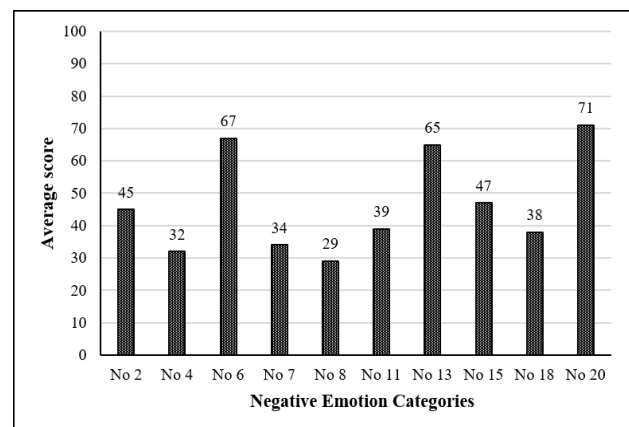


Figure 4 Average negative emotion values per indicator

The results of the graph in Figure 4 show that the highest indicator of students' negative emotions towards biotechnology learning is in the 'fear' indicator on questionnaire no. 20 with a score of 71 points. Students of Cimanggung State High School show a fairly high fear of biotechnology learning. This can be related to the nature of biotechnological materials known as overly complex materials (Duda et al., 2020) so that students are afraid to learn it. Meanwhile, the lowest negative emotion indicator towards biotechnology learning was in the 'opposed' indicator in questionnaire no. 8 with a total of 29 points. These results show that Cimanggung State High School students do not feel much challenge to the biotechnology learning carried out. The factors that cause students to feel less challenged in learning biotechnology are their lack of knowledge and difficulty in following the material, so that students do not feel challenged to try further (Elladora et al., 2024; Falk et al., 2008).

From the results of the two emotions, both are classified as medium category but the average positive emotion value of students showed higher results than negative emotional values towards biotechnology learning. The average positive emotion

score of students is 60 points, while the average value of negative emotions of students is 46 points. High positive emotions in biotechnology learning show enjoyment of the learning. Students who have high positive emotions tend to like it easily (Morrison et al., 2020). High positive emotions can support students' focus during learning (Gow et al., 2020; Plass & Kalyuga, 2019). Positive emotions can be influenced by the learning environment. A positive learning environment can not only increase motivation and learning outcomes but also affect a person's positive emotions (Gow et al., 2020). Thus, creating a comfortable and attractive learning environment must be a priority for teachers in conducting learning. On the other hand, negative emotions can also increase, one of which is if a person has an excessive workload (Han et al., 2022). This can be a record for teachers in teaching complex biotechnology learning. Teachers must determine learning activities that do not give too much workload to students.

Student motivation in biotechnology learning

The data on student motivation results is presented in the form of a graphic bar to make it easier to see the comparison. The results of the categorization of student motivation in biotechnology learning are shown in Figure 5. Based on the graph, using categorization from Azwar (2017), the highest category of student motivation in biotechnology learning is in the 'low' category with a total of 33% or as many as 23 students. Meanwhile, the lowest motivation category is in the 'very low' and 'very high' categories with a total of 6% or as many as 4 students. In the graph, the motivation of Cimanggung State High School students in biotechnology learning is dominated by 'low' and 'moderate' motivation.

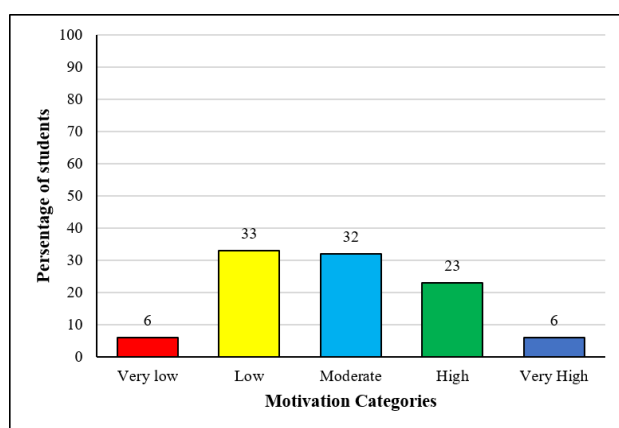


Figure 5. Categories of Student Motivation in Biotechnology Learning

The highest motivation score obtained in the study was 91 points with the lowest score of 60 points. The average motivation score obtained by students in this study was 73.35. These results are not much different from the results of research from

Fadilah et al. (2025) which shows an average motivation score for science learning of 3.64 or with a score of 72.8. The average score category of all students in this study is included in the 'medium' category. This average score indicates that students are motivated to learn biotechnology. Students respond to biotechnology learning in a normal way.

In addition to the overall average motivation score, this study also saw the results of the average motivation score for each indicator. There are three indicators taken in the instrument SALES In this study, namely learning goal orientation, task value and self-efficacy (Velayutham et al., 2011). Each indicator showed a different motivational value in this study. The results of the average motivation value data per indicator are presented in Figure 6.

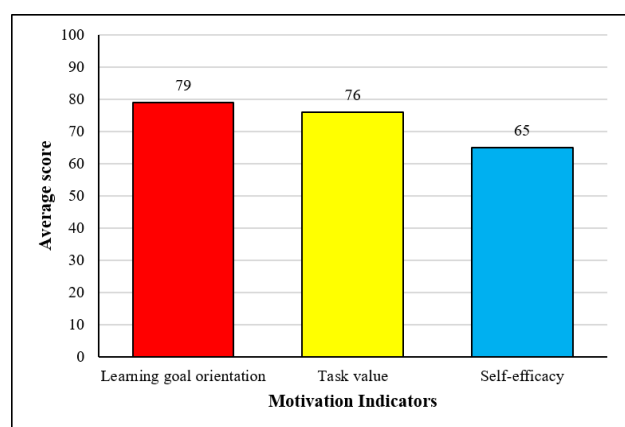


Figure 6 Average motivation value per indicator

Based on Figure 6, the highest average motivation value is in the indicator 'Learning Goal Orientation' by 79 points, then the indicator 'Task Hair' by 76, and 'self-efficacy' as big as '65'. The average student has Learning Goal Orientation or the orientation of biotechnology learning goals that are higher than other motivations. Learning goal orientation is an encouragement for a person to be able to achieve the expected learning goals (Rizky & Ajisukmo, 2019). In biotechnology learning, students are motivated to achieve these goals due to the complex and challenging nature of the material. Students in this case feel encouraged to achieve the best learning achievements.

Indicators Task Value have an average score that is not much different from learning goal orientation. Objectives of Task Value is to help students achieve their desired competencies. This motivation indicator is related to the process of student involvement in learning (Satriya, 2021). In this case, Task Value reflect their perception of the benefits they feel for learning (Bong, 2004). Thus, students in biotechnology learning show a high level of motivation for their perception of the benefits of biotechnology.

Self-efficacy is the lowest indicator of motivation obtained by students in this study. Self-efficacy shows students' confidence in learning, in this case learning biotechnology materials. Lower results than other indicators indicate that students lack confidence in their ability to learn. This can end in a decision to give up on the challenges that exist (Sari, 2020). Complicated biology learning is one of the factors why students have self-efficacy low. For this reason, teachers need to pay more attention to this indicator so that self-efficacy students can improve even more.

High motivation in learning is supported by internal and external factors. Internal factors that support high motivation are having Learning Goal Orientation obvious, expectations in Task Value appropriate, and self-efficacy tall (Hattie et al., 2020). All of these internal factors can be supported by external factors. External factors that can affect students' learning motivation in learning, especially biotechnology, is interesting learning. Engaging learning methods such as the use of digital technology can improve learning outcomes compared to traditional learning methods (Liu et al., 2017).

Students in learning tend to be happier and motivated to learn if the material they learn is considered interesting and fun (Nuraysha et al., 2024). Biotechnology materials are often thought of as complex and complex materials (Agustina et al., 2017; Elladora et al., 2024; Steele & Aubusson, 2004). In order for students to find biotechnology material interesting and fun, teachers must innovate in presenting the material. Biotechnology materials can be packaged with interactive learning media or with practicum activities that are close to students' lives. Slowly, teachers must begin to dispel the view that biotechnology material is difficult material.

Another factor that can increase student motivation in learning is the role of teachers and learning methods in teaching (Garn & Jolly, 2014). Teachers who always provide motivation and provide positive vibes are able to invite their students to be equally motivated in learning. In addition, fun learning methods or appreciation for students' work in learning can increase student motivation in learning (Garn & Jolly, 2014; Mendoza-García, 2025). Biotechnology materials provide ample opportunities for teachers to use a wide variety of learning methods and approaches that can increase student motivation.

The relationship between positive and negative emotions towards student motivation in biotechnology learning

The relationship between positive and negative emotions and student motivation was analyzed using a multiple correlation test. Data on positive emotions, negative emotions, and motivation were used to examine the relationship between them. The aim was to determine the extent of the relationship between

positive and negative emotions and student motivation in biotechnology learning. The results of the multiple correlation test are shown in Table 7.

Table 7 Results of the multiple correlation test

Sig. F	R
0.001	0.426

Based on Table 7, the significance value shows a figure of 0.001 (<0.05), indicating that there is a relationship or correlation between positive and negative emotions and student learning motivation in biotechnology learning. The table also shows that the level of correlation is $R = 0.426$, which falls into the category of moderate correlation. Thus, positive and negative emotions are proven to have a moderate relationship with students' learning motivation in biotechnology learning.

The results of this analysis are in line with the research by (MacIntyre & Vincze, 2017), which also used a correlational method. The results of this study show that there is a relationship between positive and negative emotions and student learning motivation. Positive emotions play a significant role in student learning motivation. Other studies also show that different emotions will affect behavioral motivation (Beall & Tracy, 2017). Emotions within an individual drive motivation, thereby improving work performance (Alrabai, 2022).

In neuroscience studies, emotions and motivation share the same system in the human brain. Emotions and motivation are linked to the same gene in the brain system, where an emotion arises when a reward or punishment is received (Rolls, 2025). The connection between emotions and motivation in the human brain appears to have different functional patterns due to overlapping systems (Cromwell et al., 2020). This results in emotions and motivation having different outcomes but originating from the same system.

Positive emotions, negative emotions, and students' learning motivation in this study are all dominated by the moderate category. This means that students' emotions and motivation are at the same level within them. In psychological studies, emotions and motivation can be considered the same process, where emotions are the "readout" of motivational potential (Buck, 1985). Emotions are not merely the result of motivation but act as a driver for human behavior (Pessoa, 2009).

The relationship between emotions and motivation in biotechnology learning highlights the urgency of designing learning environments that prevent a decline in students' emotions and motivation. Biotechnology learning should be designed to make students feel engaged, thereby improving their learning performance (Camacho-Morles et al., 2021). At the same time, learning should

also enhance students' learning motivation, as it has a significant correlation with learning outcomes (Nugraha et al., 2021).

D. Conclusion

The conclusions of this study indicate that positive emotions among students are more prevalent in the moderate category, accounting for 44% of students, while the high and low categories account for 22-23%. The highest positive emotional values are found in students' enthusiasm for biotechnology learning. Meanwhile, negative emotions among students are dominated by the moderate category, accounting for 34%, and the high category, accounting for 30%. The highest negative emotion scores were found in the aspect of fear in biotechnology learning. Furthermore, students' motivation toward biotechnology learning was predominantly in the low and moderate categories. The highest motivation aspect was in learning goal orientation. Of the three, positive and negative emotions toward motivation showed a significant relationship with moderate levels of relationship quality. The results of this study provide valuable input as an empirical basis for determining the appropriate learning strategy. Based on the findings of this study, it is recommended to conduct further research exploring the effects of using innovative learning models or methods, such as technology-enhanced learning, on improving students' positive emotions and motivation in biotechnology. Future studies should also examine the relationship between emotions and motivation with the development of critical thinking, creativity, collaboration, and communication (4C skills) in biotechnology learning, in order to provide a more comprehensive understanding of the role of affective factors in supporting students' 21st-century skills.

E. Acknowledgement

A heartfelt thank you to SMA Negeri Cimanggung, Sumedang Regency, for their permission and cooperation in conducting this research. The author would also like to thank the students of class X who have been willing to be respondents and provide data honestly and enthusiastically. Sincere appreciation is also extended to the supervisor for guidance, direction, and valuable input during the preparation of this article, fellow Biology Education master students of period 2023, Class B. The author also expresses his gratitude to the Department of Biology Education, University of Education Indonesia for the academic support that has been provided during the research process. not to forget the LPDP through the Indonesian Education Scholarship which has supported my research. Finally, the author would like to thank all those who cannot be mentioned one by one, but have provided assistance and support in the completion of this article.

F. References

- Acosta-Gonzaga, E., & Ramírez-Arellano, A. (2021). The influence of motivation, emotions, cognition, and metacognition on students' learning performance: A comparative study in higher education in blended and traditional contexts. *Sage Open*, 11(2), 21582440211027561. DOI: <https://doi.org/10.1177/21582440211027561>
- Aguillon, S., Siegmund, G.-F., Petipas, R., Drake, A., Cotner, S., & Ballen, C. (2020). Gender differences in student participation in an active-learning classroom. *CBE Life Sciences Education*, 19(2), ar 12. DOI: <https://doi.org/10.1187/cbe.19-03-0048>
- Agustina, W., Rustaman, N., & Purwianingsi, W. (2017). The teaching problems in biotechnology a preliminary research toward teachers' of secondary school in East Bandung. In *4th International Conference on Research, Implementation and Education of Mathematics and Science Proceedings*. Yogyakarta. Retrieved from <https://consensus.app/papers/the-teaching-problems-in-biotechnology-a-preliminary-agustina-purwianingsi/1b320a305e5f5cc3a5bfcbd092b21481>
- Alrabai, F. (2022). Modeling the relationship between classroom emotions, motivation, and learner willingness to communicate in EFL: Applying a holistic approach of positive psychology in SLA research. *Journal of Multilingual and Multicultural Development*, 45, 2465–2483. DOI: <https://doi.org/10.1080/01434632.2022.2053138>
- Azwar, S. (2017). *Metodologi penelitian psikologi (II)*. Yogyakarta: Pustaka Pelajar.
- Badan Standar Kurikulum dan Asesmen Pendidikan. (2024). *Capaian pembelajaran pada pendidikan anak usia dini, jenjang pendidikan dasar, dan jenjang pendidikan menengah pada Kurikulum Merdeka*. Retrieved from https://kurikulum.kemdikbud.go.id/file/1718471412_manage_file.pdf
- Beall, A., & Tracy, J. (2017). Emotivational psychology: How distinct emotions facilitate fundamental motives. *Social and Personality Psychology Compass*, 11(2), e12303. DOI: <https://doi.org/10.1111/SPC3.12303>
- Bong, M. (2004). Academic motivation in self-efficacy, task value, achievement goal orientations, and attributional beliefs. In *The Journal of Educational Research* (Vol. 97, Issue 6, pp. 287–297). Heldref Publications. DOI: <https://doi.org/10.3200/JOER.97.6.287-298>
- Børte, K., Nesje, K., & Lillejord, S. (2020). Barriers to student active learning in higher education. *Teaching in Higher Education*, 28, 597–615. DOI: <https://doi.org/10.1080/13562517.2020.1839746>
- Buck, R. (1985). Prime theory: An integrated view of motivation and emotion. *Psychological Review*, 92, 389–413. DOI: <https://doi.org/10.1037/0033-295X.92.3.389>
- Camacho-Morles, J., Slemp, G., Pekrun, R., Loderer, K.,

- Hou, H., & Oades, L. (2021). Activity Achievement Emotions and Academic Performance: A Meta-analysis. *Educational Psychology Review*, 33, 1051–1095. DOI: <https://doi.org/10.1007/s10648-020-09585-3>
- Cooksey, R. W. (2020). Descriptive statistics for summarising data. In *Illustrating Statistical Procedures: Finding Meaning in Quantitative Data* (pp. 61–139). Springer Singapore. DOI: https://doi.org/10.1007/978-981-15-2537-7_5
- Creswell, J. W., & Guetterman, T. C. (2019). *Educational research planning, conducting, and evaluating quantitative and qualitative research* (Six). Pearson.
- Cromwell, H., Abe, N., Barrett, K., Caldwell-Harris, C., Gendolla, G., Koncz, R., & Sachdev, P. (2020). Mapping the interconnected neural systems underlying motivation and emotion: A key step toward understanding the human affectome. *Neuroscience & Biobehavioral Reviews*, 113, 204–226. DOI: <https://doi.org/10.1016/j.neubiorev.2020.02.032>
- D'Mello, S. K., Moulder, R. G., & Jensen, E. (2024). Momentary measures of emotions during technology-enhanced learning prospectively predict standardized test scores in two large samples. *Learning and Instruction*, 90, 101872. DOI: <https://doi.org/10.1016/j.learninstruc.2023.101872>
- Duda, H. J., Wahyuni, F. R. E., & Setyawan, A. E. (2020, November). Plant biotechnology: Studying the misconception of biology education students. In *AIP Conference Proceedings* (Vol. 2296, No. 1, p. 020101). AIP Publishing LLC. DOI: <https://doi.org/10.1063/5.0030449>
- Elladora, S., Gaylan, E., Taneo, J., Callanga, C., Becbec, J., Bercero, G. I. M., Piloton-Narca, M., & Picardal, M. (2024). Challenges in teaching biotechnology in the Philippine STE program. *International Journal of Learning, Teaching and Educational Research*, 23(3), 367–389. DOI: <https://doi.org/10.26803/ijlter.23.3.18>
- Fadilah, R., Sastria, E., & Pranata, O. D. (2025). Analisis motivasi belajar siswa dalam pembelajaran IPA di Madrasah Tsanawiyah kawasan industri. *Konstruktivisme: Jurnal Pendidikan dan Pembelajaran*, 17(1), 37–50. DOI: <https://doi.org/10.35457/konstruk.v17i1.4025>
- Falk, H., Brill, G., & Yarden, A. (2008). Teaching a biotechnology curriculum based on adapted primary literature. *International Journal of Science Education*, 30, 1841–1866. DOI: <https://doi.org/10.1080/09500690701579553>
- Garn, A., & Jolly, J. (2014). High ability students' voice on learning motivation. *Journal of Advanced Academics*, 25, 24–27. DOI: <https://doi.org/10.1177/1932202X13513262>
- Gosal, S. (2021). Biotechnology. *CABI Compendium*. DOI: <https://doi.org/10.1079/hc.72173918.20219903039>
- Gow, A., Li, L., & Zhou, J. (2020). The role of positive emotions in education: A neuroscience perspective. *Mind, Brain, and Education*, 14, 220–234. DOI: <https://doi.org/10.1111/mbe.12244>
- Gurjar, D. M. (2022). Motivation: A psychological perspective. *International Journal of Advanced Research in Science, Communication and Technology*, 2(1), 140–142. DOI: <https://doi.org/10.48175/ijarsct-2475>
- Habibullah, H., Durahim, Y., Pamungkas, T., Haryundari, M. L. I., & Rusnila, R. (2022). The effect of motivation on students's mathematics learning outcomes in the new normal era. *Jambura Journal of Mathematics Education*, 3(2), 63–69. DOI: <https://doi.org/10.34312/jmathedu.v3i2.15114>
- Han, L., Li, Q., Zhang, Y., Liu, T., Niu, R., Wang, Q., & Zhao, L. (2022). Negative emotional status and influencing factors among young employees in center of disease control and prevention. *BMC Public Health*, 22(1), 398. DOI: <https://doi.org/10.1186/s12889-022-12806-9>
- Harms, U. (2002). Biotechnology education in schools. *Electronic Journal of Biotechnology*, 5, 5–6. DOI: <https://doi.org/10.4067/S0717-34582002000300003>
- Hattie, J., Hodis, F., & Kang, S. (2020). Theories of motivation: Integration and ways forward. *Contemporary educational psychology*, 61, 101865. DOI: <https://doi.org/10.1016/j.cedpsych.2020.101865>
- Have, T., & Neves, M. P. (2021). *Dictionary of global bioethics* (Vol. 371, pp. Springer-Cham). Cham: Springer. DOI: https://doi.org/10.1007/978-3-030-54161-3_99
- Liu, K.-S., Chen, H.-C., & Lin, M.-H. (2017). A study of the effects of digital learning on learning motivation and learning outcome. *Eurasia Journal of Mathematics, Science and Technology Education*, 13, 3553–3564. DOI: <https://doi.org/10.12973/EURASIA.2017.00744A>
- Lo, M.-T. (2024). The intraindividual dynamics of university students' motivation and emotions: The role of autonomy-supportive learning climates and learning activities. *British Journal of Educational Psychology*, 94(4), 1011–1032. DOI: <https://doi.org/10.1111/bjep.12703>
- Ma, Q. (2021). Biotechnology: Recent developments, emerging trends, and implications for business. In A. Hooke (Ed.), *Technological Breakthroughs and Future Business Opportunities in Education, Health, and Outer Space* (pp. 112–132). IGI Global Scientific Publishing. DOI: <https://doi.org/10.4018/978-1-7998-6772-2.ch007>
- MacIntyre, P., & Vincze, L. (2017). Positive and negative emotions underlie motivation for L2 learning. *Studies in Second Language Learning and Teaching*, 7, 61–88. DOI: <https://doi.org/10.14746/SSLLT.2017.7.1.4>

- Mendoza-García, M. F. (2025). Influence of motivation on academic learning in high school students. *International Journal of Social Sciences* 8(2), 31-41. DOI: <https://doi.org/10.21744/ijss.v8n2.2385>
- Morrison, R., Lawrence, A., Kästner, N., Alexander, R., Lowe, L., Aragón, O., Silton, R., Silton, R., Cherbuin, N., Styliadis, C., Richter, S., Kahrilas, I., Gatt, J., Nusslock, R., Mueller, S., Polnaszek, K., Papadelis, C., & Bookwala, J. (2020). The neuroscience of positive emotions and affect: Implications for cultivating happiness and wellbeing. *Neuroscience & Biobehavioral Reviews*, 121, 220-249. DOI: <https://doi.org/10.1016/j.neubiorev.2020.12.002>
- Nugraha, D. Y., Nugraha, D., & Widyastuti, W. (2021). The correlation between learning motivation and learning outcomes on mathematics subjects in XII science class senior high school 4 Bone. *Anatolian Journal of Education*, 6(1), 157-166. DOI: <https://doi.org/10.29333/AJE.2021.6113A>
- Nuraysha, A. D., Winarno, N., Fadly, W., Hakim, L., & Emiliannur, E. (2024). Analyzing student's motivation towards science learning in junior high school. *Jurnal Penelitian Pendidikan IPA*, 10(7), 4139-4148. DOI: <https://doi.org/10.29303/jppipa.v10i7.7297>
- Pessoa, L. (2009). How do emotion and motivation direct executive control? *Trends in Cognitive Sciences*, 13, 160-166. DOI: <https://doi.org/10.1016/j.tics.2009.01.006>
- Plass, J., & Kalyuga, S. (2019). Four ways of considering emotion in cognitive load theory. *Educational Psychology Review*, 31, 339-359. DOI: <https://doi.org/10.1007/s10648-019-09473-5>
- Putri, D. H., Pranata, O. D., & M, N. (2024). Analisis emosi siswa dalam lingkungan akademik: Studi deskriptif dan komparatif. *Biosfer : Jurnal Biologi Dan Pendidikan Biologi*, 9(1), 9-20. DOI: <https://doi.org/10.23969/biosfer.v9i1.12533>
- Qalbina, P., & Ahda, Y. (2019). Characteristics of biotechnology learning materials generally used by biology education students in Padang City. In *Journal of Physics: Conference Series* (Vol. 1185, No. 1, p. 012154). IOP Publishing. DOI: <https://doi.org/10.1088/1742-6596/1185/1/012154>
- Rizky, A., & Ajiuksmo, C. R. (2019). Pengaruh orientasi pembelajaran dan konsepsi belajar terhadap prestasi akademik mahasiswa tahun pertama. *Jurnal Psikologi Talenta*, 5(1), 8-18. DOI: <https://doi.org/10.26858/talenta.v5i1.8351>
- Rolls, E. (2025). Emotion, motivation, reasoning, and how their brain systems are related. *Brain Sciences*, 15(5), 507. DOI: <https://doi.org/10.3390/brainsci15050507>
- Sari, T. (2020). Self-efficacy dan dukungan keluarga dalam keberhasilan belajar dari rumah di masa pandemi covid-19. *Education Journal: Journal Educational Research and Development*, 4, 127-136. DOI: <https://doi.org/10.31537/ej.v4i2.346>
- Satriya, E. (2021). Korelasi antara task value (nilai tugas) siswa dengan nilai ulangan harian. *Jurnal Ilmiah Aquinas*, 4, 133-140. DOI: <https://doi.org/10.54367/aquinas.v4i1.1044>
- Schunk, D., & DiBenedetto, M. (2020). Motivation and social cognitive theory. *Contemporary Educational Psychology*, 60, 101832. DOI: <https://doi.org/10.1016/j.cedpsych.2019.101832>
- Steele, F., & Aubusson, P. (2004). The challenge in teaching biotechnology. *Research in Science Education*, 34, 365-387. DOI: <https://doi.org/10.1007/S11165-004-0842-1>
- Suryanda, A., Kurniati, T., & Damayanti, S. (2020). Pengembangan Multimedia Interaktif Berbasis Inkuiri untuk Praktikum Virtual pada Materi Bioteknologi di SMA. *PSEJ (Pancasakti Science Education Journal)*, 5(1), 8-16. DOI: <https://doi.org/10.24905/psej.v5i1.18>
- Szyperski, T. (1998). ¹³C-NMR, MS and metabolic flux balancing in biotechnology research. *Quarterly Reviews of Biophysics*, 31, 41-106. DOI: <https://doi.org/10.1017/S0033583598003412>
- Velayutham, S., Aldridge, J., & Fraser, B. (2011). Development and validation of an instrument to measure students' motivation and self - regulation in science learning. *International Journal of Science and Education*, 33(November 2014), 37-41. DOI: <https://doi.org/10.1080/09500693.2010.541529>
- Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of personality and social psychology*, 54(6), 1063-1070. DOI: <https://psycnet.apa.org/doi/10.1037/0022-3514.54.6.1063>
- Wijnia, L., Noordzij, G., Arends, L., Rikers, R., & Loyens, S. (2024). The effects of problem-based, project-based, and case-based learning on students' motivation: A meta-analysis. *Educational Psychology Review*, 36(1), 29. DOI: <https://doi.org/10.1007/s10648-024-09864-3>
- Zeller, M. (1994). Biotechnology in the high school biology curriculum: The future is here!. *American Biology Teacher*, 56, 460-464. DOI: <https://doi.org/10.2307/4449889>