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ORIGINAL ARTICLE

Development and Validation of the Achievement Emotions Questionnaire – Biology

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ABSTRACT

This study was aimed at developing and validating a scale that measures the emotions of secondary school students toward Biology. Before selecting a particular subject, it is very important to measure student's emotions toward that subject. The emotions were measured in two academic contexts: class-related and learning-related situations. The participants were 840 (410 male and 430 female) secondary school students aged 13–15 years from various schools in the Uttar Pradesh State of India. Two separate scales were constructed. Scale 1 measures secondary school students' emotions in class-related situations, and scale 2 measures emotions in test-related situations. The psychometric properties of both scales have been tested by factor analysis. Correlation analysis confirms good convergent validity, and Cronbach's alpha reveals a good internal consistency of the scale. The validity and reliability values show that the tool has all the necessary psychometric properties and can be used for measuring secondary school students' emotions toward Biology.

KEY WORDS: Achievement, biology, emotions, psychometric properties

INTRODUCTION

Emotions are present in different academic settings among learners and significantly influence their learning and achievement (Destacamento, 2018). Emotions are central to all educational activities (Govaerts and Gregoire, 2008). In academic settings, students experience a wide variety of emotions: some enjoy learning something new; on the other hand, some find it boring. Despite the importance of emotions in educational setting, it has long been a neglected topic except for one emotion, that is, test anxiety (Peixoto et al., 2015). The researches on test anxiety have dominated the researches on emotions for a long time and this situation has changed recently when some researchers (Pekrun et al., 2002) started to investigate the concept of emotions in relation to academic achievement. Pekrun (2006) has defined achievement emotions as emotions that are linked to achievement activities and achievement outcomes (p. 317).

Originally, the Achievement Emotions Questionnaire (AEQ) is a self-reported instrument developed by Pekrun et al. (2005) to measure college students' emotions. It measures nine emotions (enjoyment, hope, pride, relief, anger, anxiety, shame, hopelessness, and boredom) in three different academic situations: attending class, learning activity, and taking tests or exams. The class-related emotion scale measures the eight emotions: class-related enjoyment, hope, pride, anger, anxiety, shame, hopelessness, and boredom. The learning-related emotion scale measures learning-related enjoyment, hope, pride, anger, anxiety, shame, hopelessness, and boredom. The test-related emotion scale measures test-related enjoyment, hope, pride, relief, anger, anxiety, shame, and hopelessness.

The control-value theory of achievement emotions (CVTAE) (Pekrun, 2006) organizes emotions according to three dimensions: valence (positive vs. negative), activity level (activating vs. deactivating), and object focus (activity vs. outcome). Hence, the AEQ measures achievement emotions, separating them into four quadrants; positive activating achievement emotions (enjoyment, hope, and pride); positive deactivating achievement emotion (relief); negative activating achievement emotions (anger, anxiety, and shame); and negative deactivating achievement emotions (hopelessness and boredom).

Initially, AEQ was developed to measure college students' achievement emotions (Pekrun et al., 2005). Academic Emotions Questionnaire – Mathematics (2005) was constructed by Pekrun, Goetz and Frenzel to measure mathematics-related achievement emotions. The AEQ-Elementary School (AEQ-ES) was adapted from AEQ (Pekrun et al., 2011) to measure elementary school students' emotions toward mathematics. In addition, AEQ-PhysicsPac was validated by Bhansali and Sharma (2020), to measure undergraduate students' academic emotions toward physics practical. The AEQ has been needed to be adapted in various other subjects and at different age groups. It is a good starting point for measuring emotions in different contexts.

Present Tool

In the present study, the researchers developed and validated the AEQ to measure secondary school students' emotions. Due

to the specific subject domain nature of emotions (Lichtenfeld et al., 2012; Govaerts and Gregoire, 2008), the present instrument measures secondary school students' emotions toward Biology. The CVTAE (Pekrun, 2006) provides a theoretical taxonomy of the internal structure of achievement emotions. The researcher's focus was on those emotions that occur in the school context, that is, class and test-related emotions. The original AEQ (Pekrun et al., 2005) was used as the basis for AEQ-B, but researchers did not measure all nine emotions as in the original AEQ. The researchers tried to develop a relatively short instrument that was satisfactory for the purpose. The study conducted by Peixoto et al. (2015) found that there is a strong correlation (>0.90) between Hope and Pride, Hope and Enjoyment, and Anxiety and Shame. Therefore, the researchers decided to retain enjoyment, pride, and anxiety but to exclude shame and hope. Boredom is not applicable to test situations, whereas relief only exists in the context of taking tests (Sudhan, 2015). Therefore, in the present tool, six emotions (enjoyment, pride, anger, anxiety, boredom, hopelessness) for class-related situations and six emotions (enjoyment, pride, relief, anger, anxiety, hopelessness) for test-related situations were selected by the researchers (Table 1).

According to Pekrun et al. (2011), a multidimensional structure is more adequate for representing achievement emotions. Hence, the researchers tested the model with six interrelated emotions.

The four quadrants (according to CVTAE) for the present tool are:

1. Positive activating: Enjoyment, Pride
2. Positive deactivating: Relief
3. Negative activating: Anger, Anxiety
4. Negative deactivating: Hopelessness, Boredom.

The classification of achievement emotions on the basis of valance, activation, and object focus is given in Table 2.

METHOD

Participants

The sample of the present study was 840 secondary school students aged 13–15 years. The sample includes 410 male and 430 female students. These students were from 5 private and 4 public schools of Uttar Pradesh state of India, selected by the cluster sampling technique. As the Uttar Pradesh state of India is rich in diversity, participants were come from different cultures, classes, castes, and socioeconomic backgrounds. Hence, the researchers found this population as the best representative for generalization to other culture, class, and caste. Initially, the scale was administered on 900 students, but 60 students were excluded due to missing values on more than five items. For factor analysis, Tabachinik and Fidell (2012, as cited in Uslu, 2021) suggest that a sample size of 300 is good, 500 is very good, and a sample of 1000 is excellent. Gorsuch (1983, as cited in Costello and Osborne, 2005) recommend a minimum sample to item ratio of at least 5:1, but a widely-cited rule of thumb from Nunnally (1978, as cited in Costello and Osborne, 2005), that suggest sample to item ratio of 10:1, which is considered as good sample size. For the AEQ – Biology (AEQ-B), the data were collected in two stages. In the first field try-out (pilot study), the first draft of the AEQ-B (both class and test-related emotions) was administered on 320 secondary school students, and exploratory factor analysis (EFA) was employed. In the second try-out (main study phase), the data were collected from 520 secondary school students, and confirmatory factor analysis (CFA) was employed (Table 3). For Government school students (U.P. Board), the test items were given in both Hindi and English. While translating the items into the Hindi language, all the parameters (Streiner, 2015) of translation were kept in mind.

Measures

AEQ-Biology (AEQ-B)

The AEQ-B has been developed and validated by the researchers for measuring secondary school students' emotions toward Biology in two academic contexts, that is, class-related and test-related situations. Six emotions for class-related situations and six emotions for test-related situations were selected under the three dimensions of control value theory of achievement emotions (Table 1). The items for the present tool were created by the researchers with the help of existing literature reviews (e.g., Pekrun, 2006; Smith

Table 1: Matrix of situational achievement emotions measure in AEQ-B

Situations	Emotions/Dimensions
Class-related emotions	Enjoyment
	Pride
	Anger
	Anxiety
	Boredom
	Hopelessness
Test-related emotions	Enjoyment
	Pride
	Relief
	Anger
	Anxiety
	Hopelessness

Table 2: Achievement emotions classified on the basis of valance, activation, and object focus

Object focus	Positive		Negative	
	Activating	Deactivating	Activating	Deactivating
Activity focus	Enjoyment	-	Anger	Boredom
Outcome focus	Pride	Relief	Anxiety	Hopelessness

Table 3: Sample for factor analysis

Factor analysis	N	Male	Female
Exploratory factor analysis	320	145	175
Confirmatory factor analysis	520	265	255

and Lazarus, 1990) and the research tools related to the area (AEQ – Pekrun et al., 2005; AEQ-S – Bieleke et al., 2021; AEQ-ES – Lichtenfeld et al., 2012; test emotions questionnaire [TEQ] – Pekrun et al., 2004; AEQ-PA – Peixoto et al., 2015; Govaerts and Gregoire, 2008). The items contained a variety of expressions that described the subjective experiences of the various emotions. The researchers constructed a total of 40 items for class-related situations and 37 items for test-related situations under different emotions. A detailed discussion of each emotion/dimension and the item construction has been given below.

- Enjoyment – Enjoyment refers to the pleasant feeling of happiness and delight experienced by certain stimuli. In the present tool, items related to enjoyment include feeling of joy and excitement experienced by students while attending the Biology class or taking a test (examples: "I am excited to attend Biology class", "I enjoy preparing the Biology test").
- Pride – Pride refers to a feeling of satisfaction derived from one's own achievement. Students experience the feeling of pride when they are satisfied with their performance and achieve their goals (examples: "I am proud that I can easily understand the Biology content", "I am satisfied with my Biology test preparation").
- Anger – Anger refers to frustration or irritation with someone or something. Students get angry as a result of some unpleasant things in the class or when they are not interested in a particular subject (examples: "I get in a bad mood while going to Biology class", "While preparing for the Biology test, I feel irritated").
- Anxiety – It refers to a feeling of uneasiness, restlessness, or concern. Students become anxious when they do not understand the material or not fully prepared to face the test (examples: "Before going to Biology class I feel nervous", "Thinking about the Biology test makes me feel tensed").
- Hopelessness – Hopelessness is defined as a lack of optimism or hope. Students feel hopelessness when they are not motivated and do not consider themselves as capable of achieving a goal (examples: "In Biology class, I become hopeless when the teacher asks questions", "I have lost all hope to get success in Biology test").
- Boredom – Boredom refers to an unpleasant feeling of tediousness or lack of interest. Students get bored in class when they perceive the situations as meaningless or find the task uninteresting (example: "I get bored in Biology class").
- Relief – Relief is a pleasant or relaxing feeling. Generally, students feel relaxed after taking the exam (example: "I feel relieved when Biology test is over").

The preliminary draft of the scale was given to the experts in the field of Psychology and Education and requested to assess the clarity and relevance of each of the statements within the dimension. To check the unanimity of the experts, the content validity index (CVI) was calculated. For content validity of the scale, emotions should be assessed with terms that individuals use to describe their feelings (Govaerts and Gregoire, 2008). According to Polit et al., (2007, as cited in Yusoff, 2019), when at least six experts review the research tool, CVI should not be <0.83. After calculating the CVI, 10 items (I-CVI <0.83) of class-related emotions and 4 items of test-related situations were deleted and a few items were modified as per the suggestions received from the experts. To check the relevancy of the scale, the researcher calculated the S-CVI/Ave (Scale-level CVI based on the average method), and it was found to be 0.83 for class-related emotions and 0.92 for test-related emotions. On the other hand, the clarity of the scale based on S-CVI/Ave was 0.82 for class-related emotions and 0.92 for test-related emotions. In this way, 30 items for class-related emotions and 33 items for test-related emotions were selected for the first draft of the scale.

Procedure

To collect the data, the researchers contacted administrators of various schools and requested for permission to collect the data. The participation of the students was voluntary, and students were assured of the confidentiality of their responses. The data were collected during school hours. Students were asked to rate each item on a 5-point Likert-type scale (1 = Strongly disagree to 5 = Strongly agree).

Data Analysis

The psychometric properties of the social skills scale were tested by factor analysis. First, EFA was carried out using SPSS Version 20.0 (IBM). The principal component matrix was used with varimax rotation. For factor selection, multiple criteria were used. The eigenvalues of the producing factors should be more than one (Hinkin, 1995). The factor loading of the items should not be <0.4 (Costello and Osborne, 2005) and the total variance explained by the factors should be over 50% (Uslu, 2021).

Second, the factor structure was confirmed by CFA using the AMOS Version 23.0 (IBM). The analysis was conducted using maximum-likelihood estimation. The goodness-of-fit was assessed through: χ^2/df, comparative fit index (CFI), and Tucker-Lewis index (TLI). The value of CFI and TLI should be ≥0.90 (Kim, 2016). On the other hand, the badness-of-fit of the model was assessed through root mean square error of approximation (RMSEA), which should be ≤0.08 (Sun, 2005).

Third, convergent validity of the scale was determined by intra-class correlation and to know the pattern of relationship between emotions, the inter-factor correlation coefficient was calculated. The reliability of the scale was analyzed using Cronbach's alpha.

RESULTS AND DISCUSSION

As the researchers measure student's emotions in two academic contexts (class-related and test-related), two scales were separately constructed. These two scales can be used together or separately according to the purpose of the research.

Scale 1 (Class-related Emotions)

EFA

After collecting the data from the first field try-out, EFA was employed for identifying the dimensionality of items. Before performing the EFA the Kaiser-Meyer-Olkin test (KMO =.93) and Bartlett's statistic indices ($\chi^2(435) = 6236.21$, $p < 0.000$) were calculated and the results of these tests show the suitability of the data for the analysis (Abd ElHafeez et al., 2022). The KMO of above 0.90 is marvelous to perform EFA (Howard, 2016). To identify the latent dimensions that underlie the data, EFA with principal components matrix and varimax rotation was employed (Table 4).

After doing EFA, six factors/emotions were identified with 30 items (factor loading >0.4), but one item of class anxiety cross-loaded with class anger. When the researchers select a factor loading of more than 0.5, all the items are loaded onto their respective factors. The factor loading of more than 0.5 indicates that all the statements are appropriate and can be retained in the scale (Costello and Osborne, 2005). The factor loading of the scale items ranged from.54 to.78 and the eigenvalues of the seven factors were 13.25, 1.85, 1.50, 1.46, 1.20, and 1.01, respectively. The total variance explained by the statements was found to be 67%. In Social Science, the variance values explained by the scale items over to 50% is considered sufficient (Uslu, 2021).

CFA

To examine the factor structure of the scale emerging with the EFA, CFA was employed on the second sample data (N = 520). The CFA was conducted to compare goodness-of-fit indices for the following two models:

Table 4: Exploratory factor analysis of class-related emotions

Class-related emotions	Factor loading					
Factors and items	**1**	**2**	**3**	**4**	**5**	**6**
Factor 1: Enjoyment						
1. I am excited to attend Biology class.	0.71					
2. I enjoy Biology class.	0.78					
3. I am eager to answer the questions in Biology class.	0.71					
4. During discussions in Biology class, I participate with enthusiasm.	0.73					
5. Biology class motivates me to learn more about the subject.	0.67					
Factor 2: Pride						
6. I am motivated to attend Biology class because I am counted among the best students of the class.		0.65				
7. I am proud that I can easily understand the Biology content.		0.71				
8. I take pride in being able to answer more questions correctly.		0.73				
9. I am proud of the contributions I make in Biology class.		0.72				
10. I would like to tell my friends about how well I perform in Biology.		0.63				
Factor 3: Anger						
11. I get in a bad mood while going to Biology class.			0.73			
12. I feel frustrated in Biology class.			0.75			
13. I cannot listen to the Biology teacher patiently.			0.69			
14. I want to walk away from the class because I do not understand the content.			0.74			
15. After the Biology class, I get irritated.			0.69			
Factor 4: Anxiety						
16. Before going to Biology class I become nervous.				0.58		
17. I feel anxious in Biology class because the subject matter is too difficult for me.				0.56		
18. When the Biology teacher asks the questions, my heartbeat increases.				0.74		
19. I worry because I am not able to understand the Biology content.				0.57		
20. In Biology class, I feel that I am not as competent as my fellow students.				0.61		
Factor 5: Boredom						
21. I get bored in Biology class.					0.65	
22. I feel lethargic in Biology class because it makes me bored.					0.61	
23. I find it hard to remain active during Biology class.					0.69	
24. During Biology class, I frequently watch the clock waiting for class to end.					0.72	
25. I want to leave Biology class because it is so boring.					0.70	
Factor 6: Hopelessness						
26. Before going to Biology class, I feel hopeless.						0.54
27. Even before entering the Biology class, I already know that I would not understand the content.						0.60
28. I have lost all hope of understanding Biology material.						0.64
29. In Biology class, I become hopeless when the teacher asks questions.						0.72
30. The thought that I have to study Biology throughout the year makes me hopeless.						0.70

Factor loading<0.5 is not shown in the table

- Model 1: Goodness-of-fit indices were tested with two factors – positive and negative emotions (Figure 1).
- Model 2: Goodness-of-fit indices were calculated with six interrelated factors (Figure 2).

Analysis was conducted using maximum-likelihood estimation. The goodness-of-fit of the model was assessed through: CFI, the TLI, and the RMSEA.

Table 5 shows the goodness-of-fit indices for the two models. The indices for model 1 (two-factor model – positive and negative emotions) are less suited to the data. On the other hand, the goodness-of-fit indices of model 2 (six interrelated factors) are good. These findings of CFA are in line with those of Peixoto et al., (2015) and Lichtenfeld et al. (2012), which show that a multidimensional structure is more adequate for representing achievement emotions than a simple positive and negative structure.

Descriptive statistics, item-total correlations, and reliabilities

Table 6 shows descriptive statistics, item-total correlations, and internal consistency of the scale. The reliability values (Cronbach's alpha) were (≥0.89) good for all the dimensions (Cortina, 1993). Convergent validity of the scale was assessed by calculating the correlation coefficient between each item

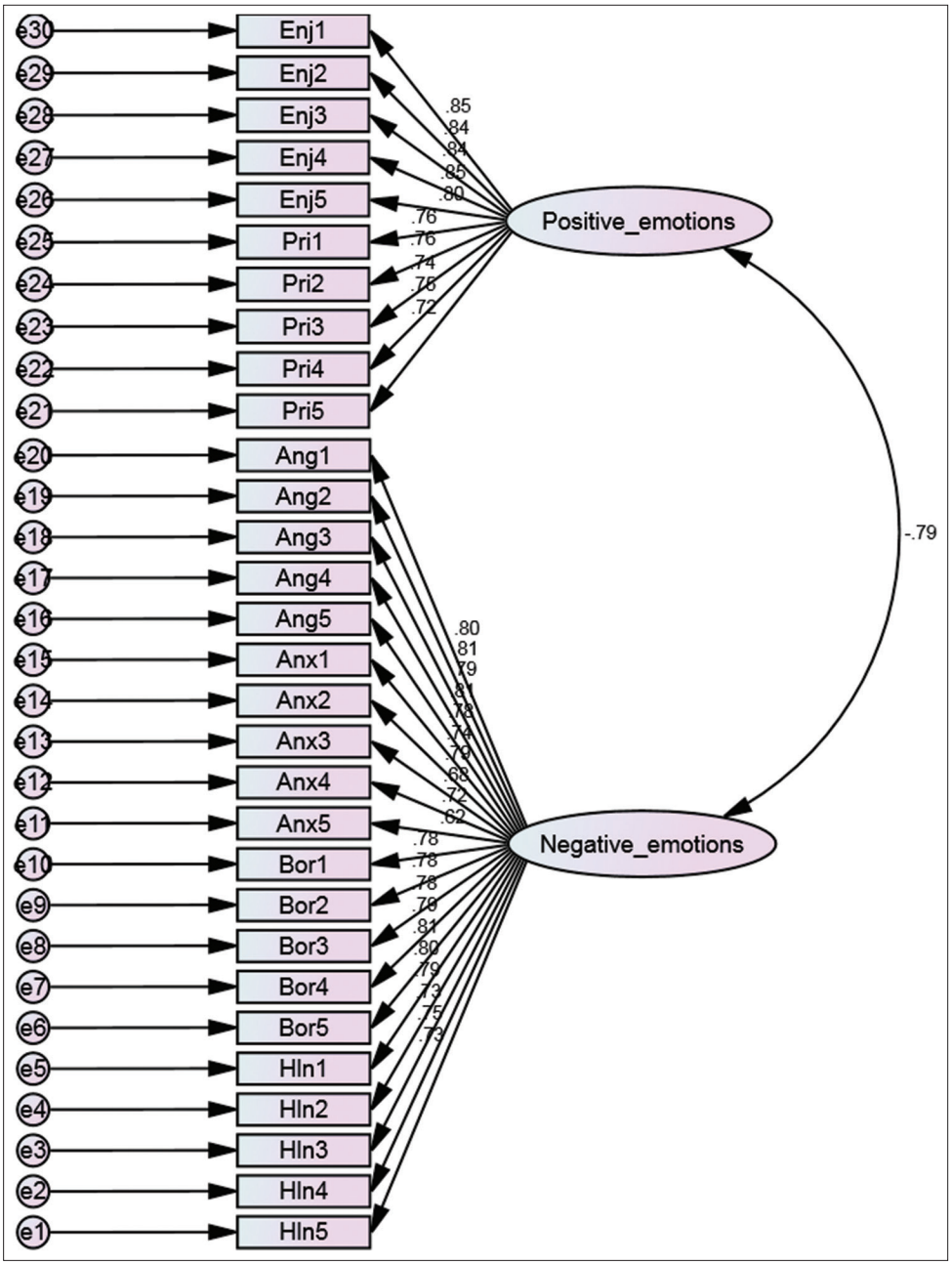

Figure 1: Two-factor model of Achievement Emotions Questionnaire – Biology (class-related emotions)
Enj: Enjoyment, Pri: Pride, Ang: Anger, Anx: Anxiety, Bor: Boredom, Hln: Hopelessness

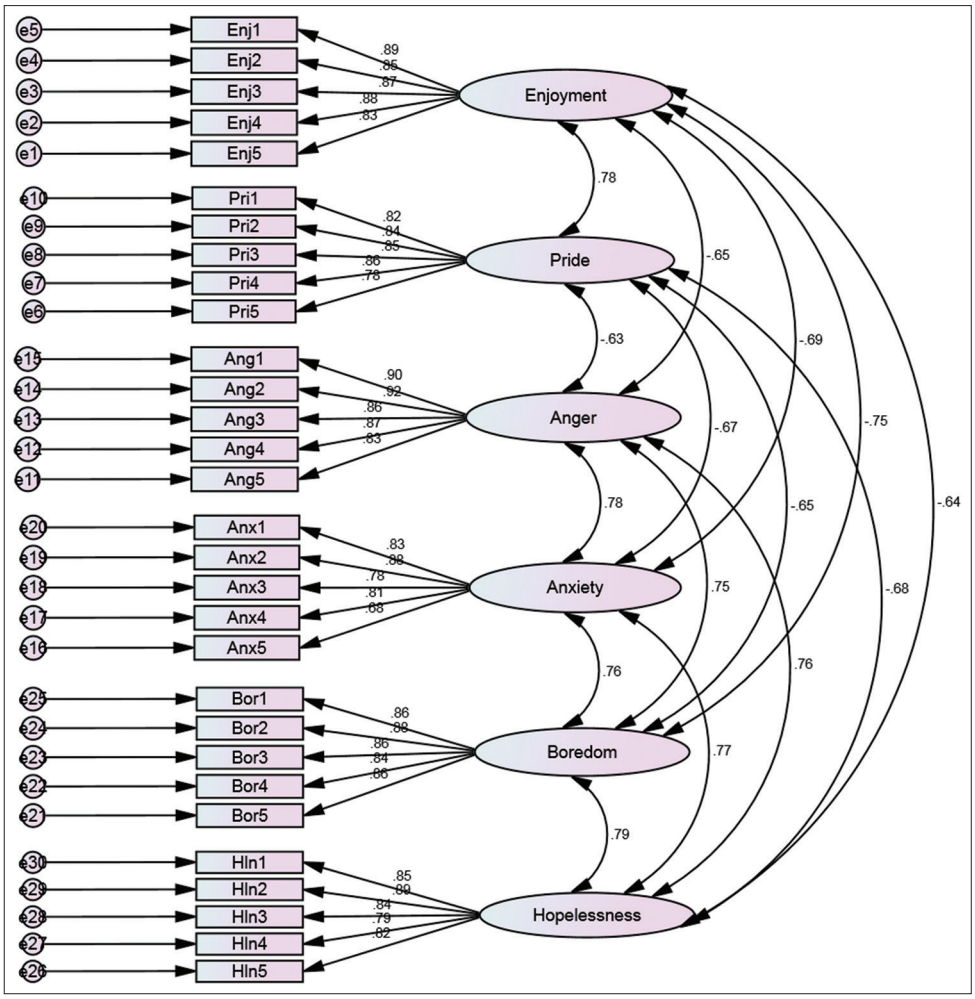

Figure 2: Six inter-related factor model of Achievement Emotions Questionnaire – Biology (class-related emotions)
Enj: Enjoyment, Pri: Pride, Ang: Anger, Anx: Anxiety, Bor: Boredom, Hln: Hopelessness

Table 5: Goodness-of-fit indices

Model	χ^2	*df*	*p*	CFI	TLI	RMSEA
Model 1	3888.90	404	<0.000	0.76	0.73	0.12
Model 2	1656.30	390	<0.000	0.91	0.90	0.07

df: Degree of freedom, CFI: Comparative fit index, TLI: Tucker-Lewis index, RMSEA: Root mean square error of approximation

and the total of the dimension (Abd ElHafeez et al., 2022). The Correlation coefficient between each item and the total of the dimension signifies that every item of the scale is correlated well with the corresponding dimension and each item effectively represents the dimension where it has been included.

Inter-factor correlation matrix

To know the pattern of relationship between emotions, the correlation coefficient between each of the factors/dimensions (inter-factor correlation matrix) was calculated (Pekrun et al., 2011).

Table 7 shows that positive emotions (enjoyment and pride) correlate positively with each other. Similarly, negative emotions (anger, anxiety, boredom, and hopelessness) also

Table 6: Descriptive statistics, item-total correlations, and reliabilities for each dimension

Emotions	M	SD	ICC	α
Enjoyment	15.87	5.84	0.88	0.93
Pride	15.94	5.72	0.86	0.91
Anger	13.31	5.86	0.89	0.94
Anxiety	14.61	5.63	0.83	0.89
Boredom	13.94	6.08	0.88	0.93
Hopelessness	14.12	5.90	0.86	0.92

M: Mean, SD: Standard deviation, ICC: Intra-class correlation coefficient, α: Cronbach's alpha

Table 7: Inter-factor correlation matrix

Emotions	1	2	3	4	5	6
Enjoyment	1	-	-	-	-	-
Pride	0.72	1	-	-	-	-
Anger	−0.62	−0.58	1	-	-	-
Anxiety	−0.64	−0.62	0.71	1	-	-
Boredom	−0.70	−0.60	0.71	0.71	1	-
Hopelessness	−0.60	−0.62	0.71	0.69	0.74	1

correlate positively. Moreover, there are negative correlations between positive and negative emotions. This pattern of relationships is also found in Peixoto et al., (2015), Govaerts and Gregoire (2008), and Fierro-Suero et al. (2020). All the items of class-related achievement emotions questionnaire are given in Appendix A.

Scale 2 (Test-related Emotions)

EFA

EFA was employed on the data collected for test-related emotions in Biology. The Kaiser-Meyer-Olkin test (KMO = 0.91) and Bartlett's statistic indices (χ^2 [435] = 5764.68, $p < 0.000$) were calculated and the results of these tests also show the suitability of the data for the analysis (Abd ElHafeez et al., 2022). The KMO of above 0.90 is marvelous to perform EFA (Howard, 2016). EFA was employed with principal components matrix and varimax rotation (Table 8).

The initial run resulted in 6 factors/emotions with all the 33 items (factor loading >0.4), but one item of enjoyment cross-loaded with pride; one item of pride cross-loaded with enjoyment; and one item of hopelessness cross-loaded with anxiety. When the researchers select factor loading of more than 0.5, all the items were loaded onto their respective emotions, but one item of anger, one item of anxiety, and one item of hopelessness, were not loaded in any factor. Therefore, the researchers deleted those three items (no loading on any factor) and attempted to derive a new solution. The new run (factor loading >0.5) resulted in a clear six-factor with 30 items. The factor loading more than 0.5 indicates that all the statements

Table 8: Exploratory factor analysis of test-related emotions

Test-related emotions	Factor loading					
Factors and items	**1**	**2**	**3**	**4**	**5**	**6**
Factor 1: Enjoyment						
1. I enjoy preparing for the Biology test.	0.71					
2. I am excited to show my knowledge in the Biology test.	0.72					
3. Because I enjoy learning Biology, I study hard to get good grades.	0.74					
4. I enjoy attempting the questions in the Biology test.	0.70					
5. I feel happiness that I can answer the questions to the best of my knowledge.	0.69					
Factor 2: Pride						
6. I am satisfied with my Biology test preparation.		0.62				
7. I feel proud, when I do exercises for preparing Biology test.		0.63				
8. During the Biology test, I feel proud because I know answers of most of the questions.		0.68				
9. After the Biology test, I am very satisfied with my performance.		0.71				
10. My marks in Biology make me feel pride.		0.79				
11. It gives me a strong feeling of pride when I achieve a better score in Biology in comparison of my fellow students.		0.68				
Factor 3: Relief						
12. I feel relieved when Biology test is over.			0.74			
13. After finishing the Biology test, my tension vanishes.			0.80			
14. After the Biology test, I feel as I have put off weight from my mind.			0.76			
15. After the Biology test, I feel free.			0.71			
Factor 4: Anger						
16. While preparing for the Biology test, I feel irritated.				0.74		
17. While preparing for the Biology test, time pressure makes me angry.				0.81		
18. I get irritated about the content of Biology that I need to prepare for the test.				0.73		
19. During the Biology test, I feel frustrated.				0.67		
20. Difficulty of Biology questions makes me angry.				0.68		
Factor 5: Anxiety						
21. Thinking about the Biology test makes me feel tensed.					0.60	
22. I am worried about the preparation of the Biology test.					0.78	
23. Before going to the Biology exam, I feel panic.					0.73	
24.I get nervous during the Biology test.					0.75	
25. During the Biology test, I feel anxious due to time limitations.					0.52	
Factor 6: Hopelessness						
26. I have lost all hope to get success in the Biology test.						0.79
27. I have lost all hope as I do not have the ability to do well in the Biology test.						0.77
28. Because I am so hopeless during the Biology test, I forget the content that I actually know						0.72
29. When I do not have enough time to complete the Biology test, I become hopeless.						0.56
30. I do not expect a good score in the Biology test, no matter how hard I do.						0.71

Factor loading <0.5 is not shown in the table. The rotation converged in seven iterations

are appropriate and can be retained in the scale (Costello and Osborne, 2005). The factor loading of the scale items range from 0.55 to 0.78 and the eigenvalues of the six factors were 11.16, 2.75, 2.20, 1.60, 1.24, and 1.07, respectively. The total variance explained by the statements was found to be 66%. In Social Science, the variance values explained by the scale items over to 50% is considered sufficient (Uslu, 2021).

CFA

CFA was employed on the second sample data (N = 520) on test-related emotions. The CFA of the second scale was also conducted to compare goodness-of-fit indices for the following two models:

- Model 1: goodness-of-fit indices were tested with two factors – positive and negative emotions (Figure 3).
- Model 2: goodness-of-fit indices were calculated with six interrelated factors (Figure 4).

Table 9 shows the goodness-of-fit indices for the two models. The goodness-of-fit indices for model 1 and model 2 are in line with those of in class-related emotions. Model 1 (two-factor model – positive and negative emotions) shows poor fit indices and model 2 (six interrelated factors) shows good fit indices. Therefore, the findings suggest that, in test-related situation also, a multidimensional structure is more adequate for representing achievement emotions of students.

Descriptive statistics, item-total correlations and reliabilities

Table 10 shows descriptive statistics, item-total correlations, and internal consistency of the scale. The reliability values

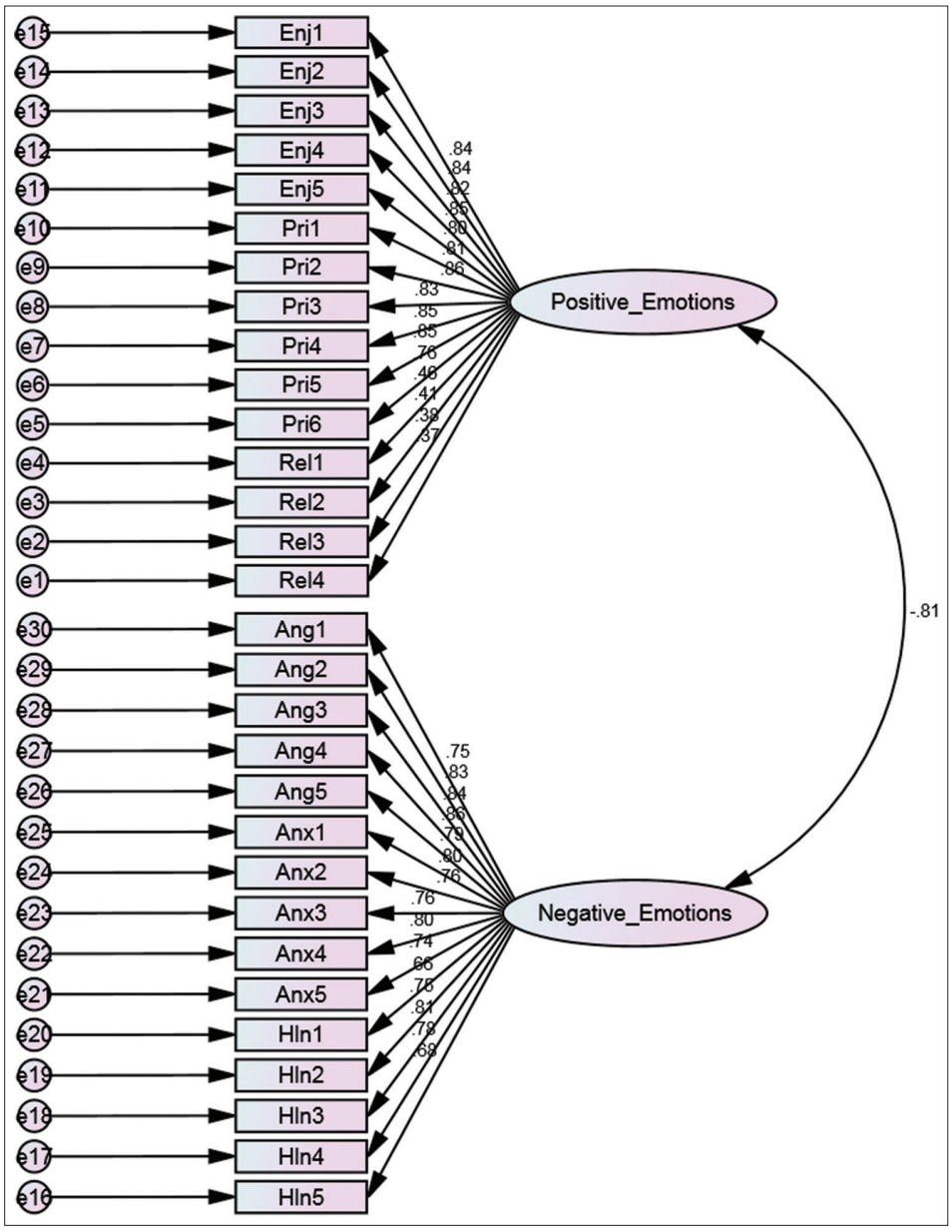

Figure 3: Two-factor model of Achievement Emotions Questionnaire – Biology (test-related emotions)
Enj: Enjoyment, Pri: Pride, Rel: Relief, Ang: Anger, Anx: Anxiety, Hln: Hopelessness

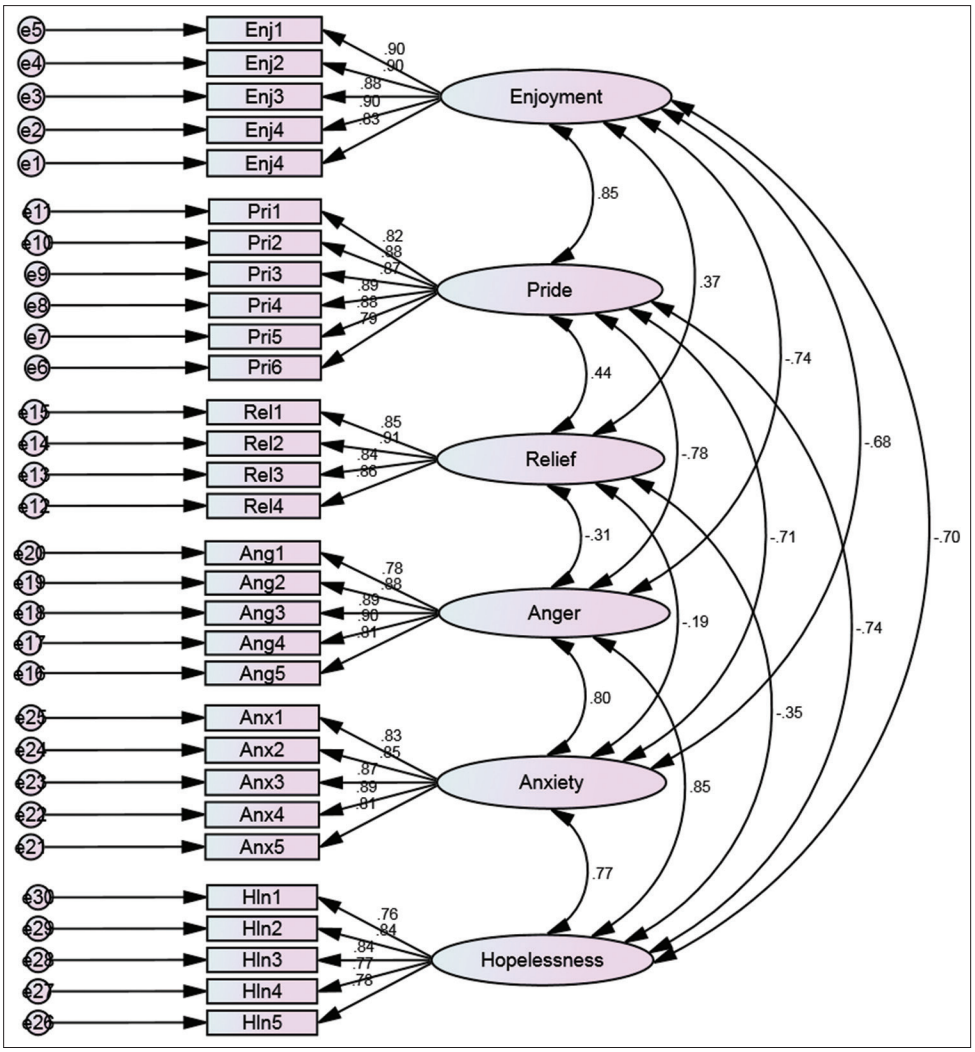

Figure 4: Six-factor model of Achievement Emotions Questionnaire – Biology (test-related emotions)
Enj: Enjoyment, Pri: Pride, Rel: Relief, Ang: Anger; Anx: Anxiety, Hln: Hopelessness

Table 9: Goodness-of-fit indices

Model	χ^2	*df*	*p*	CFI	TLI	RMSEA
Model 1	4453.67	404	<0.000	0.74	0.72	0.13
Model 2	1793.16	390	<0.000	0.91	0.90	0.08

df: Degree of freedom, CFI: Comparative fit index, TLI: Tucker-Lewis index, RMSEA: Root mean square error of approximation

Table 10: Descriptive statistics, item-total correlations and reliabilities for each dimension

Emotions	M	SD	ICC	α
Enjoyment	16.67	5.91	0.90	0.94
Pride	19.25	7.10	0.87	0.94
Relief	14.11	4.38	0.89	0.92
Anger	13.64	5.63	0.87	0.92
Anxiety	16.09	5.70	0.87	0.92
Hopelessness	14.22	5.63	0.83	0.89

M: Mean, SD: Standard deviation, ICC: Intra-class correlation coefficient, α: Cronbach's alpha

(Cronbach's alpha) were (≥0.89) good for all the dimensions (Cortina, 1993). Convergent validity of the scale was assessed by calculating the correlation coefficient between each item and the total of the dimension (Abd ElHafeez et al., 2022). The Correlation coefficient between each item and the total of the dimension signifies that every item of the scale is correlated well with the corresponding dimension and each item effectively represents the dimension where it has been included.

Inter-factor correlation matrix

To know the pattern of relationship between emotions, the correlation coefficient between each of the factors/dimensions (inter-factor correlation matrix) was calculated (Pekrun et al., 2011). Table 11 shows that positive emotions (enjoyment, pride, and relief) correlate positively with each other. Similarly, negative emotions (anger, anxiety, boredom, and hopelessness) also correlate positively. Moreover, there are negative correlations between positive and negative emotions. However,

Table 11: Inter-factor correlation matrix

Emotions	1	2	3	4	5	6
Enjoyment	1	-	-	-	-	-
Pride	0.80	1	-	-	-	-
Relief	0.38	0.42	1	-	-	-
Anger	−0.69	−0.72	−0.28	1	-	-
Anxiety	−0.63	−0.66	−0.18	0.74	1	-
Hopelessness	−0.65	−0.68	−0.31	0.79	0.70	1

test-related relief has low negative correlations with negative emotions. Relief shows a negligible negative correlation with anxiety (very close to positive correlation). The relationship of test-related anxiety with relief is likely due to the pressure released after taking the test. The relationship of relief with all the positive and negative emotions shows that, whether the students experience positive or negative emotions while taking the test, they feel relieved to some extent after the test. All the items of test-related achievement emotions questionnaire are given in Appendix B.

CONCLUSION

It can be concluded from the validity and reliability values that the tool has all the necessary psychometric properties and can be used for measuring secondary school students' emotions toward Biology. The above given measures clearly indicate that all the items are part and parcel of the main construct. The tool measures students' emotions in both class and test-related situations. Attending the class of Biology and preparing for the test can induce different emotions among learners at the secondary level; therefore, the present tool can be useful for teachers, researchers, and psychologists to measure and understand secondary school students' emotions toward Biology.

Before selecting a particular subject, it is important to measure student's emotions toward that subject. Students' degree of participation in class is highly influenced by their emotions. When students have an emotional connection to the subject, they are more interested to participate, ask questions, and put efforts into education. Parental expectations, socioeconomic status, and the perceived value of science education exert pressure on students to select the science subject. There is pressure on students to select science subject even if they are not interested in or skilled in the subject because it is frequently seen as a pathway to prominent employment and higher education. Hence, it is the duty of the educators and teachers to guide learners in choosing the subject as per their interest and skills. Before selecting the science education, the teachers measure the emotions of the learners toward science.

There are few limitations that are to be given consideration. Since this scale measures achievement emotions in relation to the Biology subject only at the secondary level; therefore, the generalizability of the scale is restricted to the similar standard. More work is needed to measure emotions in other subjects. However, the present scale would provide a helping hand to the learners themselves, to provide feedback regarding self-assessment of their emotions and a sense of competence regarding the subject.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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APPENDICES

Appendix A: Class related achievement emotions questionnaire –Biology (CRAEQ-B)

Class-related emotions

1. I am excited to attend Biology class.
2. I enjoy Biology class.
3. I am eager to answer the questions in Biology class.
4. During discussions in Biology class, I participate with enthusiasm.
5. Biology class motivates me to learn more about the subject.
6. I am motivated to attend Biology class because I am counted among the best students of the class.
7. I am proud that I can easily understand the Biology content.
8. I take pride in being able to answer more questions correctly.
9. I am proud of the contribution I make in Biology class.
10. I would like to tell my friends about how well I perform in Biology.
11. I get in a bad mood while going to Biology class.
12. I feel frustrated in Biology class.
13. I cannot listen to the Biology teacher patiently.
14. I want to walk away from the class because I do not understand the Biology content.
15. After the Biology class, I get irritated.
16. Before going to Biology class, I become nervous.
17. I feel anxious in Biology class because the subject matter is too difficult for me.
18. When the Biology teacher asks the questions, my heartbeat increases.
19. I worry because I am not able to understand the Biology content.
20. In Biology class, I feel that I am not as competent as my fellow students.
21. I get bored in Biology class.
22. I feel inactive in Biology class because it makes me bored.
23. I find it hard to remain active during Biology class.
24. During Biology class, I frequently watch the clock waiting for class to end.
25. I want to leave Biology class because it is so boring.
26. Before going to Biology class, I feel hopeless.
27. Even before entering the Biology class, I already know that I would not understand the content.
28. I have lost all hope of understanding Biology material.
29. In Biology class, I become hopeless when the teacher asks questions.
30. The thought that I have to study Biology throughout the year makes me hopeless.

Appendix B: Test related achievement emotions questionnaire –Biology (TRAEQ-B)

Test-related emotions

1. I enjoy preparing for Biology test.
2. I am excited to show my knowledge in the Biology test.
3. Because I enjoy learning Biology, I study hard to get good grades.
4. I enjoy attempting the questions in the Biology test.
5. I feel happy that I can answer the questions to the best of my knowledge.
6. I am satisfied with my Biology test preparation.
7. I feel pride, when I do exercises for preparing Biology test.
8. During the Biology test, I feel pride because I know answers of most of the questions.
9. After the Biology test, I feel satisfied with my performance.
10. My marks in Biology make me feel pride.
11. It gives me a strong feeling of pride when I achieve a better score in Biology in comparison of my fellow students.
12. I feel relieved when Biology test is over.
13. After finishing the Biology test, my tension vanishes.
14. After the Biology test, I feel as I have put off weight from my mind.
15. After the Biology test, I feel free.
16. While preparing for the Biology test, I feel irritated.
17. While preparing for the Biology test, time pressure makes me angry.
18. I get irritated about the content of Biology that I need to prepare for the test.
19. During the Biology test, I feel frustrated.
20. Difficulty of Biology questions makes me angry.
21. Thinking about the Biology test makes me feel tensed.
22. I remain worried about the preparation of the Biology test.
23. Before going to the Biology exam, I feel panic.
24. I get nervous during the Biology test.
25. During the Biology test, I feel anxious due to the limitation of time
26. I have lost all hope to get success in Biology test.
27. I have lost all hope as I do not have the ability to do well in the Biology test.
28. Because I am so hopeless during the Biology test, I forget the content that I actually know.
29. When I do not have enough time to complete the Biology test, I become hopeless.
30. I do not expect good score in the Biology test, no matter how hard I do.