Emotions in physics learning

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Abstract. In recent years, emotions in learning have received more and more attention, and the relationship between emotions and learning has been of particular interest in many studies, including the field of science learning. Physics, a subject that explores the laws of nature through rational thinking and tests learners' logical thinking and exploratory skills, has won more attention and research as a representative of the sciences. Despite the increasing attention to emotions in physics learning, there is still a lack of exploration of the relationship between emotions and physics learning. This study introduces the main concepts and learning emotions related to physics learning, summarises the description of the factors that influence physics learning and emotions, and explores the relationship between the two.

Keywords: Physics，learning，emotions.

1 Introduction

Anxiety, enjoyment, and physics achievement of high school students have sparked vast discussion. Physics is one of the most challenging subjects that can cause stress. When students study physics, the frequency of positive emotions decreases, while the frequency of negative emotions increases as learning difficulty increases. However, if a person has a good grasp of the subject, he may find it enjoyable and thus achieve higher levels of success.

Some researchers believe that the affective domain plays a crucial role in the learning process. Various emotions such as anxiety and pleasure have a significant impact on students' desire to learn. Previous studies also reveal a negative influence of

P. Dou and K. Zhang (eds.), *Proceedings of the 2024 International Conference on Social Sciences and Educational Development (ICOSSED 2024)*, Advances in Social Science, Education and Humanities Research 912,
https://doi.org/10.2991/978-2-38476-382-5_22

students' anxiety on physics learning [1]. Agentic engagement is a key factor influencing students' basic psychological needs and reducing test anxiety [2]. Meanwhile, some researchers found that the average frequency of positive emotions decreased due to the increasing number and difficulty of physics knowledge points [3]. The Physics Laboratory Anxiety Scale can effectively capture and measure anxiety levels, ultimately improving the overall results of the research on the relationship between emotions and physics learning [4]. Prioritising positive emotions helps foster a more engaging and motivating learning environment. Furthermore, throughout the learning process, positive emotions are more important in the acquisition phase of learning than in the practice phase [5]. However, negative emotions also have a positive impact on students' attitudes towards physics learning [6].

Given the lack of a comprehensive review, this study attempts to provide a comprehensive analysis. It can provide implications for physics learning and contribute to education. A multidimensional approach involving both documentary and qualitative research was employed to investigate the relationships in different contexts.

2 Physics Leaning

Physics learning is extremely important to foster and stimulate the development of physics problem-solving skills and lifelong learning skills such as critical thinking [7], under which students can only stand out if they are fully engaged in the classroom [8]. Students should often discuss professionally relevant issues, combine theory with practice, and conduct scientific experiments while learning theoretical knowledge [7]. However, studies have shown that today's physics classrooms are still mostly didactic [9], lacking interaction, discussion, and practice. These students include not only those who perform poorly due to learning difficulties but even many of their academic peers who drop out of physics due to its boring content. Therefore, the study of physics learning has become increasingly important in such an era where science and technology are given particular importance.

Learning strategies, motivation, self-efficacy, and achievement are the four aspects that influence the effectiveness of physics learning. While more researchers believe that self-efficacy is a dimension of learning motivation, the two cannot be juxtaposed. However, emotion has a significant effect on all of these dimensions [10].

Some scholars have stated that motivation is more influential than other factors [8]. Distinguished from extrinsic motivation, intrinsic motivation is an activity performed for intrinsic satisfaction, an action performed for interest and challenge. In a physics learning scenario, this intrinsic motivation may be curiosity about the essential workings of things, a sense of achievement for successfully completing an experiment, or successfully understanding a complex theory. External motivation, on the other hand, is generated for an external product, such as a reward or reward for completing a task or solving a problem. [7]

Learning motivation has several dimensions: self-efficacy, goal setting, and goal commitment [11]. Goal setting is a form of control for learning motivation. When confident goal commitment is maintained, achievement in turn increases. Self-efficacy is the most important and widely discussed of these three dimensions [10]. Physical self-efficacy naturally includes students' interpretations of their prior accomplishments, self-evaluations of their abilities, and personal estimates of their performance on subsequent questions posed, defined as the individual's assessment of his/her own success in carrying out the completion of a particular task or problem as an assessment of one's confidence [12]. The self-efficacy of students with high levels of self-achievement increases over time, and vice versa. It determines students' choice of tasks that require a lot of effort, and the degree of persistence and endurance in difficult situations. Self-efficacy is positively correlated with academic performance [8].

Some researchers have proposed a core self-evaluation scale (CSE) for measuring learning effectiveness. Its core features are emotional stability, self-esteem, and self-efficacy. According to self-enhancement theory, people with high CSE are emotionally stable by being sensitive to and pursuing positive stimuli, and by being insensitive to and thus avoiding negative emotions. This is corroborated by the high degree of congruence between an individual's extrinsic behaviour and intrinsic motivation in self-congruency theory [13]. Individuals with high CSE also have high levels of performance in this self-regulated learning process of setting goals, using strategies, and monitoring performance in order to accomplish tasks. This leads to the chain reaction that high self-evaluation leads to high self-efficacy, and high self-esteem, which in turn leads to high emotional stability and good grades [10].

Similarly, learning strategies, which have a parallel position with motivation, are also closely related to physics learning. A researcher proposed an exploratory model about the results of learning strategies in the output of the three stages of learning

(surface, depth, and transfer), and concluded that it is important to embed them in the learning topic in order to develop the different stages of learning more clearly and to promote the best strategies associated with them [9].

3 Emotions and Physics Learning

Positive emotions can accelerate learning [14]. Regulating academic emotions improves learning outcomes. Emotion regulation broadly encompasses identifying emotional goals, selecting strategies for emotion regulation, and implementing strategies to regulate emotions [15]. Emotions have been categorized as characteristic emotions (relatively stable human traits that respond to relatively universal, stable ways of reacting to the world, course-specific, test-specific emotional experiences, derived from memory, influenced by subjective beliefs) and state emotions (situationally influenced, interludes in academic life) [16].

There are two relatively separate research traditions in emotion management. One is the emotion regulation tradition, what emotions they have when they have them, and how they experience and express them, and how they manage them. The other is the emotional intelligence tradition. Adaptation in emotion regulation is a product of three factors: awareness (whether it should be), goals (intensity identified), and strategies (developed based on the first two) [17].

Positively activated emotions are a positive predictor of metacognition, and significant reductions in positive emotions lead to reduced proficiency and goal attainment. Negative emotions have also been found to be a predictor of metacognition, including procrastination and goal avoidance [13]. The two emotions, potency and activation, are considered to be the basic determinants of the effects of emotions on learning. Positive activation emotions are expected to encourage the usage of flexible, in-depth processing policies like explanation, organization, and metacognition, while negative activating emotions are expected to lead to the usage of more rigorous, superficial processing policies like simple practice. Similarly, negative disabling emotions are assumed to result in decreased devotion and the adoption of artificial shallow processing techniques [18].

However, it is vital to note that high accomplishment emotions are not always advantageous, and negative accomplishment emotions are not always unfavorable [8]. For instance, a negative activation emotion like anxiety over an approaching examination, might boost a person's inspiration to study and make preparation for it.

Under this situation, the negative activation emotion efficiently enhances engagement, potentially improving future learning. Anxiety is often defined as the scary and unsettling emotions that result from a person's incapacity to escape from their actions and cope with the expectation of dissatisfaction [12].

When students' academic talents are examined, they frequently fear failure [19], a condition known as accomplishment anxiety. Students may have achievement anxiety when evaluating their own learning, such as when they are working on a class assignment and realize they are unable to solve the problem. Students may also experience achievement anxiety when they are judged by their peers or teachers. For example, when students debate course topics with other students in class, they may suffer achievement anxiety if they regard the discussion as an evaluation environment in which others assess their abilities. Similarly, answering questions provided by the teacher can cause achievement anxiety, especially if pupils do not know the correct answer and are concerned about how the teacher perceives them. As a result, because active learning courses are designed to feature a significant number of tasks in which students can be assessed, they may be more likely to generate student anxiety than standard lecture courses, which could explain why some students decline to participate in active learning [18].

According to research, emotions have an impact on a variety of cognitive functions, including attention, memory storage and reclamation, social judgment, decision-making, and cognitive problem-solving [20]. Anxiety can be associated with a deterioration in academic memory. Furthermore, learning anxiety causes pupils to focus more on dangers and failures, limiting their cognition and variety of activities while consuming their limited cognitive resources [21]. As a result, this influences students' processing of the current learning activity. Anxiety can be associated with a deterioration in academic memory. In addition, learning anxiety means that students focus more on threats and failures, which restricts their cognition and range of activities and takes up their limited cognitive resources [22]. In turn, this affects students' processing of the learning task at hand. When students fail to meet the cognitive demands of academic activities, they progressively develop low engagement in learning.

Failure frustration acts as a mediator variable between emotional worry and academic achievement. Scholars undergoing learning anxiety are involved in task-irrelevant thinking, have fewer intellectual resources accessible for task purposes, and are less attentive during the learning process, resulting in inefficiency

and lower academic achievement [23]. Several studies have investigated the link between learning anxiety and academic accomplishment in exact areas, mainly physics. Preceding research has shown that physics anxiety is a negative predictor of physics performance [24]. Physics anxiety may impair performance by diverting cognitive resources from task-relevant purposes (i.e., physics tasks) to task-irrelevant aspects. Negative emotions (e.g., anxiety) can reduce learning effectiveness and may even lead to significant learning delays. Prolonged anxiety can lead to decreased self-efficacy, burnout and impair academic performance. Moderate anxiety can facilitate physical learning. The more severe the emotional anxiety, the more trouble learners have with project-based learning, which affects the learner's satisfaction with this mode of instruction [19].

One study also showed that learner satisfaction is a significant positive predictor of academic performance while anxiety negatively predicts academic performance. Anxiety is considered an unstable psychological state during the learning process, and according to the theory of humanistic psychology, it can affect people's behavior over a long period of time. However, more attention should be paid to learners' emotional changes with the negative predictive effect of emotional anxiety [24].

Statistical anxiety is the most significant direct predictor of performance. Students who were more anxious about statistics performed worse on exams and procrastinated more. Statistical anxiety was indirectly linked to reduced energy and time spent studying. Contrary to expectations, trait anxiety was initiated to be absolutely linked with both statistical anxiety and academic accomplishment. This finding can be explained by the variability of trait anxiety assessments [25].

4 Research Gaps and Future Research Directions

Few researchers have examined the theoretical framework between them, including the internal mechanism of emotion generation, and the causes of emotional changes, to corroborate the results of empirical studies. Furthermore, studies have shown that differences in grade levels and difficulties in learning physics can lead to differences in emotions. As such, learning difficulty and age are important factors concerning the change of mood in physics learning. Therefore, a continuous and dynamic research perspective is particularly important. Most studies focus on the emotional state of the subject at a certain point in time or even at a certain moment in time, ignoring the dynamic nature of emotional change.

Physics learning is a complex process, and most studies only discuss the influence of a single-dimensional factor, thus ignoring the influence of other factors. Moreover, most research only stops at analysing the topic, without presenting the opinions and suggestions given to physics learning or physics teaching.

In terms of the types of emotions, perhaps because physics is a very difficult subject, most of the articles on the relationship between emotions and physics learning have only explored the relationship between negative emotions (e.g., anxiety) and physics learning, while little or no research has examined the relationship between positive emotions and their relationship. Moreover, previous studies do not differentiate emotions in more detail but mostly focus on one particular emotion. Emotion intensity was seldom quantified.

In terms of research subjects, there are more studies on secondary school students and fewer on college students; more studies on a single age group and fewer covering more age groups; more studies on groups studying with utilitarian purposes (exams, etc.) and fewer studies on interest-oriented learners. Moreover, most researchers have not fully considered the individual differences of the research subjects due to the differences in their own learning ability, interest in learning, and emotional regulation ability, which leads to the inability to accurately reflect the real situation of all the research subjects.

Based on these research gaps, it can be concluded that in future research we can combine other disciplines such as psychology and biology to increase the establishment of the theoretical framework, enrich the variety of emotions, and expand the research sample to make the empirical research more comprehensive.

5 Conclusions

This study provides a comprehensive and in-depth exploration of the role of emotions in the physics learning process, aiming to reveal how emotions affect students' physics learning experience and learning effectiveness. Firstly, emotions, as an important part of individual mental activities, have a non-negligible impact on physics learning. Positive emotions can improve learning efficiency and learning outcomes. On the contrary, negative emotions may hinder students' learning process and reduce their interest and self-confidence in learning.

This study not only enriches the theoretical framework of the relationship between emotions and physics learning but also provides useful guidance for educational

practice. Future studies can further explore the mechanisms by which emotions affect specific aspects of physics learning, as well as how to more effectively regulate students' emotional states through instructional design. At the same time, educators should pay attention to students' emotional health and integrate emotional education into the whole process of physics teaching.

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