

Optimizing Distance Education with Emotionally Intelligent Decision Support Systems

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Article Info:

DOI: 10.22399/ijcesn.2658

Received : 21 April 2025

Accepted : 23 May 2025

Keywords

Emotional Artificial Intelligence
Emotions
Distance Education
Personality Types
Emotional Condition

Abstract:

This article discusses the rapid development of emotional artificial intelligence and its significance in distance education. It highlights the necessity of considering students emotions to enhance educational quality. The analysis shows that emotions are reactions to stimuli and help the body adapt, with facial expressions being a universal method to express emotions. These expressions can be encoded using a facial movement coding system, simplifying the process of reading emotions. Additionally, the article also examines the influence of personality types on emotions and presents existing classifications of personality types.

A functional model has been developed to organizing personalized distance education, integrating a decision support system within the LMS that considers students' emotional states. furthermore, a mathematical model for managing the distance education process has been created, taking into account students' emotional information, focusing on five primary emotions and four personality types.

The article details the development of an algorithm for providing emotional support to influence students' emotional states, which has been implemented in the decision support system for distance education. Enhancing distance education presents significant opportunities, such as a personalized learning, reduced stress, increased motivation, and efficiency all contributing to a higher quality of education.

1. Introduction

Currently, emotional artificial intelligence has undergone rapid development, because gives a real effect in socioeconomic systems [1]-[3]. Taking into account the emotions of students during the education process is easily solved by a "live" teacher, but in distance education systems this factor has previously been poorly studied. Distance education is one of the main ways of acquiring knowledge for most students and schoolchildren to the whole world. With this form of education, the process of acquiring knowledge takes place remotely using various technical means. That is, the teacher and the student are at a distance from each other and communicate through Internet resources [4],[5]. At the same time, the number of students is not a critical parameter, and they can freely

communicate with each other using telecommunication networks and means of communication. Distance education is developing rapidly and is relevant. This is an important direction today. It allows us to increase the efficiency of the implementation of the educational program and contribute to more successful socialization of students in the modern society. This form of education has its advantages and disadvantages. The main advantage is the opportunity to study independently depending on location and condition health. This makes the education process more flexible and economical. Student does not waste time traveling to the place of study, but can use it to independently study the material. This is another advantage of distance education; a lot of attention is paid to independent work, which increases the student's creative and

intellectual potential. The student can choose a convenient time and place for mastering knowledge, as well as choose a comfortable pace. Also, distance education improves students' qualifications in the field of working with information and information technologies [6]-[8]. The student learns new ways of finding information and improves his skills with the development of modern technologies. But such a education system has serious drawbacks. Firstly, the student must have constant access to Internet resources to communicate with teachers and obtain the necessary data, and also have the skills to use these resources. Secondly, due to the fact that a lot of attention is paid to independent work, the student may feel too much freedom of action and lose the incentive to learn. Thirdly, the student is deprived of live communication with teachers and colleagues, which makes it difficult to choose an approach to a specific student. With the traditional teaching method, the teacher can easily recognize some characteristics of the student and change his teaching methods. He can cheer up, calm down or explain something differently depending on his condition, thereby changing his emotions for the better. The right emotions increase learning. Those who need motivation and attention help make it easier to memorize the material. The lack of influence on emotions is a serious drawback of distance education that needs to be addressed.

2. Method

Artificial intelligence refers to the technique of creating computer systems that able to perform tasks that require human intelligence. AI is a discipline which attempts to emulate human behavior based on unchangeable, reproducible, and universal hardware. However, AI has been criticized for its lack of understanding of the basic principles of life—emotions, ethics and moral issues, and environmental criteria. To combine two disciplines, artificial emotional intelligence has emerged and studied since 1995. Artificial emotional intelligence is defined as the in-depth study of the implementation of emotional processes in learning and reasoning. AI with emotional capabilities—emotional AI—helps AI systems get a better understanding of a task or a problem. Emotional AI refers to technologies that can sense and classify human emotions [9]–[11]. Emotional intelligence refers to the abilities to recognize, understand and express emotions, as well as the ability to manage and regulate them [12]. The first use of the term was mentioned by Elfenbein and Shephard at 2002, who described emotional intelligence as the ability to reason about

emotions and of emotions to enhance thinking. EI moves through perception of emotion, using emotion to facilitate thought, understanding emotions, and regulating emotions. Emotional intelligence is one of the essential components of human capital, which also contains general intelligence, social skills and health. EI plays a significant role in different aspects of life such as mental health, life satisfaction, and job satisfaction. Emotion is the body's reaction to external or internal stimuli [13] – [15]. We can say that this is a mental process, expressed in the form of direct experiences. Emotions can be called both the internal state of a person and the external manifestation. They help our body adapt to various situations and are directly related to instincts, and also help to facilitate social interaction between people, thanks to the ability to read the emotions of others by facial expressions, gestures, posture and even tone of voice. People express their emotions using facial expressions. This is a universal way of manifesting them. By facial expressions we mean expressive movements of the facial muscles [16] – [18]. It does not depend on race or social class. With the help of facial expressions you can understand what emotions a person is experiencing at the moment and how vivid these emotions are. M.G. Frank divided facial expressions into three groups in accordance with mental functions. He believed that the muscles located around the eyes are responsible for the mind; they express various mental acts. The muscles surrounding the mouth area are responsible for human will. And finally, all the muscles of the face that are capable of expressing these feelings are responsible for feelings. Facial expressions can be voluntary or involuntary. In the first case, people use facial expressions consciously as an element of acting. And in the second - this is a reflexive process that is manifested by a person unconsciously. Paul Ekman and Wallace Friesen developed the Facial Action Coding System (FACS) in 1978 [19]. It classifies a person's facial expressions. Facial movements are assessed in motor units AU (Action Unit) units that form facial expressions. Each movement is encoded in motor units and descriptors. Descriptors are considered to be coordinated movements of groups of facial muscles. The intensity of AU involvement is determined by adding a Latin letter from A to E to its number. Let's take a closer look: A – weakly discernible, B – insignificant, C – noticeable or pronounced, D – strong or extremely noticeable, E – extreme. For example, AU1A will be a faint movement AU1. AU relative to the vertical axis of the face can be bilateral (symmetrical) or unilateral. Any emotion can be encoded using such a system. Let's give a few examples. Surprise can be

represented as: AU1 + AU2 + AU5B + AU26, where AU1 is the mechanism for raising the inner part of the eyebrow; AU2 – mechanism for raising the outer part of the eyebrow; AU5B – mechanism for raising the upper eyelid with insignificant movement; AU26 – jaw dropped. Instead of AU26 there could be AU27 - the mouth is wide open. Joy is AU6 + AU12, where AU6 is the cheek lift mechanism; AU12 is the mechanism for lifting the corner of the lip, which can be observed in Figure. 1.

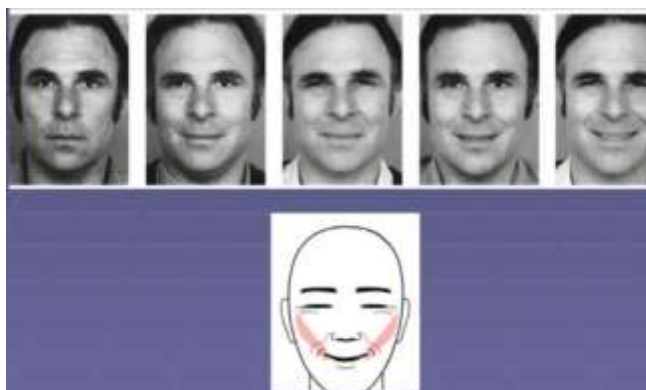


Figure 1. Lifting the corners of the lips

2.1 Models Of Personality In Systems Of Emotional Intelligence

Emotion analysis using Artificial Intelligence aims to determine and interpret human emotions through various cues such as facial expressions, body language, speech patterns, and physiological signals. This field combines elements of psychology, computer science, and artificial intelligence to develop algorithms and technologies that can accurately identify and understand human emotions. The emotions of a particular person may depend on his personality (psychotype), needs and values. Therefore, when reading emotions, it is worth taking into account the influence of a person's personality. Knowing the student's psychotype, we can predict what emotions he will experience and how he will behave in one situation or another. This will allow us to influence the

student in the right way. By psychotype we mean a mental characteristic of a person. Each personality type has its own character traits and behavioral characteristics. There is no unified classification of psychotype. The most famous is the theory of André Kerber [20]. He identified two main psychotypes: introvert and extrovert. External objects are the driving force for extroverts. Such people are more open and inclined to communicate; are emotional and clearly show their emotions to others; prefer an active lifestyle and strive for leadership. Introverts show greater interest in themselves and their mental state. Such people find it difficult to communicate, and they lead a more closed lifestyle. They are not bored spending time alone, but they feel uncomfortable. They are used to keeping their emotions under control and show them only to the people closest to them. At the same time, these are very creative people with a developed imagination. A teacher, working with an introvert and an extrovert, must use different approaches to their teaching to obtain the best result. Another common classification of psychotypes is the theory of Hippocrates, the famous ancient Greek physician and philosopher [21]. He identified four types of temperament: sanguine, choleric, phlegmatic and melancholic. Physiologist I.P. Pavlov agreed with Hippocrates' classification and associated psychotypes with the reaction of inhibition and excitation. This is presented in more detail in Table. 1.

Melancholic people have weakly expressed excitatory and inhibitory processes, because of this they become very sensitive and are often in a depressed state. Even minor events can affect them. They easily fall into depression, which is why they often have mental disorders. They are low-energy, often very suspicious and jealous. But at the same time they have developed analytical thinking and a creative approach to business. Choleric are the opposite of melancholics. They are unrestrained, active, courageous, do not know how to control their emotions, are unbalanced, but at the same time they have a strong character. They

Table 1. Psychotypes of personality

Temperament According To Hippocrates	A Brief Description	Properties Of The Nervous System According To I. P. Pavlov
Phlegmatic person	Efficient, little emotional, serious, reliable, calm	Strong, balanced, sedentary
Sanguine	Active, energetic, cheerful, carefree	Strong, balanced, agile
Choleric	Very energetic, hot-tempered, assertive, emotional	Strong, unbalanced, agile
Melancholic	Closed, vulnerable, reserved, thoughtful	Weak, unbalanced, reserved

are easily angered, often have outbursts of anger, are very impulsive and find it difficult to get along with people. But they easily absorb information and take on any task with interest, except for routine. They have pronounced leadership qualities in sanguine people, inhibitory and excitatory processes are strongly expressed, while they are mobile and balanced. Sanguine people are active and can take initiative, have a penchant for work, but are often worried that they won't be able to do something or make a mistake, because of this they experience a lot of stress and work themselves up ahead of time, they are demanding of themselves and others, but at the same time cheerful and optimistic. They are sociable and easily find common language with other people. Their emotions are mostly positive, but can change quickly. In phlegmatic people, inhibitory and excitatory processes are also highly pronounced. Phlegmatic people are the calmest type of personality. It is very difficult to piss them off. They are reasonable and balanced. They adapt poorly to something new. They find it difficult to switch from one activity to another. They are also indifferent to others and lazy. To determine the personality type, before starting work with the student, an appropriate survey is often carried out. For example, G. Eysenck's survey [22], consisting of 57 questions that must be answered "Yes" or "No". Of these, 24 are responsible for the tendency towards extraversion or introversion, another 24 for emotional stability (neuroticism) and 9 questions determine the sincerity of the answerer. Emotional stability is a sign indicating the preservation of organization and purposefulness of actions both in stressful situations and in everyday life. As a result, we get an Eysenck circle built on axes. The intersection point according to the estimates of the two scales indicates the psychotype. Another well-known example is the D. Goldberg questionnaire, which determines personality based on five factors: extraversion, agreeableness, conscientiousness,

neuroticism (emotional stability) and openness to experience [23]. These factors are also called the "Big Five". There are several implementations of this test, but the most reliable is the NEO personality test (NEO-PI-R), consisting of 240 questions.

2.2 Classification Of Emotions

Let's consider the main types of emotions that distance education students may experience. The classification of the emotions under consideration is presented in Figure. 2 [24]-[25].

Joy is one of the key positive emotions. It is associated with feelings of happiness and pleasure. It occurs at the moment of exhaustive satisfaction of a person's current needs, often provided that the probability of this was low. Surprise is not a positive emotion, but it is not a negative emotion either. This is a reaction to the occurrence of a sudden unexpected circumstances. Depending on the nature of the situation, surprise can develop into fear, interest or joy. Sadness is the opposite of joy and is a negative emotion. Occurs when it is impossible to satisfy a person's current needs, the loss of someone or something, etc. Sadness has many branches: sorrow, melancholy, despondency and sadness.

Anger is a strong negative emotion. Arises in response to unexpected circumstances that prevent a person from achieving his desired goals. Disgust is a stronger form of rejection. This is a negative emotion that arises in a person when interacting with various objects. These objects cause a contradiction with the moral, aesthetic or ideological principles of person. This emotion can be directed at oneself and cause self-condemnation. Contempt is another negative emotion. It arises in relation to an object that demonstrates behavior or qualities that are socially unacceptable, in the opinion of the subject. It can develop into anger,

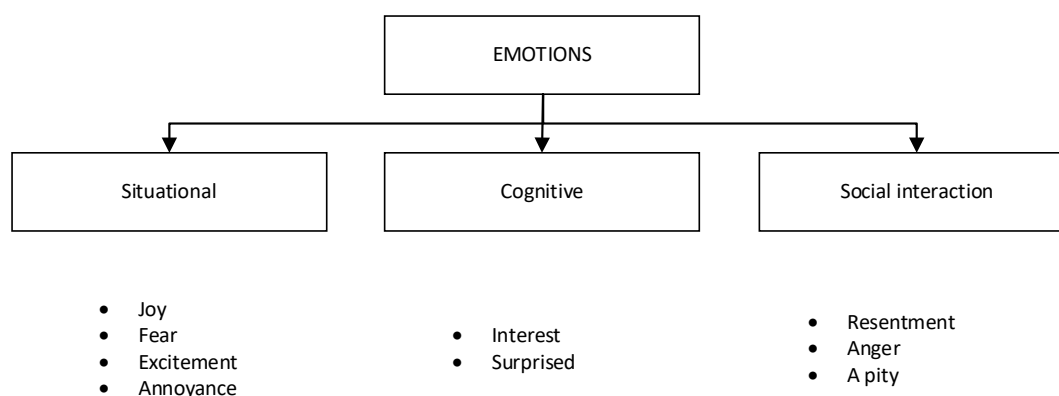


Figure 2. Classification of emotions

3.2 The Task of Managing the Distance Education Process Taking into Account Emotionally Colored Information

In distance education, the influence of the teacher on the emotional state of the student plays an important role. Since the student's emotions can affect motivation, perception, attention and assimilation of information. This means that emotions are directly related to the level of student learning. In this case, an individual approach to each student is important to us, and it is also worth taking into account the dependence of emotions on a person's psychotype. The task is to develop a decision support system when compiling an individual training module, which during training will determine the five main emotions - joy, interest, fear, sadness and anger and in various ways influence the emotional state of the student. A mathematical model of the problem of managing the distance education process has been developed. Let the student profile be denoted as a vector

$$X(t) = \{x1(t), x2(t), \dots, xn(t)\} = \{Y(t), Z(t), V(t), M(t)\}, \quad (1)$$

which includes all the parameters of the gosity.

$$Y(t) = \{y1(t), y2(t), \dots, yh(t)\} \quad (2)$$

– student parameters related to readiness for learning.

$$Z(t) = \{z1(t), z2(t), \dots, zg(t)\} \quad (3)$$

– student parameters related to the level of knowledge.

$$V(t) = \{v1(t), v2(t), \dots, vo(t)\} \quad (4)$$

– student parameters associated with the representational system.

$$Em(t) = \{Em1(t), Em2(t), \dots, Emr(t)\} \quad (5)$$

– student parameters related to emotional national state. In this case

$$n = h + g + o + r \quad (6)$$

The management function takes the following form:

$$F(t) = \{F1(t), F2(t), \dots, Fkl(t)\} \quad (7)$$

And the control function will take the following form:

$$U(t) = \{u1(t), u2(t), \dots, upl(t)\} \quad (8)$$

Functions $F(t)$ and $U(t)$ can change over time and serve as control variables. Then we have the task of finding $F(t)$ and $U(t)$ such that will maintain a stable emotional state of the student and ensure a high level of mastery of the material.

Let $X(t_0)$ be the initial state of the system, then $X(t) = \{U(t), F(t), X(t_0)\}$. An integral indicator of the effectiveness of the process of providing educational services can serve as a management criterion.

$$Qcl = \{X(t), U(t), F(t)\}$$

Thus, the task is to find such with reference values of specific emotions. In this way, seven different emotional states are recognized. The disadvantage of this method is the need for students to recruit some Prepared functions of management and control influence that will maintain a stable emotional state of the student and ensure a high level of assimilation of the material.

3.3 Analysis of Methods For Formalization of Emotionally Colored Information

There are several approaches to formalizing students' emotions during a lesson. The first option is to read facial expressions using a video camera. The algorithm recognizes the presence of a face and then determines its features. Captures the movement of parts of the face and encodes them using the Facial Action Coding System (FACS). In this case, not all motor units are considered, but only some that we need. This method has a number of disadvantages. Due to physical differences such as hairstyle, complexion, glasses or headwear, we may receive incorrect data. Another difficulty is that the student may cover his face with his hand or other object during class, which will also lead to an incorrect result.

In addition to facial expression, the student's emotions are revealed by his voice. Matthew Fernandez and Akash Krishnan in 2016 developed the "Simple Emotion" algorithm, which recognizes dozens of emotions based on human speech. The algorithm recognizes voice frequency, volume and changes in tone and compares them with reference sounds and tones.

Another way to determine emotions is testing. It can be implemented in different ways. For example, after each block of a lesson, conduct a short survey to identify the emotional state of the student and, based on its results, change the next block. Or, at the beginning of the lesson, using surveys, find out the student's characteristics (age, gender,

nationality, etc.), his psychotype and initial emotional state. Based on these facts, we can predict how the student's emotional state will change depending on the events taking place. Questions can be directly related to the student's experiences or to his academic success.

The closest way for a student to express emotions is emoji. Emoji is a graphic language that uses a combination of pictures instead of words. Let the student have an emotional status, expressed in the form of an emoji, and during the lesson he can change it in accordance with his state. By analyzing changes in emotional status, you can edit the lesson plan.

You can also determine a person's emotional state by the way he types on the keyboard. This method takes into account the time of key presses, typing speed in an interval of five seconds and other parameters. There are 19 pairs of meters in total.

The parameter values are compared with the reference values of specific emotions. In this way, seven different emotional states are recognized. The disadvantage of this method is that students need to type some prepared text.

You can also use indicators from various sensors. These indicators include electrical impulses of the body, pulse and other physical characteristics. This method allows you to determine the level of stress, but it is difficult to identify a specific emotion. This method is best used in combination with other approaches.

To increase recognition accuracy, you can use several of the listed methods for determining emotions at once. Next, depending on the recognized emotion, it is necessary to form pedagogical actions - emotional support, which will be taken into account in the learning process.

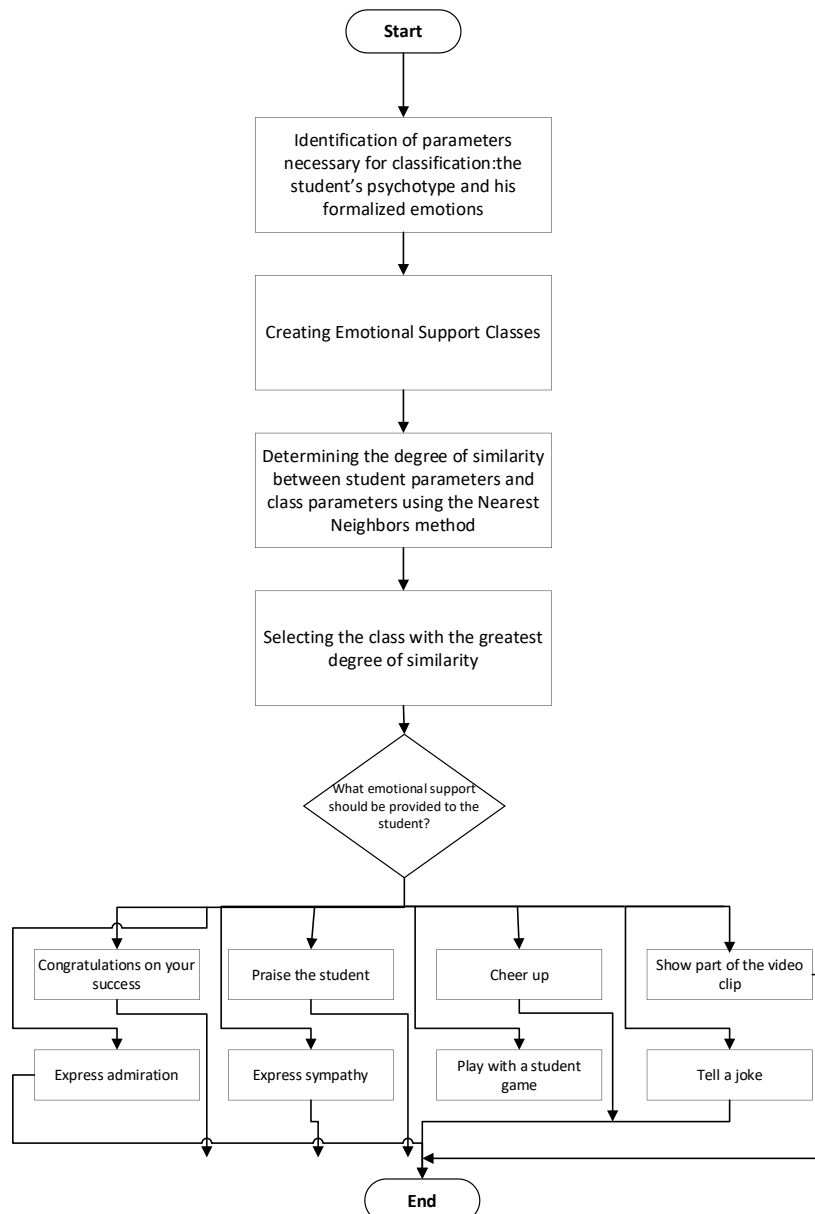


Figure 4. Developed algorithm for selecting emotional support

3.4 Analysis of methods of influence on the emotional state of students in emotional AI

There are several ways to influence the emotional state of a student. Firstly, you can change the teaching method and the complexity of the educational material, while taking into account the student's level of knowledge. For example, a teacher with a high level of knowledge should give a difficult task to a student, but based on a negative current state, it is necessary to give an easy task to increase confidence.

You can also use various multimedia components to attract attention and increase motivation. For example, depending on the emotional state, text, hypertext and audio recordings can be used to explain the material to one student, and images, video and animation can be used to explain the same material to another. The teacher can motivate the student by congratulating him on his success, expressing admiration and praising him. If a student experiences negative emotions after failure, the teacher should express sympathy and encourage him. To attract attention, you can play a game with the student. If the student is tense and needs to be relaxed, you can show him part of a video clip or tell him a joke. All these measures lead to an improvement in the emotional state and increase the efficiency of the educational process.

It is proposed in the developed DSS to provide emotional support of various types. The developed algorithm for selecting emotional support is presented in Figure: 4.

4. Conclusion

In conclusion, the incorporation of emotional artificial intelligence (AI) into distance education signifies a substantial progression in augmenting the educational experience. By acknowledging and addressing the emotion states of students, educators are empowered to establish a more tailored and efficacious educational environment. The development of functional and mathematical models, coupled with algorithms for emotional support, elucidates the capability to enhanced learner motivation, reduce stress, and increase learning efficiency. These innovations promise to elevate the quality of education, making it more adaptable and attuned to the unique requirements of each learner.

Author Statements:

- **Ethical approval:** The conducted research is not related to either human or animal use.
- **Conflict of interest:** The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper
- **Acknowledgement:** We would like to express our gratitude to University of Thi-Qar, University of Kufa and University of Technology for their continuous support and for providing the resources necessary for the completion of this research. Their commitment to fostering academic research has been invaluable to our work.
- **Author contributions:** The authors declare that they have equal right on this paper.
- **Funding information:** The authors declare that there is no funding to be acknowledged.
- **Data availability statement:** The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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