Theoretical Principles of Measuring and Interpreting Levels of Attention, Involvement and Organizing Feedback of Students to the Educational Process Using Automated Software Products

Aleksander Spivakovsky, Lyubov Petukhova, Maksym Poltoratskyi, Oleksandr Lemeshchuk, Anastasiia Volianiuk(✉), Olena Kazannikova, Nataliia Voropay, and Svitlana Chepurna

Kherson State University, Shevchenka St., 14, Ivano-Frankivsk 76018, Ukraine
{spivakovsky,petuhova,mpoltoratskyi,olemeshchuk,avolianiuk,okazannikova,nvoropay,smatvienko}@ksu.ks.ua

Abstract. The article highlights the theoretical foundations of measuring and interpreting student attention levels, engagement, and feedback, an attempt is made to characterize the possibilities of using automated software products for this purpose. The article identifies the psychological characteristics of students of the Zoomers generation, which affect the educational process and cause the revision of educational technologies. A comparative analysis of traditional and distance learning was carried out. Based on the characteristics and interpretation of visual markers for measuring the attention and involvement of the acquirers, the requirements for the software product for determining the degree of involvement and the degree of information perception are described. The article discusses the main AI-based tools that allow you to assess the level of audience attention in real time during online conferences (EmotionCues, HEADROOM and MeetingPulse) from the standpoint of the effectiveness of the analysis of the emotional component and the possibility of integration with online conference services. The theoretical analysis is the basis for further research on the measurement and interpretation of students' attention, engagement and feedback.

Keywords: Educational Process · Attention · Involvement · Organizing Feedback · Engagement · Automated Software Products · Machine Learning Technology

1 Introduction

The disruption of the digital infrastructures of different generations has led to the catalysis of mass processes, particularly in the field of education. We started work on the creation of this article during the global pandemic, quarantine measures and the introduction of distance learning into all links of the educational system. We continued the research in the conditions of martial law, when online education is the only option for obtaining education in many regions of Ukraine.

G. Antoniou et al. (Eds.): ICTERI 2023, CCIS 1980, pp. 144–159, 2023.
https://doi.org/10.1007/978-3-031-48325-7_11

The gap in communication in the remote format causes a decrease in the quality of education, but the gap from traditional learning is so great that a new look at the interaction between a teacher and a student is needed. The role of a teacher today is rapidly transforming into the role of an educational blogger, and the role of a student is transforming into a subscriber interested in content. Free access to absolutely unlimited information opens up opportunities for students to independently choose sources of knowledge, therefore, the trend of educational blogging becomes a new reality after the final loss of the monopoly on knowledge by teachers. Using the achievements of the information age opens up unlimited opportunities for the young generation both for independent learning of educational material and for improving their professional qualities and skills. At the same time, the teacher remains a trainer, coordinator, expert in his field, but his role changes to a blogger who creates and promotes educational content, is an opinion leader and an authority among student subscribers.

Note that the problem of the gap between the generation that teaches and the generation that is taught is important today. This gap is caused, in particular, by the technology of different generations, their level of digital skills and, in general, their interaction with information technologies.

The modern educational process, in the era of social networks and rapid development of technologies, differs from what it was 5–10 years ago, and is characterized by the active implementation of information and communication technologies, a combination of traditional and innovative teaching methods, and the combined use of traditional and remote forms of education. In the conditions of the informatization of the educational environment, teachers face the main tasks:

- to form the student's internal motivation to acquire knowledge and future professional activity;
- improve the skills of information culture and increase the level of digital competence;
- develop students' critical thinking;
- teach how to quickly navigate in a wide flow of information and determine its truth;
- select effective information and communication methods and teaching tools.

We consider it expedient to develop priority directions for solving these problems through the prism of the theory of generations. This research approach gained its popularity in the early 1990s, the authors of which are Neil Howe and William Strauss [19]. Researchers have argued that historical context determines human behavior: a group born in one period of time has similar personality traits common to an entire generation. According to this theory, the following generational cycles are familiar to modern society: "Baby Boomers", "Generation X", "Generation Y" (millennials), "Generation Z" (digital natives) and "Generation Alpha". Sociological studies claim that modern educational institutions educate representatives of "Generation Z".

The pedagogical community is actively researching and discussing how to teach today's youth, what forms and methods of organizing the educational environment to use, how to build an educational environment, and what information and communication means of learning will be effective. After all, the modern challenge of the forced transition to distance learning, caused by the rapid spread of the COVID-19 corona virus infection throughout the world, vividly actualized the problem of training digital natives and finding an effective educational model. We have identified contradictions, the solution

of which will contribute to increasing the level of efficiency of the use of technologies in the educational process (in particular, in distance and mixed learning formats):

- contradiction between those who teach and those who are taught;
- the contradiction between the pedagogical possibilities of information and communication technologies and the low level of effectiveness of their use in the educational process;
- contradiction between the psychological features of information perception by students who constantly interact with information technologies (generation z) and traditional content and methods of learning;
- the problem of focusing attention during classes in a distance/mixed format and the teacher's inability to monitor the level and dynamics of the learner's inclusion in the educational process;
- lack of motivation and low level of self-organization of the student in the process of distance learning and the impossibility of constant control by the teacher and the need to conduct it.

Based on the above contradictions, we see the need to study the cognitive features of modern students of higher education (zoomers generation), traditional and modern learning models, classic and new views on the student's learning process, analyze the theoretical foundations of the development of tools to control the student's level of involvement and motivation.

2 Peculiarities of Studying Students of the Zoomers Generation

According to the provisions of the Theory of Generations, the majority of modern students are the generation of people born from 1997 to 2012. The most common term used in the world to refer to them is Generation Z. However, there are other less common terms - Homelanders, Homeland Generation, Zoomers, New Silent Generation [9, p. 8]. Avoiding unpleasant associations with the letter Z, caused by the war of the Russian Federation on the territory of Ukraine, in the article we will call representatives of this generation Zoomers.

The generation of Zoomers replaced the millennials born in the 80s and early 90s. Its representatives grew and matured along with the development of technology. Zoomers cannot imagine their everyday life without gadgets and quickly master any new technology. They easily use the Internet for entertainment, communication and work. A distinctive feature of Zoomers is the fact that technology is part of their everyday life. IT has significantly influenced the way of thinking, habits and aspirations of young people. The theory of generations calls this generation "digital children" [5]. Due to the abuse of smartphones, mobile Internet and social media, the "digital children" experience many problems such as technology addiction, offline phobia and problematic use of social networks. From the point of view of socialization, it can be seen that higher education students are more influenced by psychological factors related to technology, as they use it extensively in their academic studies and access to information [10]. However, it is advisable to use these features to improve their effectiveness in online learning.

As a result of the analysis of the concepts regarding the peculiarities of the education of Zoomers students, we obtain a set of the following psychological characteristics of this generation:

- difficult to recognize authorities, especially do not recognize public opinion, do not listen to the advice of adults;
- gain experience through their own victories and failures;
- freely express their opinion and dissatisfaction;
- they value their individuality and are afraid to express themselves in different forms;
- they are "looking for themselves" and their vocation for a long time, so they are in no hurry to get a job and start a family;
- picky about the conditions of their own comfort;
- open to new impressions and emotions;
- they are energetic, restless and inquisitive;
- it is difficult for them to work for the interests of the team, they value their own benefits more;
- they are multitasking, but at the same time a bit apathetic and passive;
- know how to quickly switch and grab information "on the fly";
- they strive for career and personal growth, financial well-being.

We should also note that memorizing information is not a priority for Zoomers, because they are used to everything ready on Internet pages. And the next generation after zoomers does not know life without gadgets at all. They perceive the material clip-wise, that is, by the example of changing pictures on the Internet.

2.1 A Theoretical Overview of the Traditional Learning Model and Theories of Cognition

Today, information and communication technologies are increasingly penetrating various spheres of education. This is facilitated by both external factors related to the general computerization of society and the need for appropriate training of specialists, as well as internal factors related to the spread of modern digital technologies and software in schools, the adoption of governmental and intergovernmental programs for the computerization of education, the emergence of relevant digital experience of a large number of teachers. In most cases, the use of digital tools has a real positive impact on the activation of teachers' work and on the effectiveness of student training [15]. Digital education facing COVID - 19 pandemic). The level of technological comfort, innovativeness affect the effectiveness of using digital products for online learning [12] (Table 1).

A comparative analysis of traditional and distance learning models, which coexist in parallel in the educational process of modern higher education institutions, makes it possible not only to substantiate the feasibility of using computers in the learning process, but also to make an attempt to determine the criteria requirements for the creation of educational software products in order to measure the levels of attention and involvement of students to the educational process.

Thus, training according to the traditional model takes place under the coordination of the teacher, who directs the educational process depending on the specific situation. Within the implementation of the traditional model, learning depends on the teacher's

Table 1. Comparative analysis of traditional and distance learning

Traditional education	Distance Learning
During the evaluation of the student's work, the level of knowledge, skills and abilities is taken into account. But at the same time, there is a significant part of subjectivism	The assessment of the applicant is determined only by the level of knowledge, skills and abilities. Other factors are not taken into account
Visual perception is used much less often than hearing information	The visual channel of information transmission is involved, although a significant share of audio information (audio recordings, videos, etc.) is not excluded
The main information carriers are books, abstracts. Information is presented in a form familiar to humans, easy to read, but poorly structured	The perception of ordinary text information from the screen is much worse than that of printed or handwritten information. Factors compensating for these shortcomings are a clear structure of information, a developed system of references, a reasonable combination of visual and substantive information
During the learning process, the teacher performs a variety of functions: checking the attendance of the class, presenting the material, controlling the quality of learning, establishing interdisciplinary connections	The main workload of the teacher is transferred from the stage of conducting training sessions to the stage of preparing material for filling educational software. The teacher acts as a consultant

personality: the ability to arouse interest in the topic, the ability to conduct a casual conversation. The teacher must have extensive and in-depth knowledge of various fields, skillfully use them during the teaching of the educational component. Usually, an experienced teacher, conducting a classroom lesson, can easily determine the level of attention and involvement of the learner in the material being studied, based on the physiognomy of the listeners (characteristic features and facial expressions of a person). The external manifestation of attention, of course, requires the mobilization of all the senses, but it is most dramatically manifested in the expression of the eyes. It determines the level of emotional adjustment and what is happening in the audience. Attention and concentration are unmistakably defined in a subject whose gaze is fixed, facial muscles tense, eyebrows moved to the bridge of the nose.

At the current stage, the use of the method of visual biological feedback is reflected in traditional models of learning, which involves the transfer of knowledge face to face, and the teacher can visually cover the audience during the lesson. However, during training in the distance model, which involves the relationship of the subjects of the online educational process, it is difficult, and often impossible, for a teacher, even an experienced one, to assess the level of attention and involvement in the perception of the material based on the physiognomy of the listener on the other side of the screen. Therefore, the problem of measuring the attention and involvement of students in the educational process through the use of automated software products is actualized.

In our opinion, educational software products should meet the following requirements:

- have a developed system of help and tips for both the teacher and the student;
- provide maximum informativeness with minimal user fatigue;
- present the material in the form of separate visual modules;
- information must be clearly structured;
- to ensure that the visual presentation of information matches its content.

2.2 Theoretical Review of the Modern Model of Learning and Theories of Cognition

Early attempts to operationalize the concept of "student engagement in learning" were associated with measuring the amount of time a student spends on tasks and learning in general. Emphasis on temporary indicators was largely due to the belief that learning outcomes can be judged by the time spent [6, 11].

In the process of mastering the topic, the concept of the involvement of acquirers began to be supplemented with other characteristics, as a result of which the initial construct became more complicated. For example, scientists began to talk about the fact that student involvement is expressed not only in the time spent, but also in the efforts spent. It also began to be attributed to indicators that relate to learning in an indirect way (for example, funding, pragmatics of learning, extracurricular university activity, loyalty to the university, feeling like a part of the university, etc.) [3].

In some works, the involvement of the students is interpreted as the "energy" that the student invests in his studies. The most famous definition in this sense was proposed by A. Astin: "Student involvement is a combination of physical and mental energy spent to acquire academic experience" [1]. According to the scientist, the concept of "involvement" is related to Z. Freud's concept of "cathexis", which means investing energy in objects that are outside the subject.

The topic of measuring and analyzing student involvement in the educational process has been actively developed since the 1980s - primarily in connection with research into the possibility of reducing the number of students who drop out (surveys show that from 25 to 60% of students are constantly bored in classes and distracted from educational process). The problem of monitoring student engagement is relevant today both for the traditional classroom learning process and for mass open online courses, educational games, simulators and simulators, intelligent learning systems, etc. [18].

The following methods of measuring student involvement are most common: self-assessment of involvement by students themselves; external observation using control cards and subsequent rating; automatic measurement of the level of engagement using technical means. In particular, the research is dominated by the self-assessment method. At the same time, information systems for automatic assessment of involvement have been used for quite some time. A significant part of them is based on the analysis of the speed and accuracy of students' performance of control tasks. For example, indicators of low engagement may be random answers to easy questions or very short task completion times. There are attempts to track student behavior in five states: active, transcribing, absent, distracted, and transitioning to another activity [4]. In the era of intelligent machines that sense, control and monitor human feelings, emotions and feelings, there is

a need to develop automatic mechanisms for measuring student engagement [8]. There is a class of popular techniques for automatic estimation of the level of involvement, based on the processing of data from various electro- and neurophysiological sensors. For example, capturing brain signals to extract features of brain wave signals using an encephalogram while students are engaged [17], while viewing recorded lecture materials [7] or in the process of synchronous online learning using special brain headphones for encephalogram [13]. For the same purpose, a mechanism for monitoring attention and anxiety based on brain wave signals has been developed [2]. However, it is clear that large-scale application of such techniques is impossible.

3 Overview of Modern Tools for Determining the Levels of Student Involvement in the Educational Process

The development of information technologies and today's realities dictate to society new conditions for the organization of not only the educational process, but also generally make corrections in everyday work. It is not surprising that the use of such technologies as Skype, Zoom, Google Meet, WebEx, Microsoft Teams in the organization of various online conferences, hybrid, semi-hybrid events and in the educational process has now become widely popular.

Each of the mentioned software products can definitely be effectively used as a tool for organizing and conducting online events, but they do not provide an opportunity to analyze the degree of involvement and perception of information by users.

Currently, AI technologies are gaining wide popularity in the organization of hybrid and semi-hybrid online events. Since the use of this kind of algorithms makes it possible to analyze the emotional state, the level of perception of information in real time. Currently, quite a few systems have in their arsenal the possibility of automated shorthand, such a functional feature can be effectively applied at proto-level meetings, where, according to internal rules, the event must be accompanied by a shorthand. Such systems (systems with AI elements) include: • Sembly, • Fathom, • Notiv, • Hendrix.

The use of this kind of technology is also relevant in the organization of the educational process in the conditions of distance learning, since it does not allow to visually capture the attention and involvement of students in the educational process. Therefore, there is currently a need to develop unique software tools that will allow evaluating the degree of involvement, perception of information by the audience in the process of training or conducting any type of online event.

Next, we will consider several software tools that partially outline the problem of audience attention analysis.

3.1 EmotionCues

In the article [8], the authors describe a software product that allows assessing the emotional component of students. The approach described in the article makes it possible to evaluate the involvement of not only one specific student or student, but also to analyze the involvement of the entire audience as a whole.

It should be noted that previous research by the authors showed that emotions can be indicators of attention, involvement and behavior of students in general [2–6]. Based on previous research, the software product EmotionCues was developed. It will be useful not only to teachers who analyze the educational process, but also to parents who can analyze the degree of interest of their children in the educational process. The authors of this software product highlight the following system of requirements:

- obtaining the emotional status of all people in the video stream.
- obtaining the emotional status of an individual in a video stream. The possibility of getting to know the emotional status of the chosen person in more detail.
- the ability to create emotional portraits of different people.
- the ability to obtain results with further aggregation for deeper analysis.

Figure 1 shows the main dashboard of the EmotionCues software product.

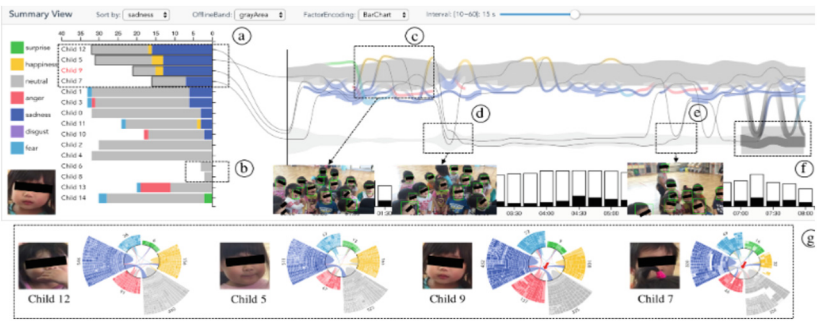

Fig. 1. EmotionCues control panel

At the first stage, a set of videos is processed and emotions are extracted using computer vision algorithms. The next stage is the preparation of interactive visualization, which can support visual analysis of the video at two different levels of detail:

- general analysis of the emotional component of the entire audience.
- analysis of the emotional component of a specifically chosen person.

Using this approach makes it possible to analyze the emotional component of not only one selected participant, but the entire audience in sufficient detail and effectively. With the help of the color system, the control panel of the EmotionCues software tool displays various emotional states of the participants of the online event, namely:

- green is used to show surprise;
- yellow determines the level of happiness;
- gray for a neutral state;
- purple - a state of anger;
- blue represents sadness;
- purple state of disgust;
- blue defines fear.

Thus, the EmotionCues system is a comprehensive solution for analyzing the level of audience engagement using emotional components. Each video is about 10 min long (1.26 GB) with a resolution of 1920 × 1080 and 30 frames per second (FPS). That is, each video for analysis consists of almost 18,000 frames in high resolution.

It is worth noting that the EmotionCues software tool is one of the most powerful tools that allows you to assess the level of audience interest. In addition, it is important to note that this software product provides an opportunity to build an emotional picture and level of interest both for the entire audience and separately for certain selected participants. But EmotionCues does not allow for real-time analysis and cannot yet be integrated with popular services: Webex, Microsoft Teams, Zoom, Vimeo.

3.2 Headroom

Headroom is another software product for remote as well as hybrid meetings. Functionality will help to balance online meetings thanks to the evaluation of the involvement of the team of participants of the online event as a whole. The main task of this software product is to improve communication at online events by replacing routine manual actions with artificial intelligence algorithms.

This software product can be effectively used both at various online events and at hybrid ones. The functionality of Headroom allows it to be used at online events of an educational nature. In addition, Headroom's internal algorithms will allow you to receive a transcript of your online event, participant notes. This kind of functionality is very similar to various minutes of meetings, which according to the rules are accompanied by a transcript.

It should also be noted that this kind of functionality will make it possible to resolve some misunderstandings that may arise in the meeting mode, to raise reasons and problems. The Headroom functionality allows you to recognize emoticons and gestures in real time. After the session is over, each participant of the online event can watch an accelerated version of the online event, which will allow you to assess how the event went, see the level of involvement of each event participant, and assess the balance of the event. Automatic compilation makes it possible to generate a video with the most vivid moments of the meeting.

Also, this system allows you to analyze: • facial expressions; • gestures; • audio accompanying the online event; • text messages accompanying the online event.

As a result of the algorithm, you will receive the aggregated results of the meeting. Also, the Headroom functionality allows you to highlight key information that was presented at the online event. It should also be noted that the information from the results of the analysis of the video stream, the video recording of the online seminar is confidential and protected information. Thus, the Headroom functionality provides the following advantages:

- audience engagement analysis, built-in algorithms for aggregating the obtained results;
- high quality audio and video recordings of the online event;
- group chat;
- this software tool is safe, all information and analysis results are confidential information;

- meeting tools that help you conduct a workshop with elements of inclusion;
- built-in automatic transcription in real time;
- built-in automatic saving of notes for the team;
- built-in gesture recognition;
- searchable meeting knowledge base (video, notes, transcript, etc.)
- custom video summaries of each meeting
- generation of a transcript based on the results of the meeting.

It should be noted that Headroom is optimized for use with Google Chrome. The team is currently working on adding full support for other popular browsers, as well as providing support for the app on mobile devices.

Since the results of the meeting (videos, audio recordings, transcripts, survey results) will be stored in the cloud, all information is confidential and only seminar participants and invited people have access to this information.

The software tool Headroom is a powerful tool for more effective holding of online meetings, seminars and conferences, the level of involvement can be assessed at the level of passing a survey with further processing.

3.3 MeetingPulse

Another representative of this kind of software is MeetingPulse. This software tool is used to hold a virtual or hybrid conference. MeetingPulse has many additional tools that event organizers need for a successful conference—from synchronous polling to sophisticated software to support online event management and delivery. This software can be integrated with the following services: • Webex, • Microsoft Teams, • Zoom, • Vimeo, • Youtube.

It should be noted that for the interaction of third-party services with MeetingPulse, the developers have previously developed an API [9] with quite detailed documentation. MeetingPulse software consists of 12 modules, each module has a certain functionality. During the online seminar, you can create a survey that can be available both immediately and at a certain time. In this way, the presenter/speaker can follow the results of the survey in synchronous mode with the conference. Such tools make it possible to better understand the state of the audience, the extent to which it perceives information.

In addition to the synchronous polling mode, there is also the option to create polls before and after the conference. This kind of survey can be effectively used to assess the residual level of information after the conference.

It should also be noted that the available voting mechanism in conference mode will allow you to shape the agenda in advance, identifying the most popular topics. Poll and voting results can be exported to a CSV file for further processing and representation of the results. During the presentation, participants or listeners can react in real time to what was said, in addition, the speaker can watch the "pulse" of the room, such auxiliary synchronous mechanisms allow the speaker to analyze the state of the audience and its ability to perceive information in real time.

At the beginning or during the online seminar, you can create questionnaires with questions for audience segmentation. This approach will make it possible to more effectively process the received information through clustering. In addition, you should note

the possibility of conducting brainstorming sessions, creating and sending invitations to your planned events.

Thus, it should be noted that MeetingPulse is a comprehensive solution for the effective conduct of online seminars with a fairly large number of tools, which allows you to assess interest in real time using the results of the participants' completion of various survey plans. But it is quite difficult to fully assess the level of audience engagement based on the emotional component using the MeetingPulse software tool.

4 A Software Tool for Analyzing the Degree of Involvement and the Degree of Information Perception

4.1 Requirements for the Software Product

In the course of the literature analysis, we highlight the following register of priority requirements. The main task of our software product is the ability to analyze the state of attention, interest and subsequent perception of information by the audience. Thus, we distinguish the following requirements:

- integration with the main systems for conducting virtual or hybrid conferences: Webex, Microsoft Teams, Zoom, Vimeo;
- the possibility of building an emotional portrait and the level of interest of an individual participant of a virtual conference from the corresponding video stream in real time;
- building an emotional portrait and the level of interest of the virtual conference audience from the corresponding video stream in real time;
- possibility of comparative analysis of received analytical information;
- possibility to cluster information by gender and age;
- creation of appropriate UI for aggregation and representation of relevant analytical information;
- conference participant registration;
- the ability to create surveys:
  - display polls before the start of the video conference,
  - displaying polls synchronously with the conference,
  - display of polls after the conference;
- access to the chat in parallel with the conference;
- export of results of polls and votes in CCV format;
- sending invitations to the relevant online event;
- creation of an interactive board for interaction of participants;
- creation of an appropriate API for further interaction of third-party services.

Each of the components of the register of requirements is an important component of the analysis and provides the teacher with information about the state of preparation and student engagement. For example, the possibility of creating a survey in parallel with the conference is useful at various stages: at the beginning of the lesson, it allows

you to update basic knowledge, identify gaps on a specific topic (which helps the teacher understand the level of preparedness of the audience, make the right emphasis in teaching the material, recommend material for repetition); in the middle of the lesson, the survey helps to maintain attention, to examine the level of perception; the survey at the end of the conference gives an opportunity to assess the remaining level of information, to repeat the main points. In general, the tool for creating surveys allows you to more qualitatively assess how the audience perceives information. The possibility of exporting to CSV format will enable better processing and analysis of the received information. Access to the chat during the conference performs several useful functions: communication (in the chat you can send text messages, various files with tasks, etc.), interaction with the audience, interactivity of the lesson (using the chat for students' answers to the questions, using quick reactions or short answers), feedback function (a student can write a comment or ask a question). The use of the chat allows you to partially check the level of attention during the lesson, as it requires additional actions from the student in accordance with the teacher's task/question (for example, typing a message or putting a mark in the chat).

Using an interactive whiteboard allows you to actively involve students in the lesson and motivate them to study, make the lesson dynamic, interactive and multimedia. The interactive whiteboard in online education is a useful tool for visualization and collaboration in creating and editing documents and images in real time, therefore it also allows analyzing the state of students' attention, their interest and involvement in the educational process.

For now, we would like to emphasize that the requirements described above are the most prioritized and those that significantly affect the ability to analyze the degree of interest and the ability to perceive information. Next, we will consider the system of external signs and visual markers that can be used in the analysis of the corresponding video stream of the virtual conference.

4.2 Characterization and Interpretation of Visual Markers for Measuring Student Attention and Engagement

So, attention is defined as a special form of mental activity, which manifests itself in the orientation and concentration of consciousness on objects significant for the individual, phenomena of the surrounding reality, on one's own experiences [16, p. 71].

The content of mental activity turns out to be quite dynamic, that is, it constantly changes with a relative delay on certain objects or actions. This fascination of a person with something, orientation and concentration is called attention. One of the characteristic features of attention is that a person subjectively feels himself where attention is concentrated. Attention is a deeply personal phenomenon. Behind it are always the subject's needs, motives, goals, and attitudes. A person's attitude towards the world and other people is manifested in emotions, feelings, and desires. This attitude is also reflected in attention. The surrounding reality, the phenomena in it, which correspond to the needs and interests of the subject, determine his attention. A change in the attitude of the subject to the object causes a change in attention. This is expressed in a change in clarity (clarity, expressiveness) of the content on which the subject's consciousness is focused.

From the numerous signals of the environment, a person selects what is necessary for purposeful activity at the moment, depending on this, assigning a certain meaning to each object. In the interaction with the environment, a selective display of objects and phenomena by consciousness is formed, which is provided by attention. Selectivity, which regulates cognitive and productive activity, is determined by the capabilities of the individual, his orientation, the purpose of his activity. Processes of voluntary regulation of activity (will) serve as mechanisms of selective attention.

Attention is not an independent reflection, not an independent mental process, attention does not have its object of knowledge. Attention to monitoring the dynamics of mental processes is a condition for reflective activity at different levels of consciousness [15, p. 247].

Like any mental phenomenon, attention cannot be studied directly, because mental phenomena are subject to direct observation only by the person who experiences them. Mediated markers are used to assess attention, such as non-verbal means of mental activity, namely non-verbal sign systems. Among such systems, the following are distinguished: optical-kinetic, para- and extralinguistic, proxemics, visual contact. Nonverbal systems are a situational reflection of a person's personal characteristics, namely his mood, emotional background, and attitude. Nonverbal manifestations are involuntary and spontaneous (nonverbal markers carry 60–80% of information, respectively, 20–40% is verbal communication).

In terms of research, the optical-kinetic system and visual contact are important. The optical-kinetic system of signs includes gestures, facial expressions, pantomime, which are presented as a property of perceived general motility. Various manifestations of facial expressions, gestures and pantomime signal the subject's emotional state. Visual contact is related to visual perception (eye movement). Visual contact helps to demonstrate attention and interest. Means of non-verbal interaction are natural and unconscious, which can be an argument for the objectivity of the non-verbal mechanism.

The face is the main source of information about a person's condition. The act of looking is a signal of interest, therefore, the most accurate information is conveyed by a person's gaze, since the expansion or contraction of the pupils is not controlled by a person. When a person is interested, his pupils are dilated (by 4 times), when negative emotions predominate, the pupils narrow (we are talking about expressed emotional states).

Based on the analysis of the literature on the researched problem, it was determined that external signs of attention include:

- a fixed, interested look (every 10 s);
- steady gaze in the direction of the speaker;
- looking into the speaker's eyes (a sign of respect, readiness for contact);
- facial muscle tension (optional);
- slightly shifted eyebrows to the bridge of the nose; • slightly squinted eyes;
- eyes are dilated, seem larger than usual;
- vertical wrinkles on the forehead (concentration); • head tilted to the side;
- nodding the head (an act of approval); • slightly squinted eyes;
- touching the chin; • the hand touches the cheek;
- the index finger is vertical to the temple, the thumb supports the chin (critical evaluation attitude);

- rubbing the bridge of the nose, manipulating glasses (concentration);
- slightly raised eyebrows, wide-open eyes (surprise); • the body is bent forward;

We draw your attention to the fact that all visual signs are arranged in order from the most significant to additional, auxiliary ones.

The opposite concept of attention, which negatively affects the student's involvement in the educational process and the quality of material perception, is inattention, which is manifested by the following visual indicators:

- rubbing the cheek with the hand (it became boring);
- wandering gaze; • looking to the side; • head rubbing;
- touching the ear (not interesting to listen to);
- supporting the chin with the palm of the hand (uninteresting, fighting the desire to fall asleep);
- lowers eyelids or takes off glasses (gets fed up when it's over);
- tapping with a finger or pen (uninteresting);
- plays with objects with fingers (careless); • supporting the cheek with the hand;
- covering the mouth with the palm of the hand;
- hands crossed on the chest (indifference);
- the body is thrown back (not interesting); • looking at the clock;

Taking into account the priority and place in the hierarchy of visual indicators, as well as the degree of complexity of their implementation in software, at this stage of the research we selected the following main visual markers of attention and involvement of students in the educational process as a basis for the development of the software product: a fixed, interested look (every 10 s), steady gaze in the direction of the speaker; eyebrows slightly shifted to the bridge of the nose; facial muscle tension (optional); head tilted to the side; nodding the head (an act of approval).

Among the visual signs of inattention, the following indicators were chosen within the scope of the study: wandering gaze; look away; covering the mouth with the palm of the hand.

4.3 Use of Machine Learning Technology

The main driving force behind video stream analysis is the use of machine learning methods and algorithms. We distinguish two main parts:

- algorithms that identify formalized visual markers from a video stream.
- algorithms that determine the level of interest of the audience and the degree of perception of information.

It can be represented schematically as follows (Fig. 2).

The use of machine learning methods will make it possible to automatically analyze and identify the visual and behavioral markers described above from the video stream. The specified visual markers must be formalized in a certain way, convenient for use and further processing by ML algorithms. With the help of built-in algorithms, the machine learning system can distinguish certain visual factors that, in our opinion, can help analyze the level of interest, as well as the degree of perception of information.

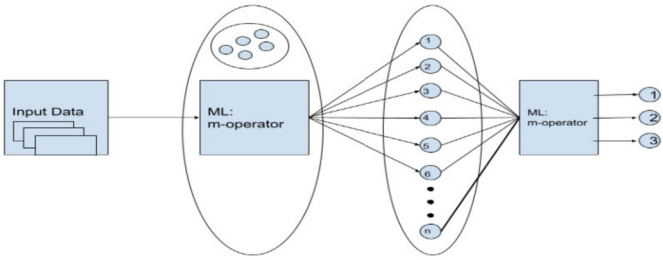

Fig. 2. Scheme of the use of ML technology in the video stream analysis system of the conference

The next step is the need to aggregate and calculate the degree of attention. This task can also be solved using machine learning methods. After extracting visual markers from the video stream, we evaluate them as indicators of the degree of interest for each specific participant. Based on the collected information, we have the opportunity to aggregate, cluster the received information and build an emotional portrait of the entire audience.

Thus, thanks to machine learning methods, we solve two main problems:

- automated selection of visual factors from the video stream.
- analysis of the influence of the received factors on the attention of the conference participants
- aggregation and further interpretation of further results.

More specifics and details of the use of machine learning methods will be described in our next scientific studies.

5 Conclusions

We reviewed the main AI-based tools that allow you to assess the audience's attention level in real time during online conferences. Among them, EmotionCues, HEADROOM and MeetingPulse. These tools allow you to analyze the emotional component of the audience in sufficient detail and effectively, but not all of them can be integrated with popular online conference services, such as Microsoft Teams or Zoom, and they also do not allow you to analyze the video stream in real time. That is why there is a need to develop a specialized software product that will allow to fully assess the level of audience engagement based on the emotional component, and can also be integrated with services for conducting online meetings.

We identified the main requirements for the software product, described the visual markers for measuring students' attention and engagement. Also, we came to the conclusion that the main technology for the development of this product is the methods and algorithms of machine learning.

References

1. Astin, A.: Student involvement: a developmental theory for higher education. J. Coll. Stud. Pers. **25**(4), 297–308 (1984)

2. Chen, C., Wang, J.: Effects of online synchronous instruction with an attention monitoring and alarm mechanism on sustained attention and learning performance. Interact. Learn. Environ. **26**(4), 427–443 (2018). https://doi.org/10.1080/10494820.2017.1341938
3. Coates, H.: Student Engagement in Campus Based and Online Education: University Connections. Taylor and Francis, London (2006)
4. Dinesh, D., Athi Narayanan, S., Bijlani, K.: Student analytics for productive teaching/learning. Paper Presented at the Proceedings - 2016 International Conference on Information Science, ICIS 2016, pp. 97–102 (2017). https://doi.org/10.1109/INFOSCI.2016.7845308
5. Features of generation Z. https://buki.com.ua/news/pokolinnya-z/. Accessed 15 Dec 2022
6. Fredrick, W.C., Walberg, H.J.: Learning as a function of time. J. Educ. Res. **73**(4), 183–194 (1980)
7. Gao, Q., Tan, Y.: Impact of different styles of online course videos on students' attention during the COVID-19 pandemic. Front. Public Health **10** (2022). https://doi.org/10.3389/fpubh.2022.858780
8. Ho, M., Mantello, P., Ghotbi, N., Nguyen, M., Nguyen, H., Vuong, Q.: Rethinking technological acceptance in the age of emotional AI: Surveying gen Z (zoomer) attitudes toward non-conscious data collection. Technol. Soc. **70** (2022). https://doi.org/10.1016/j.techsoc.2022.102011
9. Howe, N.: How the Millennial generation is transforming employee benefits. Benefits Q. **30**(2), 8–14 (2014)
10. Kurmanova, A., Kozhayeva, S., Ayupova, G., Aurenova, M., Baizhumanova, B., Aubakirova, Z.: University students' relationship with technology: psychological effects on students. World J. Educ. Technol. Curr. Issues **14**(4), 1225–1233 (2022). https://doi.org/10.18844/wjet.v14i4.7743
11. McIntyre, D.J., Copenhaver, R.W., Byrd, D.M., Norris, W.R.: A study of engaged student behaviour within classroom activities during mathematics class. J. Educ. Res. **77**(1), 55–59 (1983)
12. Negm, E.: Intention to use internet of things (IoT) in higher education online learning – the effect of technology readiness. High. Educ. Skills Work-Based Learn. (2022). https://doi.org/10.1108/HESWBL-05-2022-0121
13. Peng, S., Chen, L., Gao, C., Tong, R.J.: Predicting students' attention level with interpretable facial and head dynamic features in an online tutoring system. Paper Presented at the AAAI 2020 - 34th AAAI Conference on Artificial Intelligence, pp. 13895–13896 (2020)
14. Pobegaylov, O.: Digital education facing COVID - 19 pandemic: technological university experience. Paper Presented at the E3S Web of Conferences, p. 273 (2021). https://doi.org/10.1051/e3sconf/202127308090 (2021)
15. Psychology: Textbook, Edited by Trofimov, Y. 4th edn., 560 p., Stereotype. Kyiv, Lybid (2003)
16. Serdyuk, L.: Psychology: study guide. For distance learning, 233 p. "Ukraine" University, Kyiv (2005)
17. Shaw, R., Patra, B.K., Pradhan, A., Mishra, S.P. Attention classification and lecture video recommendation based on captured EEG signal in flipped learning pedagogy. Int. J. Hum.-Comput. Interact. (2022). https://doi.org/10.1080/10447318.2022.2091561
18. Solovyov, V., Kuklina, D., Slavgorodskyi, A., Pukhov, I., Tytko, M. Monitoring student involvement in the educational process. https://www.osp.ru/os/2018/2/13054177. Accessed 14 Oct 2022
19. Strauss, W., Howe, N.: Generations: the history of America's future, 1584 to 2069. Harper Perennial, 538 p. (1991). https://archive.org/details/GenerationsTheHistoryOfAmericasFuture1584To2069ByWilliamStraussNeilHowe/page/n3/mode/2up