Психологическая наука и образование
2025. *30*(6), 105–116.
https://doi.org/10.17759/pse.2025300606
ISSN: 1814-2052
ISSN: 2311-7273 (online)

Psychological Science and Education
2025. *30*(6), 105–116.
https://doi.org/10.17759/pse.2025300606
ISSN: 1814-2052
ISSN: 2311-7273 (online)

Научная статья | Original paper

The impact of using different types of learning materials on the characteristics of learning activity: a review of current research

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Abstract
Context and relevance. Student engagement is a key factor in successful knowledge acquisition and in improving the quality of the educational process. With the growth of digitalization in education and the implementation of multimedia and interactive technologies, there is a need to systematically study the influence of different types of learning materials on learners' engagement and cognitive activity. **Objective.** The aim is to determine the nature of the relationship between engagement and the types of learning materials (multimedia, interactive, and traditional), as well as to identify the factors that influence the effectiveness of their use. **Methods and materials.** An analytical review of contemporary domestic and international studies was conducted, including experimental, cross-cultural, and psychophysiological research. Various formats of learning materials and methods for assessing engagement were considered, including self-reports, questionnaires, and psychophysiological indicators (EEG, ECG). **Results.** The analysis showed that multimedia materials contribute to increased cognitive and emotional engagement through visual and auditory stimuli, while interactive technologies strengthen students' active participation and improve academic performance. Embodied and body-oriented technologies reduce cognitive load and promote deeper assimilation of the material. The effectiveness of learning materials depends on their design, content, individual learner characteristics, and the conditions of their use. **Conclusion.** The choice of instructional formats and modes of presenting information should be oriented toward learners' age, level of preparation, and perceptual characteristics. The implementation of multimedia, interactive, and embodied technologies can significantly improve the quality of learning and student engagement; however, further research is needed to determine the most effective combinations and conditions for their use.

Keywords: student engagement, learning materials, multimedia, interactive learning, cognitive load, embodied cognition, VR/AR technologies, psychophysiological assessment methods

For citation: Ageev, N.Ya., Dokuchaev, D.A., Dubovik, I.A., Marchenko, O.P. (2025). The impact of using different types of learning materials on the characteristics of learning activity: a review of current research. *Psychological Science and Education, 30*(6)*,* 105–116. (In Russ.). https://doi.org/10.17759/pse.2025300606

Ageev N.Ya., Dokuchaev D.A.,
Dubovik I.A., Marchenko O.P. (2025)
Psychological Science and Education,
30(6), 105–116.

Влияние использования различных типов учебных материалов на характеристики учебной деятельности: обзор современных исследований

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Резюме

Контекст и актуальность. Вовлеченность учащихся является ключевым фактором успешного усвоения знаний и повышения качества образовательного процесса. С ростом цифровизации образования и внедрением мультимедийных и интерактивных технологий возникает необходимость систематически изучать влияние различных типов учебных материалов на вовлеченность и когнитивную активность обучающихся. **Цель.** Определить характер взаимосвязи между вовлеченностью и типами учебных материалов (мультимедийные, интерактивные и традиционные), а также выявить факторы, определяющие эффективность их применения. **Методы и материалы.** Проведен аналитический обзор современных отечественных и зарубежных исследований, включающих экспериментальные, кросс-культурные и психофизиологические работы. Рассмотрены различные форматы учебных материалов и методы оценки вовлеченности, включая самоотчеты, анкеты и психофизиологические показатели (ЭЭГ, ЭКГ). **Результаты.** Анализ показал, что мультимедийные материалы способствуют повышению когнитивной и эмоциональной вовлеченности за счет визуальных и аудиальных стимулов, а интерактивные технологии усиливают активное участие студентов, повышая академическую успеваемость. Воплощенные и телесно ориентированные технологии снижают когнитивную нагрузку и способствуют более глубокому усвоению материала. Эффективность учебных материалов зависит от дизайна, содержания, индивидуальных особенностей учащихся и условий применения. **Выводы.** Выбор форматов обучения и способов подачи информации требует ориентировки на возраст, уровень подготовки и особенности восприятия обучающихся. Внедрение мультимедийных, интерактивных и воплощенных технологий способно значительно повысить качество обучения и вовлеченность обучающихся, однако требуется дальнейшее исследование для определения наиболее эффективных комбинаций и условий их применения.

Ключевые слова: вовлеченность обучающихся, учебные материалы, мультимедиа, интерактивное обучение, когнитивная нагрузка, воплощенное познание, VR/AR технологии, психофизиологические методы оценки

Для цитирования: Агеев, Н.Я., Докучаев, Д.А., Дубовик, И.А., Марченко, О.П. (2025). Влияние использования различных типов учебных материалов на характеристики учебной деятельности: обзор современных исследований. *Психологическая наука и образование, 30*(6)*,* 105–116. https://doi.org/10.17759/pse.2025300606

Introduction

One of the main challenges in education is a decline in students' interest in learning. Researchers note that due to widespread digitalization — especially the use of social networks — there is a shift from conceptual to fragmented ('clip') thinking (Bigakov et al., 2016; Girenok, 2018). Similar changes in the thinking process affect cognitive functions, including students' ability to identify causal relationships, understand textual content, interpret it, and integrate visual and verbal information. Accordingly, if the thinking process itself changes, so do the requirements for teaching materials. In this context, it is therefore important to examine different types of educational materials, as well as their relationship with the engagement of students in the educational process.

Engagement is described as a complex multidimensional construct that refers to different aspects of the educational experience (attendance, homework, school sense of belonging, etc.) and encompasses different time horizons of the learning experience (short-term affective episodes, stable dispositions, perceptions of the consequences of their decisions in the context of the educational process, etc.) (D'Mello, Dieterle, Duckworth, 2017). Such a broad definition remains poorly operationalized and conceptually ambiguous, which motivates researchers to study specific aspects of this construct (Eccles, Wang, 2012; D'Mello, Dieterle, Duckworth, 2017). Three dimensions of engagement are commonly distinguished: behavioral (external manifestations of engagement); emotional (positive and negative emotions arising in learning situations); and cognitive (orientation to a deeper understanding of the material, preference for complexity and use of self-regulation strategies) (Fredricks et al., 2004). A number of studies also distinguish psychological engagement (sense of belonging, relationships with teachers and peers, etc.), and note the relative underrepresentation of the cognitive dimension in prior research of engagement (Bondarenko, Ishmuratova, Ziganov, 2020).

Modern digital technologies are increasingly integrated into the education system and are transforming it. Research suggests that the availability of digital resources in learning per se is associated with higher engagement (Abdulganie et al., 2025). Thus, the integration of educational technologies and artificial intelligence (AI) has led to the possibility of creating adaptive educational platforms whose effectiveness in increasing engagement and improving educational outcomes (including through personalization of the process) has been demonstrated in studies (Ouyang, 2025). A recent study of active use of AI by students found that this practice leads to increased engagement at the beginning of a program, but engagement indicators decline over time (Bognar, Khine, 2025), which highlights the importance of studying process dynamics.

Self-reports remain the main method of assessing engagement. Among them, the most common is the the Multidimensional School Engagement Scale, which assesses emotional, cognitive and behavioral aspects (Wang et al., 2019) and adapted in a Russian sample (Fomina, Morosanova, 2020). Despite the ability of self-reports to capture 'invisible' aspects of engagement, they do not allow researchers to capture its dynamic nature (Kassab et al., 2023). The dynamics of engagement are manifested both in changes in motivation and interest during training, as well as in situational fluctuations depending on the type of teaching material used. Teaching materials are typically classified in the literature as follows:

1) By presentation format of the material (text, audio, presentations and video);

2) By modality of interaction used in learning (multimedia, interactive and traditional).

Few studies focus exclusively on the presentation format of educational material, because educational practice typically combines different types of materials. Research focuses on materials depending on media used (Muir et al., 2022). Multimedia materials are digital resources delivered via devices or software that combine text, graphics, animation, audio and video information (Blinova, 2017). Interactive materials provide active participation of the students, allowing them to choose actions, interact with content and receive feedback, which makes the learning process more dynamic (Kulikova et al., 2023). Traditional materials include printed and text-based resources, such as textbooks, lectures, teaching aids, workbooks and other forms that primarily support one-way transmission of information (Shedina, Teresina, 2022).

Given the dynamic nature of engagement, continuous, unobtrusive methods for monitoring engagement and cognitive load in the educational and work environment acquire special importance. This supports the development of more precise and effective methods of human interaction with technology and helps optimize the design of safe, motivating and productive learning environments. Engagement can be assessed using psychophysiological indicators, including EEG and ECG. Key EEG metrics include: power spectrum, signal mapping, alpha/theta, beta/theta, alpha/delta ratios (Ronca, Brambati, 2024; Apicella, Arpaia, 2022; Rai et al., 2025). Using ECG, fatigue can be estimated using stress indices, indices of regulatory strain, and sympathoadrenal tone (Lischke et al., 2021; Speer, Naumovski, McKune, 2024).

This review aims to systematize and analyze scientific works on the relationship between engagement and the type of educational material (multimedia, interactive and traditional), as well as to identify the main factors that influence their relationship. Overall, studies suggest that multimedia and interactive learning materials are often associated with higher engagement in learning activities than traditional learning materials. However, the strength and direction of this association vary depending on the specific type of training material.

Engagement when using multimedia learning materials

The use of multimedia is now seen as an integral part of knowledge transfer in the educational environment (Sarowardy, Halder, 2019). Multimedia refers to the use of multiple modes of presentation of information: textual (including alphanumeric), symbolic, graphic, photographic, audio and video format, including animation. When combined with digital technologies, multimedia can facilitate understanding and improve retention of the teaching material (Guan et al., 2018). The inclusion of static and dynamic visual components enhances the teacher’s oral explanations, making communication more illustrative and understandable (Alemdag, Cagiltay, 2018).

One of the most popular forms of multimedia presentation is a video lecture. Al Husseini (2024) found that students who watched video lectures exhibited a higher level of engagement than respondents who used text materials. In particular, students working with video lectures spent, on average, 30 minutes longer on assignments and interacted more actively (AL Hussaini, 2024).

Another study showed that multimedia lectures, which applied the principles of embodiment (including video presentations with a teacher on the screen), segmentation (dividing lectures into short fragments with the ability to control the pace) and signaling (highlighting key material on the screen), contributed to the growth of all forms of engagement. In particular, there was an increase in the average viewing time, the number of completed questionnaires and the number of test attempts (Gopal, Singh, Aggarwal, 2022).

A study by Shen and Pritchard (2022) examined the effect of visual cues on cognitive engagement in educational videos. The authors identified four modes of engagement: passive, active, constructive, and interactive, grouping them into shallow and deep engagement. The results showed that visual and textual cues enhance both levels of engagement, while color contrast has no effect. Visual complexity, on the other hand, only increased deep cognitive engagement.

Of particular interest are studies comparing different types of multimedia educational materials. Reed et al. (2021) compared animations and static presentations. The results showed that animations support better learning by students of non-majors and a higher level of engagement among all participants. This was especially evident among students with training in the field of neuroscience, for whom clarity and accessibility made the materials more attractive. In general, animated materials proved to be more effective than static ones both in terms of understanding and engagement.

As noted above, self-reports and questionnaires remain the main methods of studying engagement, but psychophysiological approaches are of increasing interest. A study by Italian researchers (Ronca et al., 2025) used a neurophysiological method to evaluate educational content and its impact on cognitive processes. The subjects were presented with three types of materials — an educational video, an academic video, and an encyclopedic text, while EEG, GSR, and PPG were recorded. The use of video materials, especially with visual effects, was associated with higher engagement and lower cognitive load compared to text-based materials, while reading was accompanied by increased cognitive load and decreased attention. Correlation analyses supported an association between neurophysiological indicators and students' self-assessments.

The researchers note that, despite digitalization, the use of such educational materials remains limited due to a lack of technical equipment. In a study by E. Nsabayezu and colleagues (Nsabayezu et al., 2025), the effect of the flipped classroom with multimedia support (MSFCA) method on student engagement in studying organic chemistry in secondary schools in Rwanda was studied. The results showed that MSFCA increases engagement and motivation, but rural students reported lower levels of engagement due to limited Internet access and a lack of computers. This result highlights that the lack of infrastructure in rural schools significantly reduces the opportunities for effective student engagement.

The analysis shows that multimedia educational materials have a significant impact on the level of student engagement, creating conditions for a more active perception and assimilation of information. Compared to traditional text materials, multimedia resources demonstrate higher efficiency both in stimulating students' interest and in improving the quality of understanding the educational content. A special place is occupied by animated multimedia materials, which surpass their static counterparts both in terms of cognitive assimilation, as well as in terms of emotional and behavioral engagement.

Engagement when working with interactive learning materials

Interactive materials are educational resources that involve the student's active participation in the learning process, providing opportunities for choice, interaction, and feedback (Kulikova et al., 2023). Although a substantial body of research of interactive materials and their impact on engagement exist, the topic is becoming increasingly relevant. This reflects the growing diversity of interactive methods with the development of technology, for example: in recent years, VR/AR environments and artificial intelligence have been actively used for training. Interactive materials can be implemented in various formats, including quests, role-playing games, case-based learning, gamification of content, immersive technologies and other approaches (Yakovleva, Yakovlev, 2014).

Most studies suggest that such a learning format increases engagement and the effectiveness of learning (for example, Balalle, 2024). However, individual techniques may have different effectiveness, depending on the material and the psychological characteristics of the students who perceive this material (Kos, Kanadli, 2025). In one study, two groups of medical students alternated between computer simulation and virtual reality simulation (Walls et al., 2024). Engagement in this study was assessed by physiological parameters: heart rate and eye movements. The researchers noted significantly higher levels of student engagement in virtual reality simulations, regardless of the content of the simulation itself.

In a study by Natalizio et al. (2024), a new approach to monitoring engagement through brain–computer interfaces is proposed. The models of intra-subject classification distinguished the states of engagement and rest with an accuracy of about 90%. The level of engagement was higher when watching the commercial compared to the horizontal video and when playing Tetris at medium and high speeds. A correlation was noted between subjective and EEG indicators: with high engagement, the power of the theta rhythm increased and activity in the alpha range decreased. The study supports the reliability of the EEG for detecting engagement in real time and the dependence of its level on the characteristics of the task and the type of stimuli.

Haerawan et al. (2024) compared traditional video lectures and video lectures with interactive elements. Students with access to interactive features had higher engagement and final grades. The most effective elements were quizzes, interactive diagrams, models and scenarios with development options. The authors report a positive association between the use of interactive elements and academic success. Similar results were obtained in a study (Xu et al., 2023): interactive elements significantly increased student engagement and academic performance. Working with an interactive whiteboard, participating in discussions, and taking notes together nearly doubled learning gains compared to a traditional lecture.

Researchers have also examined the problem of engagement using robot assistants. If children initially experience positive emotions when using robotic toys in learning, then later interest fades, which is a problem that is solved by using multiple robot agents simultaneously (Oertel et al, 2020).

In order to increase the effectiveness of training, it is also possible to include the student's movements in the work with the educational material. This approach is based on the theory of embodied cognition, according to which cognitive processes are closely related to human sensorimotor experience (Barsalou, 2008). Research shows the positive effect of using motor experience in learning foreign languages, mathematics, and other disciplines, especially when gestures are associated with the concepts being studied, repeated by students, and such practice used for a long time (Macedonia, 2019). Reducing cognitive load can be achieved by expanding the boundaries of the body and offloading some operations to digital systems. This process involves the student's bodily experience and reduces the cognitive load. Despite the popularity of the theory of embodied cognition, few comparative studies of embodied and traditional learning using digital technologies exist. Most studies focus on describing technologies without analyzing their effectiveness in comparison with traditional learning. A systematic review reported no statistically significant differences between the approaches (Ale et al., 2022), which may be due to the chosen metrics and the short-term nature of the experiments.

It has been shown that the reliance of cognitive processes on motor experience may differ in different age periods, which must be taken into account when developing digital learning materials for children and adolescents of different ages. For example, a study where images and depicted gestures were used to teach foreign words (with students required to repeat the gestures), showed that children aged 11–12 learned words equally well in both conditions — using visual stimuli and using gestures — whereas the 13–14-year-old group showed the greatest effect when gestures were used rather than visual stimuli. This pattern is consistent with results obtained in adults (Mathias et al., 2022).

The analysis shows that interactive teaching methods have a positive effect the engagement and academic performance. Most studies note that the use of VR/AR, gamification, and collaborative tools enhances students' attention and interest, although effectiveness depends on the presentation format and the characteristics of the students. In general, the experiments demonstrate an increase in engagement in the use of interactive elements, which makes them a promising area for the development of educational practices. The integration of digital technologies also expands the possibilities of adapting educational materials to the individual needs of students, emphasizing the need for further research on the optimal forms and conditions for the use of interactive approaches.

Discussion

The analysis of the presented studies indicates the significant impact of the format of educational materials on the level of student engagement. Overall, the literature converges on the view that the use of multimedia, interactive and embodied technologies tend to enhance the cognitive, emotional and behavioral activity of students. In particular, formats such as animations and video lectures with visual elements contribute to a better understanding of the educational material and increase the time spent interacting with it. Interactive methods, including virtual and augmented reality, case learning and gamification, contribute to the growth of educational motivation and academic success, which is confirmed by both students' self-assessments and data from psychophysiological research. One of the key trends identified in the analysis is the importance of individual differences and the learning context. Thus, students without specialized training may benefit more from multimedia animations, while students with relevant experience learn the material better when combining visual and interactive components. Age also plays an important role: for students aged 11–12 and 13–14, physical interaction with educational materials has a different impact, which underlines the need for age-related adaptation of digital educational resources. The results of a large number of studies indicate that video content and interactive environments contribute to preventing cognitive overload and maintaining concentration compared to traditional text materials.

Additionally, psychophysiological methods such as EEG and ECG enable real-time tracking of engagement and cognitive load. Many studies examine engagement in the learning process using hardware methods (EEG, ECG, etc.). EEG-based engagement indices typically rely on the analysis of brain rhythms, spectral characteristics of the EEG and the topography of activity. These markers allow researchers to assess the degree of attention, cognitive load and activation, which reflects the student's engagement. EEG markers allow an objective assessment of attention and engagement, especially in real time (for example, in adaptive learning). An analysis of the functional relationship between brain regions is also used. Thus, the high coherence between the frontal and parietal areas in the performance of tasks indicates coordinated brain activity, characteristic of engagement. Fatigue (its level and dynamics) is measured on the basis of ECG indicators, such as stress and indices of regulatory strain, the sympathoadrenal tone index. Changes in HRV parameters during fatigue make it possible to objectively assess the functional state of the body and autonomic homeostasis. A decrease in indicators reflecting parasympathetic activity may serve as an early marker of fatigue onset. In this regard, HRV monitoring can be a useful tool in the prevention of overexertion and overload.

Conclusions

The review shows that the use of various types of educational materials (multimedia, interactive and traditional) has a significant impact on student engagement and the effectiveness of learning. Although some studies report no statistically significant differences between interactive and traditional teaching methods, the general trend suggests an increase in engagement and academic success when using modern digital technologies, including VR/AR, animated materials and gamified approaches. Thus, the integration of multimedia and interactive elements into the educational process, as well as the use of AI-based technologies, offers opportunities to personalize learning, increase engagement, and improve educational effectiveness. The results of the analysis emphasize the need for further research to determine the optimal forms, conditions and combinations of various types of educational materials, depending on the age and cognitive characteristics of students.

Objective methods for assessing academic engagement are developing in several directions. Biometric and physiological methods include heart rate monitoring, electroencephalography, galvanic skin reaction, and pupillary activity tracking, which reflect the level of attention and emotional state. Behavioral methods include tracking eye movements, analyzing interactions with learning platforms, and video analysis of facial expressions and speech to assess motivation and fatigue. Big data analytics and artificial intelligence methods make it possible to identify patterns of engagement and classify students by activity level. In addition, sensor technologies and wearable devices such as fitness bracelets and VR/AR environments are being used to monitor physical activity and interaction, which contributes to a more accurate assessment of engagement.

Overall, the choice of teaching formats and modes of information presentation should be guided by the students’ age, level of training and perceptional characteristics. The introduction of multimedia, interactive, and embodied technologies can significantly improve the quality of learning and student engagement, but further research is needed to determine the most effective combinations and conditions for their use.

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Contribution of the authors

The authors' contribution is equal. All authors participated in the discussion of the results and approved the final text of the manuscript.

Вклад авторов

Вклад авторов равноценный. Все авторы приняли участие в обсуждении результатов и согласовали окончательный текст рукописи.

Conflict of interest

The authors declare no conflict of interest.

Конфликт интересов

Авторы заявляют об отсутствии конфликта интересов.

Поступила в редакцию 12.09.2025 Received 2025.09.12
Поступила после рецензирования 28.10.2025 Revised 2025.10.28
Принята к публикации 05.12.2025 Accepted 2025.12.05
Опубликована 24.12.2025 Published 2025.12.24