Original Article
IRISTI 14.01.11 10.51889/2960-1649.2025.64.3.003

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Opportunities and Challenges of Developing Self-Learning Through Artificial Intelligence and Virtual Reality

Abstract

Introduction. Background of this research has brought artificial intelligence and virtual reality to the forefront of education. *Methodology and Methods* focus on theoretical integration of these technologies into self-learning, which has a profound impact on educational practices, providing personalised, adaptive, and contextualised learning experiences. However, there is a gap in understanding how these technologies relate to the development of self-learning skills. Our study examines the transformative potential of artificial intelligence and virtual reality in self-learning by investigating its impact on learner engagement, retention, and independence. A research purpose is to evaluate the effectiveness of these technologies. *Results* demonstrate significant intrinsic motivation as self-managed and self-organised skills. The consistency illustrates the potential of artificial intelligence and virtual reality to improve student self-control and motivation. However, there are still some challenges that hinder the use of these technologies in education. *Scientific novelty* addresses issues including cyber sickness, technical demands, ethical concerns related to data privacy, and algorithmic bias. *Practical significance* is that by overcoming these challenges, artificial intelligence and virtual reality, through interdisciplinary collaboration, can become a key factor in the democratisation of education, ensuring access to quality education for diverse populations.

Keywords: artificial intelligence, virtual reality, education, students, motivation.

Introduction. Nowadays, with the generations of new learners, the landscape of education and professional development continues to evolve into something transformative. The traditional educational approaches face challenges in meeting the diverse needs of learners. Self-directed learning (SDL) refers to the method in which students study independently to complete their learning objectives, establish goals, implement, and evaluate their learning outcomes (Knowles, 1975). With SDL, students can take control of their learning by making decisions for themselves about what they need to learn, their goals, the materials they require, how they will learn, and what they will learn.

Gurr and Drysdale (2020) state that Methodist Ladies' College (MLC) was a leading school in using digital technologies in the learning process. David Loader, a principal of MLC, is a pioneering Australian educator best known for his groundbreaking role in creating the world's first laptop classroom in the 1990s. (https://collections.museumsvictoria.com.au/articles/17840). Loader (2019) highlights that teachers not only address the academic tasks for students, but they should also understand the problems students face during the learning and teaching process. Artificial Intelligence (AI) and virtual reality (VR) might bring significant changes to education. Young people should be prepared for the demands of society, and teachers should equip them with the skills required by modern society. Gurr and Drysdale (2020, p. 25) described David Loader as a strategic leader in

the education domain; D. Loader said to adopt 1:1 computing, a process which includes four stumbling blocks, such as computers fulfilling the school educational philosophy, development to use laptops in the classroom, philosophy of personal computing, change from teaching settings to learning organization. Although David Loader did not explicitly focus on AI and VR, his insights are highly relevant to leading school communities through technology-driven change. Furthermore, Gurr & Drysdale (2020) do not directly examine AI and VR in education. Still, they demonstrate that leadership in such challenging times depends on fundamental purpose, adaptability, collaboration, and continuous learning – abilities that include awareness and preparation for the successful integration of AI and VR.

While VR-based self-directed learning holds immense potential for revolutionizing self-directed learning (SDL), offering learners unprecedented control, personalization, and immersive experiences (Buzio et al., 2017), AI-based SDL is increasingly recognized as a foundation for lifelong learning, especially in the context of rapid technological advances and rapidly changing modern societies. SDL is deeply rooted in various educational theories, emphasizing learner autonomy. Ten Cate et al. (2011) explored how intrinsic motivation influences SDL. This theory posits that when learners feel autonomous and competent, they are more likely to engage in self-directed learning activities. Similarly, Hu (2019) discusses the implications of SDL for competency-based medical education, emphasizing the need for students to take responsibility for their learning journeys. The integration of cognitive load theory further explains the challenges learners face in balancing intrinsic and extrinsic motivational factors when managing their learning experiences. This study synthesizes key research findings on SDL, discusses its underlying theories, and examines how AI and VR are changing traditional models of self-directed learning.

Materials and Methods. This study used a literature review approach based on theories of self-organization, self-learning, and the integration of information technology in education. Research sources were systematically reviewed from major databases (Scopus, Web of Science, ERIC, Google Scholar), focusing on work on digital technologies conducted over the past two decades. The analysis used thematic synthesis, grouping studies into a theoretical framework, and identifying recurring themes to explain the impact of digital technologies on self-learning (Figure 1).

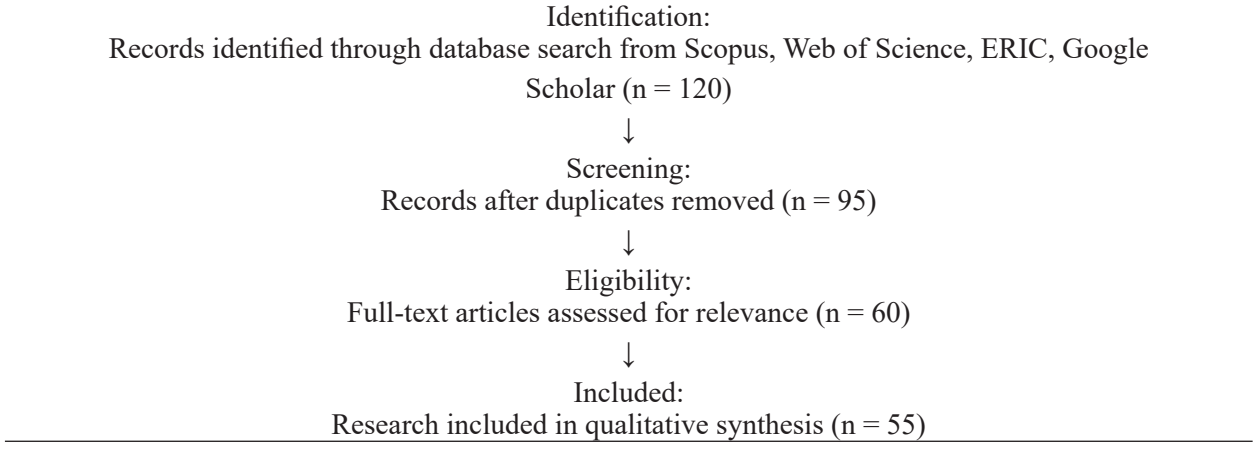

Figure 1: PRISMA Flow

Authors of this study are based on the following theoretical foundation:

- theory of self-organisation and self-development (D. Gurr, L. Drysdale, ten Cate, R.A. Kusurkar, G.C. Williams, P.L. Nesbit, D.V. Day, J.W. Fleenor, L.E. R.E. Atwater, Sturm, R.A. McKee, A. E. Gottfried, A.W. Gottfried, R.J. Reichard, D.W. Guerin, P.H, Oliver, R.E. Riggio, I.E. Ditkovskaya, A.I. Kalinina, T.E. Kirikovich, etc.);

- modern theory of self-education (R.G. Brockett, R. Hiemstra, D.R. Garrison, M.S. Knowles, G. Grow, A. Silamut, S. Petsangsri, P.W. Richardson, H.M.G. Watt, N. Selwyn, V. Curran, D.L. Gustafson, K. Simmons, H. Lannon, Ch. Wang, M. Garmsiri etc.);

- conceptual provisions of the theory of development of self-education skills (D. Urhahne, L. Wijnia, I.F. Medvedev, D.M. Puzyrevsky, N.A. Nozdrina, M. Alizadeh, N. Cowie, A. Bandura, P.C. Candy, P. Strousopoulos, C. Troussas, G. Makransky, G.B. Petersen, B.J. Zimmerman, etc.);

- Theory of implementation of information technologies in the educational process (D. Loader, W. Hu, Z.-J. Liu, N. Tretyakova, V. Fedorov, M. Kharakhordina, S. Vert, D. Andone, A. Marougkas, C. Troussas, A. Krouska, C. Sgouropoulou, C. Hua, J. Wang, etc.);

- Theory and methodology of informatisation of educational activities and designing and implementing electronic teaching aids (H. Luan, P. Géczy, H. Lai, J. Gobert, Stephen J.H. Yang, H. Ogata, J. Baltes, R. Guerra, Ping Li, Chin-Chung Tsai, I.E. Ditkovskaya, St. Duggan, J. Hawkins, A.A. Trifonov, etc.).

To evaluate the effectiveness of these technologies, the method of theoretical analysis of existing studies of the problem was used, allowing for a comprehensive understanding of the multifaceted impact of digital technologies on SDL. This approach involved critically reviewing systematic literature and empirical research to identify key dimensions.

Results. *The Impact of AI on Self-Directed Learning Processes:* In 2021, J. Hawkins wrote: "The twenty-first century will be transformed by intelligent machines in the same way that the twentieth was transformed by computers" (Hawkins, 2021). This fully applies to the problems of transforming education and self-education. Luan et al. (2020) examine how AI and big data are transforming educational research and practice, enabling learners to develop personalised learning experiences that empower them to take control of their learning. Artificial intelligence technologies enable personalized learning that responds to the unique needs and preferences of learners, by increasing their engagement and autonomy. Nesbit (2012) examined how AI facilitates immediate feedback and personalized instruction, which are essential for developing critical thinking and self-regulation skills. AI can be used in educational practices not only to support individual learning journeys, but also to foster a culture of lifelong learning. Furthermore, Urhahne and Wijnia (2023) discussed the potential of AI tools to create inclusive and equitable learning environments, suggesting that educators can design sustainable learning systems that support the diverse needs of learners, ultimately increasing opportunities for self-directed learning. This integration highlights the importance of technology in shaping modern learning experiences, as learners are able to take control of their own learning.

Education is one of the key areas where AI shows significant potential for transformation. The advent of AI has brought significant benefits to human life. Artificial intelligence systems personalize the learning and teaching process and automate administrative (management) tasks. In addition, AI can also provide new opportunities for assessment/reflection of knowledge. AI can make teachers' work easier by providing personalized learning experiences, automating administrative tasks, providing real-time feedback, facilitating professional development, improving teaching strategies, and influencing education. AI can also help create adaptive curricula that ensure equal learning opportunities for children with special educational needs. AI helps create personalized curricula that consider the student's strengths, weaknesses, interests, and learning goals. This allows everyone to move at their own pace, focusing on the aspects that require the most attention. The use of machine learning and deep learning techniques in education is not a new phenomenon. Adaptive exams (tests that adjust to the student's capabilities, such as correct answers triggering more difficult test questions, and incorrect answers triggering easier test options) and models that automate the checking and grading of student work have been around for many years.

Using AI in the learning process helps students develop the following skills: workflow organization, reflection, critical thinking, and fact-checking. Instead of creating content from scratch, students learn to delegate tasks to performers, which are technologies. Essential skills of thinking and fact-checking are necessary for evaluating the results of neural networks and analyzing the relevance and timeliness of these results.

Overuse of AI for problem solving can hinder students' critical thinking skills and independent learning. For example, AI can provide solutions to complex problems in seconds as a homework helper, but it may not fully understand social and humanitarian issues such as moral dilemmas and situational questions. One of the main challenges in artificial intelligence is the risk of bias. Machine learning algorithms are often trained on data that contains hidden biases. Therefore, assessment and acceptance algorithms can be not only vague, but also biased. For example, AI that predicts student performance may, on the one hand, favor students from well-funded schools and, on the other hand, underestimate students from under-funded schools.

Key components of AI-based educational systems include adaptive learning technologies that personalize material according to the specific needs of individual students, as well as data analytics tools that help teachers identify learning gaps and understand patterns in student performance. Using generative AI, teachers can quickly create content for educational materials, presentations, and similar assignments. The solutions also allow you to analyze learning metrics, adapt curricula to the needs of specific students, and automate routine operations. There are several key use cases for artificial intelligence in education: personalization of learning, including assistance to students with special needs, resource planning and forecasting of learning outcomes, curriculum development and other forms of automation of routine teacher tasks, administration of the learning process, and ongoing assistance during learning (Ditkovskaya, 2024; Duggan, 2020; Maltsev, 2024; Talgatov, Kassymova, and Nurtanto, 2024).

The Impact of VR on Self-Directed Learning Processes: Nowadays, VR has become a promising tool in educational institutions, attracting the interest of educators due to its potential to improve the quality of learning (Urazaliyeva, Bekalaeva, Kassymova, 2024). VR offers unprecedented opportunities to cultivate self-directed learning by immersing learners in rich, interactive environments that they can navigate autonomously. Unlike conventional learning tools, VR places individuals at the center of experiential simulations where they make decisions, explore concepts, and solve problems in contexts that mirror or extend real-world scenarios. According to Alizadeh and Cowie (202), this autonomy can foster core drivers of self-directed learning such as intrinsic motivation, curiosity, and sustained engagement. Another essential advantage of VR is the immersive ability to transport users to inaccessible locations, such as historical monuments, remote areas, outer space, or even the human body. This offers unique perspectives that can enhance engagement, which may result in better understanding (Marougkas et al., 2023). Moreover, VR's immersive nature fosters a stronger sense of presence, thus motivating learners to participate and explore topics more deeply and actively (Hua & Wang, 2023).

Moreover, VR learning platforms can also provide secure, consistent, and individualized learning environments, which in turn allow learners to express their initiative and develop their understanding of the subject through repeated practice (Gan et al., 2023). Another key benefit of VR is that it offers learners opportunities to practice and improve skills in a safe, controlled setting without the fear of real-world consequences (Leung et al., 2018). Additionally, those platforms customized to individual learning styles and paces may provide targeted support and feedback based on specific needs (Zizza et al., 2018). Some of the latest advancements of VR technologies are AI-enhanced VR platforms, which further strengthen this potential by adapting experiences to individual learner profiles. Intelligent systems can monitor performance and dynamically adjust task complexity or provide tailored

feedback, enabling learners to progress at their own pace and according to their evolving needs. For example, language learners might practice conversational skills with AI-driven avatars that respond contextually. At the same time, science students can conduct virtual experiments, test hypotheses, and observe outcomes without the constraints of physical laboratories (Chen et al., 2022). Thus, VR integration into education, including SDL, allows students to take an active role in their learning through experiential, case-based activities and social interaction (Vert & Andone, 2019).

However, integrating VR for SDL also introduces several significant challenges that require careful attention to maximize its educational benefits. VR-supported SDL requires proper scaffolding and thoughtful instructional design because learners might feel overwhelmed by the huge number of choices VR environments or distracted by immersive environments' sensory features, which can hinder focus and cognitive processing (Phoon, Idris, & Rahina, 2021; Radianti et al., 2020). Additionally, Alizadeh and Cowie (2022) mentioned that VR-related discomfort, such as cybersickness, may further limit sustained participation for some users. They conducted a small scoping longitudinal study with a group of five volunteer participants. During the first stage of their research, participants reported experiencing varying levels of cybersickness.

Moreover, educators need comprehensive training and ongoing support to effectively help students navigate these complex virtual spaces and integrate VR meaningfully into their self-directed learning (Merchant et al., 2014; Phoon, Idris, & Rahina, 2021). However, despite these hurdles, when applied with clear pedagogical goals and aligned with learning theories, VR can be an effective driver for fostering SDL. Since it can provide personalized, immersive, and interactive experiences that promote deeper understanding, skill development, and motivation, helping to prepare learners to succeed in complex and rapidly changing environments (Strousopoulos & Troussas, 2024; Dede, 2020; Makransky & Petersen, 2021). Thus, as VR technology progresses and becomes more accessible, its potential to transform self-directed learning and educational outcomes is likely to grow significantly.

Self-Education Models: What distinguishes self-education from formal education is the process of independent learning and mastering knowledge and skills. There are many models of self-education, which can be divided into individual and group, as well as formal and informal (Knowles, Holton, & Swanson, 2015). Research concepts and models of self-education consider this process as an important tool for developing personality and professionalism, offering various approaches and strategies for effective self-education (Candy, 1991; Tough, 1979). Self-education is a multifaceted process that can be adapted to individual needs and interests (Brookfield, 1986). Various research concepts and models of self-education offer tools and approaches that will help make this process more effective and efficient (Zimmerman, 2002). Main concepts and models:

1) The concept of self-education as a continuous development process: Assumes that self-education is an ongoing process that should be included in everyday life, allowing a person to constantly expand their knowledge and skills (Illeris, 2004).

2) Model based on goals and motivation: Emphasizes the importance of defining specific goals for self-education and motivation that will support the process (Schunk & DiBenedetto, 2020).

3) Model based on resources and tools: Considers access to a variety of resources (books, articles, online courses, expert consultations) and self-education tools (planning, self-monitoring, feedback) (Candy, 1991; Garrison, 1997).

4) Model based on self-regulation and self-motivation: Proposes to develop the ability to plan, control, and evaluate your progress, as well as maintain motivation and interest in the process of self-education (Zimmerman, 2002; Pintrich, 2004).

The Garrison model identified three dimensions that indicate the effectiveness of independent learning. These are self-management, self-control, and motivation.

D.R. Garrison also paid special attention to the context of cognitive responsibility and strong control of students' internal motivation, which are necessary for effective learning through independent learning (Garrison, 1997). In turn, the G. Grow (1991) model shows the stages of independent learning, where students move from dependence on the teacher to complete independence in the learning process. The peculiarity of the Grow model is that it plays a decisive role in guiding this process and changes depending on the stage. He emphasises in his works that students cannot begin the process of independent learning without the guidance of the teacher (Grow, 1991). In the structure of scientists Silamut and Petsangsri, independent learning is combined with knowledge management. According to the authors, this strategy contributes to the development of digital literacy skills. The authors believe that learning management processes, such as knowledge discovery and application, can be integrated with structured steps of self-directed learning (Silamut & Petsangsri, 2020).

Day et al. (2014) reviewed 25 years of broad themes in leadership and leadership development in education. The authors emphasize that personal motivation is essential for effective leadership development. They argue that for development programs to be successful, participants must be intrinsically motivated and committed to learning and personal growth. The article suggests that leadership development programs should be designed to enhance and align participants' intrinsic motivations, rather than relying solely on extrinsic motivation. Furthermore, Day et al. (2014) identify motivation as a key psychological factor that influences an individual's ability to self-directed learning, starting with their leadership development initiatives. In addition, Gottfried et al. (2011) examined academic intrinsic motivation in childhood and adolescence as a predictor of three aspects of leadership motivation. They included three aspects - two intrinsic motives and one extrinsic motivation (Table 1). The first two of the leadership motives are intrinsic, while the third is influenced by external forces. The study found that academic intrinsic motivation was highly correlated with affective congruence and noncognitive components of leadership motivation, supporting the authors' argument that intrinsic motivation is a condition that reflects continuity across the lifespan for self-development.

Table 1. *Three aspects of motivation in education*

Aspects of motivation	Descriptions	Examples in Self-Directed Learning
Affective identity motivation	leads to concerns about the enjoyment and identity associated with being a learner.	A student enjoys discovering new knowledge and sees themselves as a lifelong learner who loves learning.
Non-calculative motivation	concerns learning for its own sake, not for external rewards or recognition.	A person studies philosophy and science topics on their own, not for grades or promotions, but out of pure curiosity.
Social-normative motivation	concerns learning out of a sense of duty or responsibility.	A teacher pursues professional development through self-directed courses to better support their students, seeing it as their ethical duty.

The PPC model (Figure 2) emphasises characteristics of the individuals and their interaction between individual attributes (Person), teaching and learning activities (Process), and organisational factors (Context). Based on these key themes of this model, Curran et al. (2019) provided an updated holistic view of SDL in a digital age as a continuous professional education. Learning strategies, goal setting, and reflective practices are used in the learning and teaching transactions, which are the procedural core of SDL. The PPC model aligns well with AI and VR-driven SDL as they offer distinctive advantages in each of these

areas, becoming a powerful tool for supporting self-directed learning:

1. Personalising learning processes based on learner profiles;

2. Facilitating adaptive processes through real-time feedback and intelligent tutoring systems; and integrating contextual data to create appropriate learning environments (Gureckis & Markant, 2012);

3. Immersive experiences increase learner motivation and engagement, helping individuals take initiative and sustain interest in their learning projects (Dede, 2009; Schunk & DiBenedetto, 2020);

4. Sense of agency and control in VR environments boosts learners' confidence in their ability to direct their learning (Bandura, 1997; Zimmerman, 2002);

5. VR enables learners to tailor experiences to their needs, supporting diverse learning styles and preferences (Johnson et al., 2016);

6. VR environments can be structured around specific learning goals, enabling learners to set, pursue, and achieve objectives autonomously (Candy, 1991);

7. VR can also facilitate group learning and social interaction, enriching the sociocultural context of self-directed learning (Garrison, 1997).

Russian researchers note that the traditional didactic cycle of "mastering new knowledge – consolidation – monitoring and evaluation" in the era of digital technologies as AI and VR will inevitably transform, bringing it closer to a model of problem-based learning based on independent discovery, understanding and overcoming the "gap" between existing knowledge and teachings – and their inadequacy for solving new types of problems. The new didactic logic, having not so much a cyclical, but rather an open and continuous character, takes the following form (Kondakov, Sergeev, Abramov, 2024; Selwyn, 2024; Shutikova & Beshenkov, 2020; Wu, Burdina, & Gura, 2023):

- focusing (defining the topic, idea, project concept, based on the achieved educational level and based on current educational deficits);
- problematization (highlighting the problem within the framework of a previously defined topic, assessing its significance);
- goal setting (transforming the problem into a task or a set of tasks);
- information search, during which a value attitude towards socially and personally significant information is built;
- developing a solution to the problem (or a set of alternative solutions), considering the collected information;
- checking the functionality of solutions (experiment, expert assessment, etc.);
- reflexive after-action (assessment, self-assessment of the progress and results of work with the participation of AI);
- return to a certain stage of this cycle, to the previous cycle or transition to a new cycle (depending on the results of the reflexive after-action).

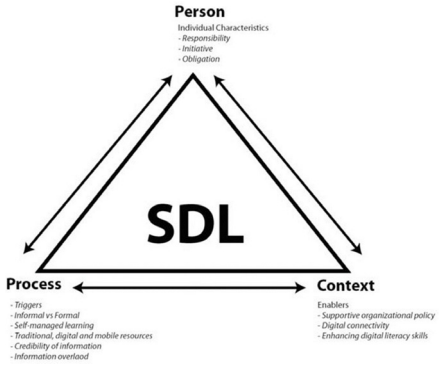

Figure 2: PPC Model of Brockett & Hiemstra (2012), updated by Curran et al. (2019)

In the axiologically oriented, non-linear personal didactic model of self-education (Kirikovich, 2014), there is no teaching process; the teacher and the student in one

person are the student himself, provided that the teacher provides competent pedagogical support for this process at the initial stages of self-education. The teaching function, which mainly involves managing the student's educational activities, must be consciously assumed by the student himself. To achieve this, he must master several essential skills for independent learning. The first of them is the ability to build personal information models of knowledge representation as its subjective image in the form of concepts, skills, identified connections, and patterns. The information model of knowledge representation reflects the connections and dependencies between concepts, the subjective image of the information model of knowledge representation may be different for each student, but the concepts and connections between concepts identified during self-study are objective. As a result, information models of knowledge representation have a personal character, reflecting the characteristics of an individual's development. The second important skill necessary for independent learning is the ability to apply the self-study method based on the "self-study algorithm", which corresponds to the project-technological type of activity organization culture. The basic concept is that the project is transformed into a "self-learning algorithm" for a schoolchild, which includes the following stages: design, implementation, and reflection. The third important skill is an individual's ability to overcome difficulties during self-learning, which we have defined as the capacity to manage the development of one's personality. As a result, the following stages of self-organization of a schoolchild's personality in self-learning as self-management of development are distinguished:

1) actualization of the student's cognitive activity in the conditions of openness of the educational process;

2) overcoming by the student of an internal contradiction at the points of choice, as a result of which qualitative changes occur either in values, or in experience, or mental capabilities, or the personal qualities of an individual, personality, and subject of activity;

3) manifestation of the student's cognitive activity for the implementation of self-management of the vector of his development;

4) transition of the personality to a new quality (Kirikovich, 2014).

Kalinina (2014) writes that the ideal model of self-education is two-dimensional. Only by adhering to the principle of "two-dimensionality" of self-education, i.e., focusing on the implementation of both processes of self-education and self-training, can one achieve a long-term result and form an educated person capable of changing themselves and the world around them for the better through constant self-improvement. Whatever the direct goals, in order to form a personality, it is necessary to simultaneously achieve indirect goals. In other words, any task or assignment must be thought out and constructed by the teacher in such a way that, by fulfilling the direct goal, the student indirectly fulfills the teacher's direct goal. Moreover, whatever the dominant process (self-training or self-education), the presence of both processes is necessary for the implementation of the ideal model of self-education. Thus, the model we present is ideal not in the sense of "the best", but ideal from the point of view of the embodiment of the principle of "two-dimensionality" in the theory of self-education (Kalinina, 2014).

Thus, the formation of self-educational activity in students is a step-by-step process, providing for gradual progress from episodic self-educational attempts to a stable system of self-educational activity. The basis of this process is the modelling of educational situations that develop the ability to set a goal, plan one's education, navigate information, and manage professional self-development. Self-education contains enormous pedagogical opportunities and is an important factor in the preparation of highly qualified specialists who are not only armed with a system of knowledge, skills, and abilities, but are also prepared for life, are able to think and act actively and creatively, and develop and improve themselves. Self-education is a set of processes for the formation of universal skills of self-education and self-training. Self-education and self-training are

essential components of self-education, which is the path to self-realization, the ultimate stage of an individual's realization of their potential (Medvedev, 2013; Puzyrevsky & Nozdrina, 2022).

Discussion. Transformation of the information foundations of pedagogical activity, which make up the learning process, inevitably causes other profound changes. By leveraging AI and VR technologies, teachers can focus on the core tasks of education and student personal development (Knowles, 1975; Lyakh, Sarafanova, Aleksandrova, 2020; Liu et al., 2020; Trifonov, 2023). A teacher becomes necessary for a student as an image of a mature personality, "successful adulthood" and "successful professional", demonstrating effective strategies of learning and self-education. A teacher of the AI era is a motivator and facilitator, an empath (understanding and accepting every child, teenager, especially the "difficult"), and a mediator (a qualified intermediary in interpersonal and intergroup conflicts). Subject training of such a teacher fades into the background; the focus is on the synthesis of psychological and pedagogical competencies, the main purpose of which is to cultivate the "human in a person". In a pessimistic scenario, the development of digital technologies renders teachers into operators of "smart" digital platforms, pushing them to the periphery of the educational process. There is a risk of professional deskilling among teachers. Traditionally, any methodological deficiency of a teacher required advanced training, the next step along the path of continuous professional and personal growth. However, with the presence of AI, a situation arises where many of the teacher's methodological deficiencies can be addressed by leveraging AI and VR and utilising the appropriate tools.

Despite the promising potential of digital technologies, such as AI and VR, to enhance SDL, challenges remain. Richardson and Watt (2010) discuss the conflicting discourses surrounding the practice of SDL in professional settings, highlighting the need for organisations to support environments that support self-directed learning. As employees are expected to take greater responsibility for their professional development, understanding these dynamics will be crucial for promoting SDL in the workplace. Luan et al. (2020) highlight the challenges of implementing digital technologies in education, arguing that these challenges can be addressed along three dimensions: research, policymaking, and industry. They call for future research, policymaking, and collaboration to overcome these challenges and ensure that AI and VR are used to improve education equitably and responsibly. In education, artificial intelligence has the potential to transform learning by personalising it, improving outcomes, providing feedback, and supporting informed decision-making. However, implementing them also poses significant challenges.

Another challenge is that guaranteeing fair access to VR tools remains essential. High hardware, software costs, and technical demands can exacerbate existing educational disparities and limit access for under-resourced students (Makransky & Petersen, 2021; Phoon, Idris, & Rahina, 2021). Furthermore, VR integration in education faces several key challenges, such as ensuring user comfort to prevent motion sickness, addressing technical limitations such as poor infrastructure, overcoming resistance from poorly trained teachers, and meeting the need for high-quality, curriculum-aligned content. Table 2 provides concrete examples and possible solutions related to the use of AI in education.

Table 2. *Major challenges, examples and possible solutions for integrating AI into education*

Major Challenges	Examples	Possible Solutions
Educational institutions collect confidential data from applicants before university admission.	Student performance, health issues, financial status and demographics, etc.	It is recommended that teachers, students, and parents be included in the development of the admissions policy.

AI models trained on biased datasets may exacerbate inequality among students.	Underestimating students' capabilities in an inclusive environment can lead to demotivation.	There is a need to design inclusive systems that accommodate diverse learning styles and learning environments.
Not all students or schools have equal access to the infrastructure needed for AI-powered tools.	Some areas, such as remote villages, may not have high-speed internet or smart devices and may lack specialists.	Local government and educational institutions should invest in accessibility and digital platforms, especially in under-resourced areas.
Educators and learners may lack the understanding and skills to effectively use AI tools or data.	Some teachers do not know how to use learning analytics data on their intranet website.	Teachers should be provided with ongoing professional development in AI literacy, data interpretation, and digital pedagogy.
User Experience and Comfort	Motion sickness and discomfort during prolonged use	Design ergonomic devices, limit session duration, and provide breaks
Technical Issues and Infrastructure	Insufficient bandwidth and outdated hardware cause lag and crashes	Upgrade infrastructure, use cloud VR, and provide technical support
Teacher Training and Acceptance	Teachers unfamiliar with VR technology resist adoption	Provide professional development and hands-on training
Content Development and Quality	Lack of high-quality, curriculum-aligned VR content	Collaborate with educators to develop relevant content

To effectively overcome these barriers (Table 2), institutions must prioritise ergonomic design and session management, invest in infrastructure and support, provide comprehensive teacher training, and foster collaboration between content developers and teachers. Addressing these challenges holistically is critical to the successful and sustainable implementation of VR in educational settings (Urazaliyeva, Bekalaeva, Kassymova, 2024). While digital technologies bring transformative potential to education, they must be approached with caution, fairness, and foresight. The focus should be on responsible innovation, balancing technological progress with ethical, pedagogical, and social considerations. Successful adoption depends not only on tools but also on leadership, policy, infrastructure, and a commitment to inclusive digital transformation.

Day et al. (2014) and Gottfried et al. (2011) highlight the important role of intrinsic motivation in leadership and self-directed learning, demonstrating that sustained personal growth depends on intrinsic drivers such as enjoyment, curiosity, and a sense of responsibility. These findings are particularly relevant when considering the integration of AI and VR in education. While they have the transformative potential to offer immersive and engaging environments, personalised learning paths, rapid feedback, and adaptive content, their effectiveness depends not only on their technological sophistication but also on how they nurture students' intrinsic motivation. If AI-driven systems and VR platforms focus solely on efficiency and extrinsic incentives (e.g., test scores or grades), they risk neglecting the affective and normative dimensions that underpin lifelong learning. Therefore, one of the key challenges is to design systems that support, rather than replace, self-directed learning and motivational autonomy.

Conclusions. Overall, educators and students lack the understanding and skills to effectively utilise artificial intelligence and virtual reality tools. SDL is a key component of lifelong learning, closely linked to the evolving landscape of education shaped by digital technologies and their integration offers significant opportunities to enhance SDL by providing personalised learning experiences that empower learners. However, some challenges require ongoing research to address the complexities of SDL in diverse contexts. By exploring these issues

and contributing to a deeper understanding of SDL, educators and researchers can empower learners to engage in equitable learning journeys in a technology-driven world. VR can benefit self-directed learners by stimulating intrinsic motivation and engagement through immersive experiences, thereby providing a feeling of presence and deepening learners' understanding of the subject matter. VR platforms offer secure, individualised, and customised learning environments, some enhanced by AI, that support repeated practice, may provide personalized feedback, and enhance skill development without real-world risks. However, for effective integration and equitable access, challenges such as cognitive overload, cybersickness, high costs, and the need for educator training must be addressed. Nonetheless, if VR-supported SDL is aligned with sound pedagogical principles, it may hold significant potential to transform SDL and improve educational outcomes.

The study demonstrated the transformative nature of self-directed learning with the help of AI and VR. However, the article clarifies that the path to fully realising these benefits has its challenges. Differences in access to digital education and digital technologies are significant barriers. In addition, there are ethical issues related to the confidentiality of data necessary to ensure a safe learning environment. Closing these gaps will require the joint efforts of teachers, policymakers, and developers. Assuming these issues are addressed and the gaps are filled, AI and VR-driven SDL will not only materialise but also become a key factor in lifelong education. To fully understand this development, long-term research is necessary to examine how artificial intelligence impacts learning outcomes and student motivation. As AI technology advances, its incorporation into self-directed learning holds great promise for delivering personalised, high-quality education.

References

Alizadeh, M., & Cowie, N. (2022). Self-directed learning using VR: An exploratory practice approach. Pacific Journal of Technology Enhanced Learning, 4(1), 10–11. https://doi.org/10.24135/pjtel.v4i1.130

Bandura, A. (1997). Self-efficacy: The exercise of control. W H Freeman/Times Books/ Henry Holt & Co. URL: https://psycnet.apa.org/record/1997-08589-000

Brockett, R.G. & Hiemstra, R. (2012) Reframing the meaning of self-directed learning. Proceedings of the Adult Education Research Conference (Saratoga Springs, NY). 2012. Conference Proceedings. USA, NY, Saratoga Springs: Kansas State University Libraries, New Prairie Press, pp. 155-162. URL: https://newprairiepress.org/aerc/2012/papers/22

Buzio, A., Chiesa, M., & Toppan, R. (2017). Virtual Reality for Special Educational Needs. In Proceedings of the 2017 ACM Workshop on Intelligent Interfaces for Ubiquitous and Smart Learning (IUI'17), 7–10. https://doi.org/10.1145/3038535.3038541

Candy, P.C. (1991). Self-Direction for Lifelong Learning. San Francisco: Jossey-Bass, 567 pages. Adult Education Quarterly, 42(3), 192-193. https://doi.org/10.1177/074171369204200307

Chen, Y.-L., Hsu, C.-C., Lin, C.-Y., & Hsu, H.-H. (2022). Robot-Assisted Language Learning: Integrating Artificial Intelligence and Virtual Reality into English Tour Guide Practice. Education Sciences, 12(7), 437. https://doi.org/10.3390/educsci12070437

Curran, V., Gustafson. D.L., Simmonson, K., Lannon H., Wang, Ch., Garmsiri, M. (2019). Adult learners' perceptions of self-directed learning and digital technology usage in continuing professional education: An update for the digital age. Journal of Adult and Continuing Education, Vol. 25(1), pp. 74-93. https://doi.org/10.1177/1477971419827318

Day, D.V., Fleenor, J.W., Atwater, L.E., Sturm, R.E., McKee, R.A. (2014). Advances in leader and leadership development: A review of 25 years of research and theory. The Leadership Quarterly, 25, pp.63-82. https://doi.org/10.1016/j.leaqua.2013.11.004

Dede, C. (2020). Immersive interfaces for engagement and learning. Science, 323(5910), 66–69. https://doi.org/10.1126/science.1167311

Ditkovskaya, I.E. (2024). Artificial Intelligence Technologies in Personalized Education in the Context of the Philosophy of Personalized Education [Tekhnologii iskusstvennogo intellekta v personalizirovannom obrazovanii v kontekste filosofii personalizirovannogo obrazovaniya]. Universum: Social Sciences, 3 (106), pp. 32-34. https://doi.org/10.32743/UniSoc.2024.106.3.17043 [in Russian].

Duggan, St. (2020). Artificial Intelligence in Education: Changing the Pace of Learning. UNESCO IITE Policy Brief / ed. S.Yu. Knyazeva. Moscow: UNESCO Institute for Information Technologies in Education, 44 p.

Garrison, D.R. (1997). Self-directed learning: Toward a comprehensive model. Adult Education Quarterly, 48(1), pp. 18-33. https://doi.org/10.1177/074171369704800103

Gottfried, A.E., Gottfried, A.W., Reichard, R.J., Guerin, D.W., Oliver, P.H., & Riggio, R.E. (2011). Motivational roots of leadership: A longitudinal study from childhood through adulthood. The Leadership Quarterly, 22(3), pp. 510-519.

Grow, G. (1991). Teaching learners to be self-directed. Adult Education Quarterly, 41(3), pp. 125-149. https://doi.org/10.1177/0001848191041003001

Gureckis, T.M., & Markant, D.B. (2012). Self-directed learning. Perspectives on Psychological Science, 7(5), pp. 464-481. https://doi.org/10.1177/1745691612454304

Gurr, D. and Drysdale, L. (2020). Leadership for challenging times. International Studies in Educational Administration, 48(1), pp.24-30. URL: https://www.researchgate.net/publication/342915017_Leadership_for_challenging_times

Hawkins, J.A. (2021), Thousand Brains: A New Theory of Intelligence. Hachette UK. p. 241. URL: https://dn790007.ca.archive.org/0/items/artificial-intelligence/2021_a_thousand_brains-a_new_theory_of_intelligence-Jeff%20Hawkins%20%282021%29.pdf

Hu, W.J.E.A. (2019). Robot-proof: higher education in the age of artificial intelligence. High Educ., 78, 1143–1145. https://doi.org/10.1007/s10734-019-00387-3

Hua, C., & Wang, J. (2023). Virtual reality-assisted language learning: A follow-up review (2018–2022). Frontiers in Psychology, 14, 1153642. https://doi.org/10.3389/fpsyg.2023.1153642

Johnson, L., Adams Becker, S., Estrada, V., & Freeman, A. (2016). NMC Horizon Report: 2016 Higher Education Edition. The New Media Consortium. https://www.learntechlib.org/p/171478/

Kalinina, A.I. (2014). Razrabotka ideal'noy modeli samoobrazovaniya [Development of an ideal model of self-education]. Bulletin of Moscow University. Series 20. Pedagogical education, (3), pp. 108-121 [in Russian].

Kirikovich, T.E. (2014). Axiologically Directed, Nonlinear Personal Didactic Model of Self-Learning as a Means of Implementing the Idea of Continuous Education [Aksiologicheski napravlennaya, nelineynaya personal'naya didakticheskaya model' samoobucheniya kak sredstvo realizatsii idei nepreryvnogo obrazovaniya]. Fundamental research, 3(3), pp. 600-603 [in Russian]

Knowles, M.S. (1975). Self-directed learning: A guide for learners and teachers. Cambridge Adult Education. URL: https://eric.ed.gov/?id=ED114653

Kolb, D.A. (1984). Experiential Learning: Experience as the Source of Learning and Development. Englewood Cliffs, NJ: Prentice Hall. URL: http://academic.regis.edu/ed205/Kolb.pdf

Kondakov, A.M., Sergeev, S.I., Abramov, V.I. (2024). Iskusstvennyy intellekt kak faktor transformatsii obrazovaniya [Artificial Intelligence as a Factor in the Transformation of Education]. Pedagogy, 88, 2, pp. 5-24. URL: https://sevcbs.ru/main/wp-content/uploads/2024/03/Statya-k-zhurnalu-Pedagogika-2024----2.pdf [in Russian].

Leung, T., Zulkernine, F., & Isah, H. (2018). The use of virtual reality in enhancing interdisciplinary research and education [Preprint]. arXiv. https://doi.org/10.48550/arXiv.1809.08585

Liu, Z.-J., Tretyakova, N., Fedorov, V., & Kharakhordina, M. (2020). Retracted Article: Digital Literacy and Digital Didactics as the Basis for New Learning Models Development. International Journal of Emerging Technologies in Learning (iJET), 15(14), pp. 4–18. https://doi.org/10.3991/ijet.v15i14.14669

Loader, D. (2019). ThinkPlus Interview with David Loader. URL: https://www.youtube.com/watch?v=8fz_GWNZomk

Luan, Hui, Géczy, P., Lai, H., Gobert, J.., Yang, Stephen J. H., Ogata, H., Baltes, J., Guerra, R., Li, Ping, & Tsai, Chin-Chung. (2020). Challenges and Future Directions of Big Data and Artificial Intelligence in Education. Frontiers in Psychology, 11. http://doi.org/10.3389/fpsyg.2020.580820

Lyakh, Yu.A., Sarafanova, E., Aleksandrova, M.V. (2020). To the question of the use of digital technologies in educational institutions [K voprosu ispol'zovaniya tsifrovykh tekhnologiy v obrazovatel'nykh uchrezhdeniyakh]. The european proceedings of social and behavioural sciences (EpSBS), 87. A. Shirin (Ed.). Pedagogical education: history, present time, perspectives (PEHPP 2019), 03-04 October, 2019, Veliky Novgorod, Russian (pp. 792-798). European Publisher. https://doi.org/10.15405/epsbs.2020.08.02.104 [in Russian].

Makransky, G., & Petersen, G. B. (2021). The cognitive and motivational benefits of immersive virtual reality in education. Educational Psychology Review, 33(3), 937–958. https://doi.org/10.1007/s10648-020-09586-2

Maltsev, Ya.V. (2024). The Phenomenon of Artificial Intelligence in the Context of Self-Development and Self-Realization of Being [Fenomen iskusstvennogo intellekta v kontekste samorazvitiya i samorealizatsii bytiya]. Philosophical Thought, 7, pp. 16-32. https://doi.org/10.25136/2409-8728.2024.7.70674 [in Russian].

Marougkas, A., Troussas, C., Krouska, A., & Sgouropoulou, C. (2023). Virtual reality in education: A review of learning theories, approaches and methodologies for the last decade. Electronics, 12(13), 2832. https://doi.org/10.3390/electronics12132832

Medvedev, I.F. (2013). Kontseptsiya samoobrazovaniya: osnovnyye ponyatiya i struktura. [The concept of self-education: basic concepts and structure]. Innovatsionnyye proyekty i programmy v obrazovanii = Innovative projects and programs in education, (3), pp. 42-46. URL: https://cyberleninka.ru/article/n/kontseptsiya-samoobrazovaniya-osnovnye-ponyatiya-i-struktura-1/viewer [in Russian].

Merchant, Z., Goetz, E. T., Cifuentes, L., Keeney-Kennicutt, W., & Davis, T. J. (2014). Effectiveness of virtual reality-based instruction on students' learning outcomes in K-12 and higher education: A meta-analysis. Computers & Education, 70, 29–40. https://doi.org/10.1016/j.compedu.2013.07.033

Mikropoulos, T. A., & Natsis, A. (2011). Educational virtual environments: A ten-year review of empirical research (1999–2009). Computers & Education, 56(3), 769–780. https://doi.org/10.1016/j.compedu.2010.10.020

Nesbit, P. L. (2012). The Role of Self-Reflection, Emotional Management of Feedback, and Self-Regulation Processes in Self-Directed Leadership Development. Human Resource Development Review, 11(2), 203-226. https://doi.org/10.1177/1534484312439196

Phoon, G.C., Idris, M.Z., & Rahina, N. (2021). Virtual Reality (VR) in 21st. Century Education: The Opportunities and Challenges of Digital Learning in Classroom. Asian Pendidikan, 1(2), 105-110. https://doi.org/10.53797/aspen.v1i2.15.2021

Puzyrevsky, D.M., Nozdrina, N.A. (2022). Self-Education Model [Model' samoobrazovaniya]. In Kuzmina, V.M. (ed.). Problems of Development of Modern Society. Kursk, January 20-21, 2022. Collection of scientific articles of the 7th All-Russian national scientific and practical conference. In 5 volumes. Kursk: South-West State University, 2022 [in Russian].

Radianti, J., Majchrzak, T. A., Fromm, J., & Wohlgenannt, I. (2020). A systematic review of immersive virtual reality applications for higher education: Design elements, lessons learned, and research agenda. Computers & Education, 147, 103778. https://doi.org/10.1016/j.compedu.2019.103778

Richardson, P.W. and Watt, H.M.G. (2010), "Current and future directions in teacher motivation research", Urdan, T.C. and Karabenick, S.A. (Ed.) The Decade Ahead: Applications and Contexts of Motivation and Achievement (Advances in Motivation and Achievement, Vol. 16 Part B), Emerald Group Publishing Limited, Leeds, pp. 139-173. https://doi.org/10.1108/S0749-7423(2010)000016B008

Schunk, D. H., & DiBenedetto, M. K. (2020). Motivation and social-emotional learning: Theory, research, and practice. Contemporary Educational Psychology, 60, 101832. https://doi.org/10.1016/j.cedpsych.2019.101832

Selwyn, N. (2024). On the Limits of Artificial Intelligence (AI) in Education. Nordisk tidsskrift for pedagogikk og kritikk, 10(1). https://doi.org/10.23865/ntpk.v10.6062

Shutikova, M., & Beshenkov, S. (2020). Modern digital educational environment and media education - platforms for transforming education system [Sovremennaya tsifrovaya obrazovatel'naya sreda i mediaobrazovaniye - platformy dlya transformatsii sistemy obrazovaniya]. Media Education (Mediaobrazovanie), 60 (4), 736-744. https://doi.org/10.13187/me.2020.4.736 [in Russian].

Silamut, A., &Petsangsri, S. (2020). Self-directed learning with knowledge management model to enhance digital literacy abilities. Education and Information Technologies, pp. 1-19. https://doi.org/10.1007/s10639-020-10187-3

Strousopoulos, P. & Troussas, C. (2024). Personalized Learning via Gamified Virtual Environments: Exploring Insights and Impact, 19th International Workshop on Semantic and Social Media Adaptation & Personalization (SMAP), Athens, Greece, pp. 111-115, https://doi.org/10.1109/SMAP63474.2024.00029

Talgatov, Y., Kassymova, G.K., Nurtanto, M. (2024). AI in the Classroom: A Boon or a Threat to Pedagogical Practices? Materials of International Practical Internet Conference "Challenges of Science". Issue VII, pp. 128-134. https://doi.org/10.31643/2024.19

ten Cate, O. Th. J., Kusurkar, R. A., & Williams, G. C. (2011). How self-determination theory can assist our understanding of the teaching and learning processes in medical education. AMEE Guide No. 59. Medical Teacher, 33(12), 961–973. https://doi.org/10.3109/0142159X.2011.595435

Trifonov, A.A. (2023). Metodologicheskiye osnovy sovershenstvovaniya podgotovki pedagogov k rabote v tsifrovoy obrazovatel'noy srede [Methodological foundations for improving the training of teachers to work in a digital educational environment]. Bulletin of Moscow State Pedagogical Univ. Series: Computer Science

and Informatization of Education. No. 2 (64), pp. 19-31. https://doi.org/10.25688/2072-9014.2023.64.2.02 [in Russian].

Urazaliyeva, U., Bekalaeva, A.O., Kassymova, G. (2024). Obucheniye cherez virtual'nuyu real'nost': rezul'taty pilotnogo issledovaniya angliyskogo yazyka [Virtual reality-supported education: results of a pilot study on English language]. Bulletin of the Eurasian Humanities Institute. Issue 3, pp. 235-247. https://doi.org/10.55808/1999-4214.2024-3.22 [in Russian].

Urhahne, D., Wijnia, L. Theories of Motivation in Education: an Integrative Framework. Educ Psychol Rev., 35, 45 (2023). https://doi.org/10.1007/s10648-023-09767-9

Vert, S., & Andone, D. (2019). Virtual reality authoring tools for educators. In ITM Web of Conferences (Vol. 29, Article 03008). EDP Sciences. https://doi.org/10.1051/itmconf/20192903008

Wu, W., Burdina, G., & Gura, A. (2023). Use of Artificial Intelligence in Teacher Training. International Journal of Web-Based Learning and Teaching Technologies (IJWLTT), 18(1), 1-15. https://doi.org/10.4018/IJWLTT.331692

Zimmerman, B. J. (2002). Becoming a self-regulated learner: An overview. Theory into Practice, 41(2), 64–70. https://doi.org/10.1207/s15430421tip4102_2

Zizza, C., Starr, A., Hudson, D., Nuguri, S. S., Calyam, P., & He, Z. (2018). Towards a social virtual reality learning environment in High Fidelity. In 2018 15th IEEE Annual Consumer Communications & Networking Conference (CCNC) (pp. 1–6). IEEE. https://doi.org/10.1109/CCNC.2018.8319187

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