American Journal of Social and Humanitarian Research

Vol. 7 Issue 1 **| pp.** 93-107 **| ISSN:** 2690-9626
Available online @ https://globalresearchnetwork.us/index.php/ajshr

Article

Modern Picture of Steam Education in Its Technical and Technological Aspect by Means of Digital Computer Technologies ICT

Yunusova Gulshod Nazihovna

1. Namangan State University, Department of "Digital Education Technologies," Acting Professor, Doctor of Philosophy in Pedagogical Sciences.

* Correspondence:

Abstract: At present, when information and computer technologies have reached their apogee, their creation and application has been and will be the most pressing task of the modern world. In order to create a teaching methodology in the field of STEAM, which consists of several areas. called its components: scientific, technological, educational, creative, mathematical, robotic, these in turn consist of many elements, which we call subjects of study: natural, technical, mathematical, creative, educational sciences, including chemistry, biology, geography, mathematics, physics, astronomy, engineering, aerospace, programming. In the future, specialists with several specialties at once will be in demand. Such faculties are very expensive. The purpose of the study is to determine the picture of the world of STEAM education, as well as to create teaching methods in the environment of information and computer technologies. Improving the existing methodology, as well as creating new content in this area using computer programs. Scientific research and work were analyzed using methods of analysis, synthesis, and comparison; their results were compared with our data, work done, and tables obtained. Using the method of mathematical statistics, the results of a pedagogical experiment were processed, which were obtained as a result of teaching preschoolers, pupils and students using the traditional STEAM teaching method and the method of using ICT; the methods of mathematical statistics of Pearson and Student proved our hypothesis that the use of ICT in STEM education gives higher result. A pedagogical experiment was carried out for two adjacent equal control and experimental groups; training was carried out using traditional methods and using existing and created computer programs.

Keywords: *STEAM, STEAM Education, STEAM training, modeling programs, computer programs, information computer technologies, ICT*

Citation: Nazihovna, Y. G. Modern Picture of Steam Education in Its Technical and Technological Aspect by Means of Digital Computer Technologies ICT. American Journal of Social and Humanitarian Research 2026, 7(1), 93-107

Received: 03th Oct 2025
Revised: 18th Nov 2025
Accepted: 24th Dec 2025
Published: 21th Jan 2026

1. Introduction

STEAM education is the education of the present and future, which is predicted to be in demand in the near future for personnel proficient in several fields and subjects included in them at once [1], [2]. Personnel required for high-tech equipped enterprises are able to operate and design systems, correct their shortcomings, be able to connect them in case of system or circuit failure, be able to add a computer program, repair technical equipment, have an understanding of the subject related to this equipment, work with technologies, be able to use equipment in the field, in education, in production, know design, computer graphics and their use in advertising, etc [3], [4]. We have identified the following hypotheses, the first of which is early STEM education and its gradual, continuous learning, which will last throughout a person's life [5]. The second hypothesis

is related to the use of computer technologies, which raise the level of learning, the effectiveness of learning and learning the material. The third hypothesis is related to the development of ITC technologies, the development of the latter is directly proportional to the development of STEAM education [6].

This hypothesis serves the idea and STEM approach in education through the development of IT technologies that develop the technical and technological component of STEAM. With such hypotheses, we moved on to our research, familiarized ourselves with materials and articles that taught the use of computer game programs and other types of information computer technologies in our research. So let's get acquainted with them. And we will do a thorough review and analyze them [7].

Literature review

Based on our goal, identifying the picture of the world of STEAM education [8], [9], [10], we determined its purpose in all areas of the continuous learning that should be early, such training must be continued in subsequent stages [11], [12], develop in subsequent stages of human development learning smoothly and continuously. In our study, we put forward hypotheses, the first of which, if dedicated to early STEAM learning, the second states that the use of information, digital technologies and computer programs in STEAM education [13], [14] will increase the effectiveness of learning at all stages of lifelong learning, such a methodology will serve to create new content, improving existing techniques and methods. The third involves training in this style, will give good results in training personnel who will be competent in five areas that are associated with the formation of 4K competencies [15]. Such competencies, cognition collaborativity [16], [17] future personnel will be helped in career growth [18], [19]. which requires mastery of 4K competencies [20], creativity [21], [22], practical skills [23], commutability [24], and this approach applies to both students and researchers [25], [26].

AI - artificial intelligence is already being used in the education process [27], [28], elements of virtual and augmented reality, recognition elements [29], modeling elements [30], so research in this area was important to us, because We understand that these innovations will undoubtedly make a huge contribution to STEAM learning too, [31], [32].

And in reviewing the literature on the use of new types of information technologies in education [33], as well as in our research, we noted that research has begun to be conducted using deep learning [34]. We found that projects are working abroad and grants are being allocated for STEAM education, which help to draw promising conclusions and obtain high-quality [35]. In our study, we also proved that our hypothesis that the development of the IT sphere [36], the use of ICT in teaching, increase the level of learning in STEAM [37], [38]. The development of technical competencies among future professionals is of great importance, as well as the involvement of women in STEAM education [39] and in mastering this specialty [40], [41]. It should be noted that the development of this field, its programs, various new types of information technologies, distance learning, and the creation of LMS and CMS systems, as well as their application in education, have served as a prerequisite for the development of science and technology and, of course, the technological component of STEAM education. STEAM education has five components: scientific-educational, creative, scientific, technical-technological (which is connected with science in general), as well as computer sciences and ICT, including their computer programs and IEEE transaction-based technologies used in education [42], [43]. The need for distance education an increase in the number of people connected to the Internet, and an increase in the information received, became the reason for the creation of LMS, CMS systems, the use of which helped make the choice to use some in education And some in business. During the pandemic, the demand for the use of information technology and distance learning has increased many universities have created their platforms in Moodle. The need for distance education was the reason for the creation of LMS, CMS systems, and the use of distance education gave rise to the problem of data processing, big data, the problem of storing this data, and creating auxiliary storage facilities cloud storage. This is how new types of technologies appeared that were offered to the user as applications the possibility of creating online documents, presentations, tables, as well as the emergence of new types of ICT, which were intended

for education, it was possible to create online presentations (Google presentation, iSpring Pro), tests (iSpring Quiz Maker, various online tool programs to create tests and crossword puzzles. Due to the need for online storage, etc. cloud technologies appeared thanks to the creation of cloud services Paas, Saas,. Iaac, DRaas, Kaas, Google applications and disk appeared. This contributed to the development of the creation of websites the development of distance education. Which in turn served to develop the use of constructivism from STEM programming, dividing according to the principle of "divide and conquer". This is a kind of technique or engineering in programming that creates a website in two parts, programming the external side of the site frontend, as well as the internal side of the site Backend [44].

This is STEAM, teaching constructivism, engineering, and invention, construction through IT through its technological component, or rather its element of the technological component - programming. In scientific works We noticed that the emphasis is on modeling the influence of gender stereotypes and racial differences in learning, on knowledge acquisition, on mathematics learning anxiety [45]. In STEAM education for children, the process of transition from cloud programming to code programming is important [46]. In which the learning process in Scratch [47] is important, block programming from which, thanks to STEAM learning, you can make a smooth transition, creating continuous learning in the chain of computer programs.

2. Materials and Methods

In our research, we relied on an analysis of the literature, a synthesis of their data, and results. The tables obtained by the researchers were compared with their own. We thought about our methodology, thought about its creation, what programs need to be taught, what needs to be taught and how and at what level of education: in preschool, in school or higher education. Methods of analysis synthesis, and mathematical statistics were used. We got acquainted with the ideas of research, looked for an answer to the question of what objects the scientific component is based on. Turned out to be mathematics biology, chemistry, physics geography, computer science, robotics programming, constructivism, engineering, technology and technology. Moreover, scientific discoveries give rise to new types of technologies. The creation of new types of information technologies Enrich and develop STEAM.

This develops the technological component. At three levels of education separately, we have developed a methodology for teaching STEAM education using information technology and computer programs, STEAM training was carried out using traditional methods and through existing and created computer programs.

Next, using a test and an interview-survey we conducted an intellectual test and identified the level of knowledge of the students. We revealed the correctness of our hypotheses using the Pearson test; using the Student's test, we determined that the level of effectiveness of training using information technology and computer programs is much higher than the traditional method by 16-17%, which means that this method gives a higher result. An even better result is obtained by combined training through traditional methods and methods of using information computer programs.

3. Results and Discussion

The result of our research was a number of computer programs we created and websites we proposed to improve and shape the content of STEM education. Models of learning have been created in preschool, school periods and in higher education. At the beginning of our research. We have put forward methods and curriculum for STEM education in the environment of information technology and computer programs. We have published articles on novelty in our research in Fig 1: We processed the data from the control and experimental training groups using traditional and developed methods [48].

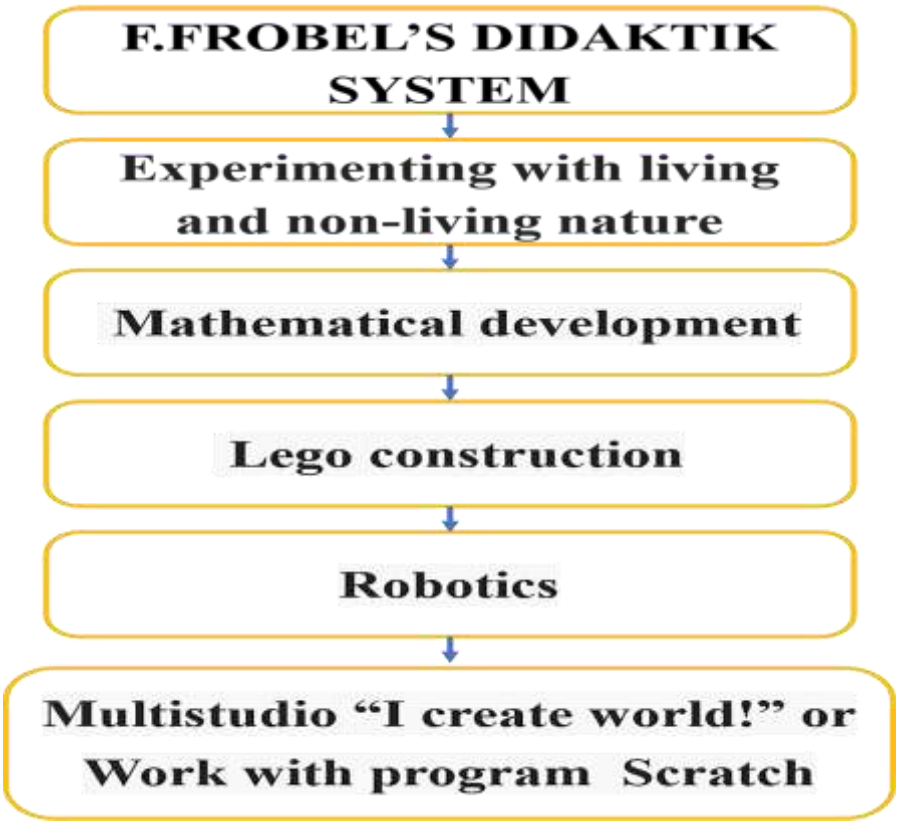

Figure 1. Modules of STEAM teaching in preschool.

Figure 2. National personaj of computer game.

In the preschool period, it is necessary to use the following computer programs and algorithmic sets in STEM education in Fig 2.

1) **LegoEducation** - for the formation of a child's algorithmic thinking;

2) **LegoMindstorms** - for the formation of programmatic thinking through robotics; initial projects;

3) **TinCerCad** - for the formation of spatial perception in object modeling.

4) **Scratch for Android** - for creative work in block programming to develop creative skills in invention, programming, construction and constructivism, innovation.

5) **Python** demonstration for children of a created set of programs for spirals, beautiful drawings;

During this period, it is necessary to use the following created programs:

1) The **"Computer + Attention + Memory + Logical Thinking"** program for focusing children's attention, developing memory and logical thinking - the program requires the child to memorize the shown drawing of an object for 20 seconds, find 10 of these exercises among the many, the task is to that the character of Panda Bear must be transferred to the other side along 10 bridges, in each of which an exercise must be completed; when Panda Bear crosses 10 bridges, exercises are given for memorizing geometric shapes, for memorizing objects of living and non-living nature, for memorizing symbols, rug patterns, etc., which helps strengthen visual memory, the child must find them among the many, looking at the picture for about 20 seconds in Fig 3;

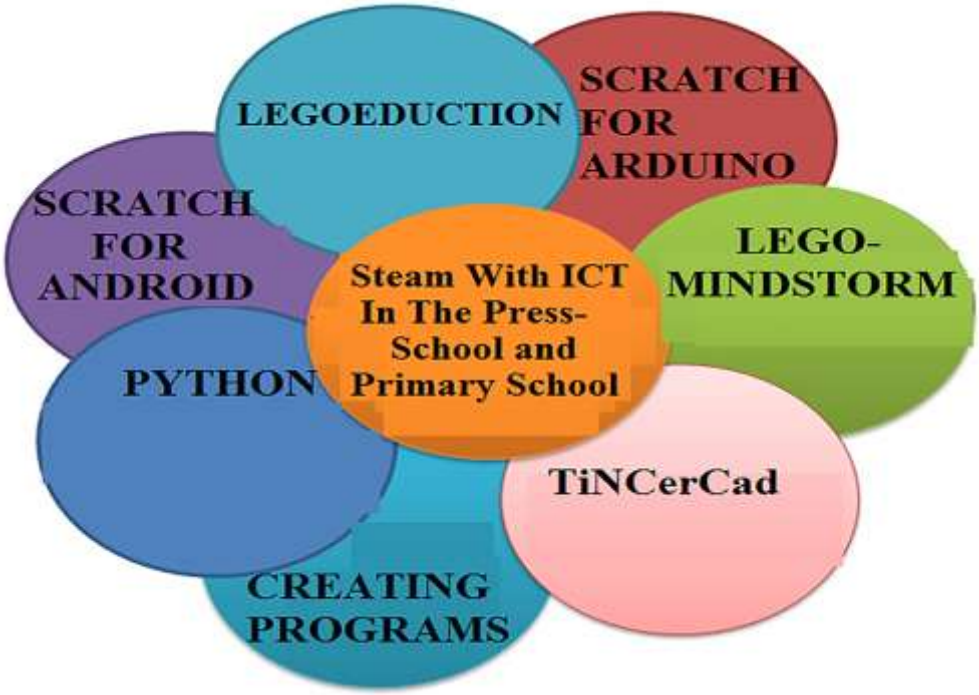

Figure 3. STEAM Education in preschool and Primaty school wiTh ICT and computer prohrams.

2) The **"Computer + alphabet of three languages: Uzbek, English, Russian"** program for teaching the alphabet of three languages, which consists of three programs - the alphabet of the English language, exercises for finding words from pictures, as well as transcribing letters, finding their spelling, programs for the Russian alphabet, as well as programs for the Uzbek alphabet, which children can write on an electronic board with an electronic pen, i.e. The program provides the child with the opportunity to write letters [49].

3) The **"Child Inventor"** program teaches English using the example of some words, ordering numbers, and assembling a robot.

4) A program for the development of children's intellectual abilities, for determining the shapes of objects **"Electronic Seguin Board"**;

5) A program for the development of children's spatial understanding of figures in space [50]. **Program for gifts from F. Froebel (Figure 4).**

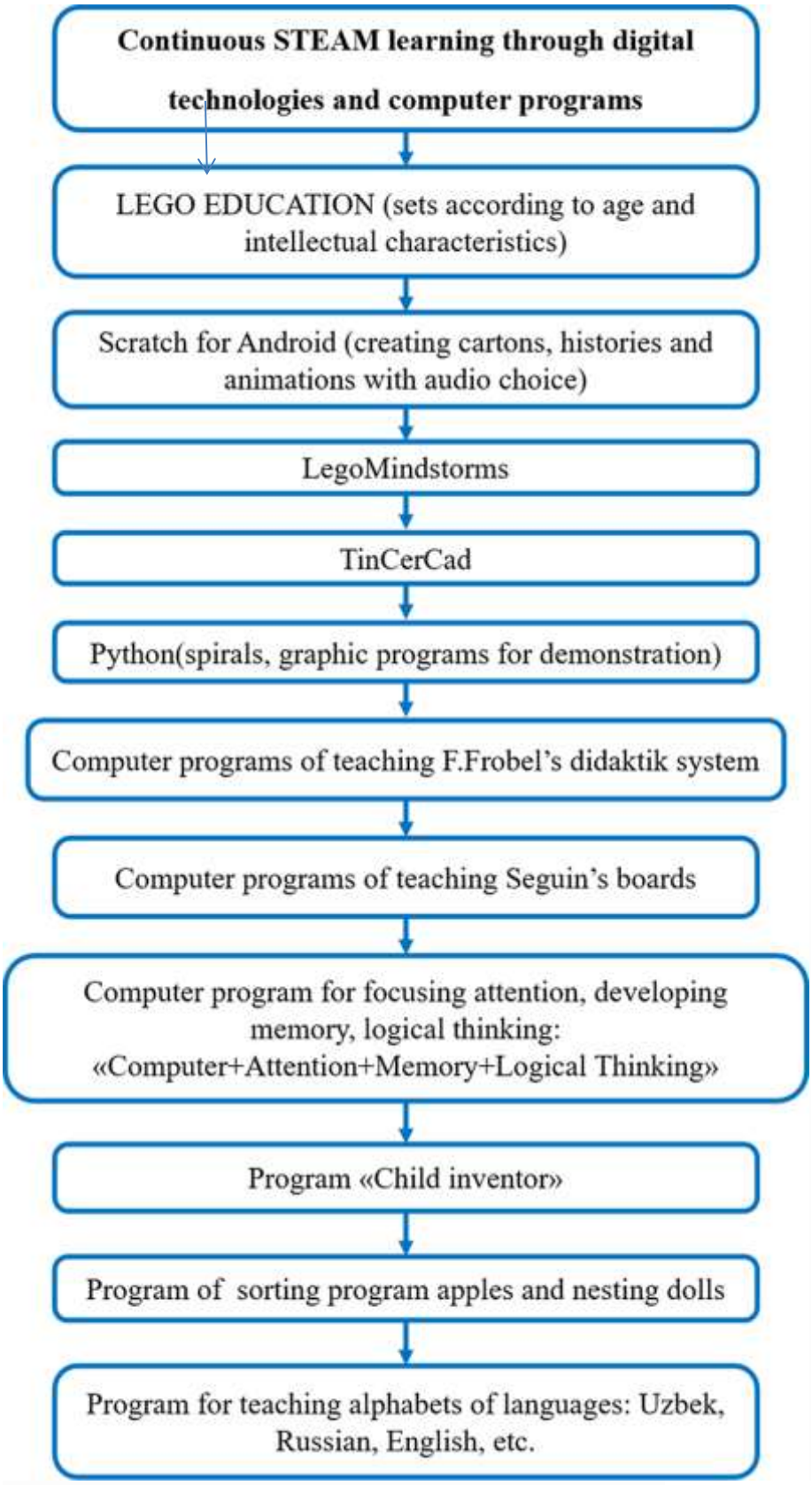

Figure 4. Metgods STEAM teaching with computer programs.

Improving didactic teaching systems using computer programs at school:

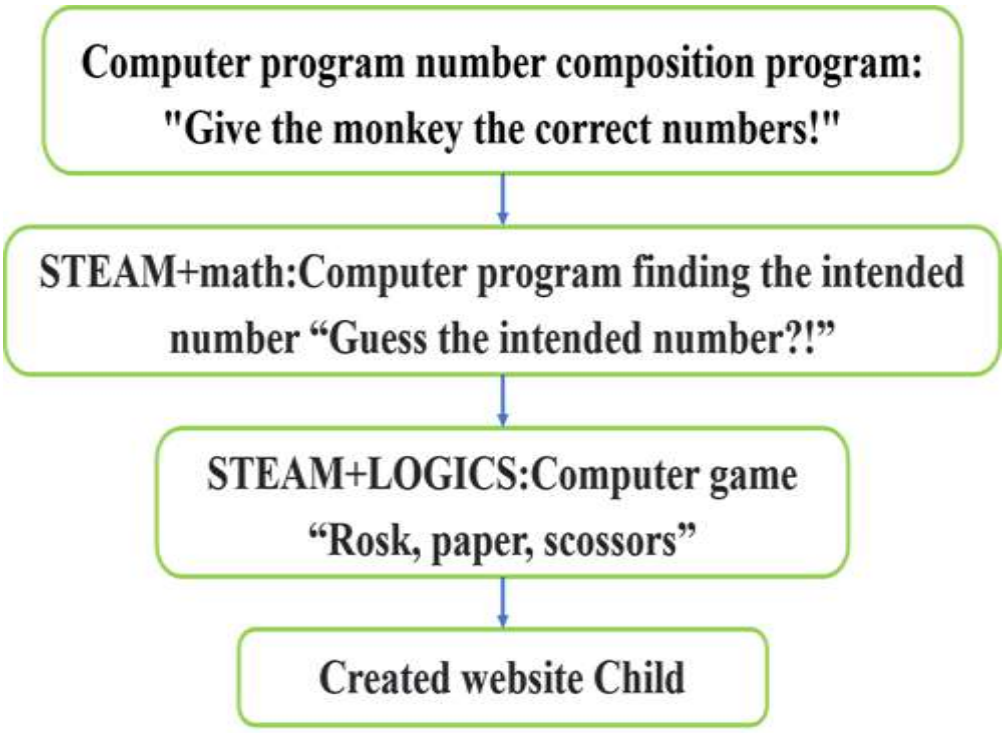

Figure 5. Teaching with computer programs. STEAM teaching with computer programs at school.

During the school period, for STEM education, it is necessary to move from block programming to code programming, from Scratch to Python, with the help of Scratch to STEAM (Figure 5).

For a smooth transition from Scratch to Python, you need training in the following programs:

1) Scratch for Arduino-SA4 block - for teaching the technical side of block programming;

2) Edublock - for training in the program for a smooth transition from block programming to code;

3) mblock - for the transition from STEAM education to code education;

4) Scratch for Android - use of a mobile application to create a cartoon, it can be used at 7-8 years old, for first and second graders;

5) Scratch for Windows - a program used in grades 5-6;

6) Python - using input into the basics of code programming.

7) Ardublock;

In this area, we propose the use of such programs and sites in school STEAM education:

1) Website for children "Child";

2) Game program "Rock, Scissors, Paper";

3) Mathematical program "Guess the intended number?";

4) Program in Scratch "Racing your car"

In higher education, it is acceptable to create websites in systems such as WordPress. Moodle [51]. Training in 3D modeling programs, CAD design technologies is also required. We can include a set of modeling training programs among such programs: ScetchUP, Blender, TinCerCaD, FreeCad, LibreCad, SolidWorks, SolveSpace, AutoDesk AutoCad, Autodesk Fusion 360, Tinkercad, progeCAD Smart 2009, Autodesk Fusion 360, Autodesk TincerCad, Microsoft 3d Builder, 3D Orchard , ZW3D, Bricscad, AutoDesk Inventor, программы Autodesk - AutoCAD, 3ds Max, Alias, Revit, Navisworks, SolidWorks PDM, SolidEdge, Compass-3D, T-FLEX,RTS Creo, NX Siemens PLM

Software, Catia, onShape system program, Trik studio-simulastion robotics, Algodoo in physics, Tincercad Circuits in electrical engineering.

As we see, it is impossible not to do without engineering programs, everything is connected with computer engineering, technology that requires a technical approach to teaching, in which attention must be paid along with the education of boys and special attention should be paid to girls.

In higher education we offer the use of such programs as:

1) Website on Statistical Physics;
2) Program for using HTML, etc. Program for creating front end;
3) A program for creating robot movement along a black line;
4) A program to create a robot moving along a white line.

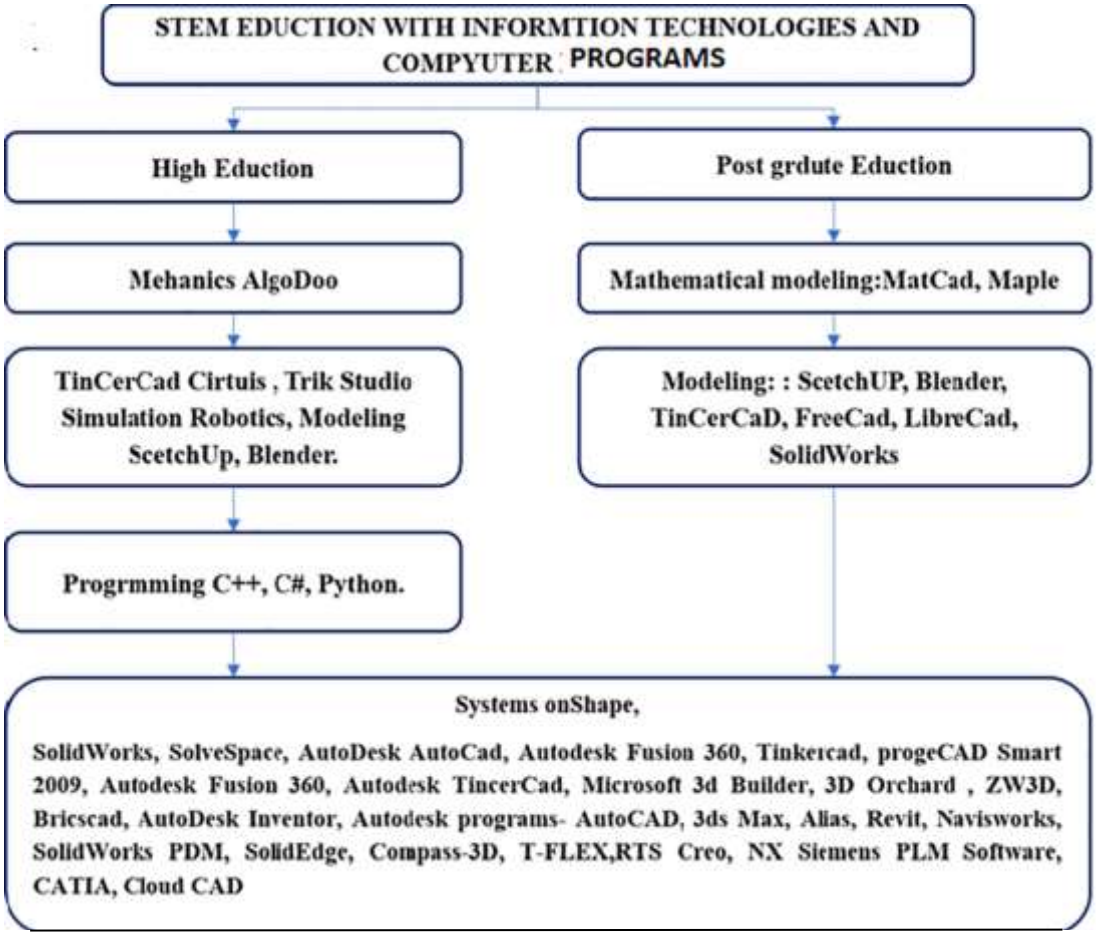

Figure 6. STEAM reaching un High School.

Teaching with 3s modeling programs, wirh SAPR texnologies, online programs, with programs of robotics, physics, modeling, teaching of work at the 3d printer (Figure 6).

The research team of the US National Research Council's Deep Learning and 21st Century Skills Committee proposes the following categories of skills that contribute to deep learning, which can be used in various contexts and areas of learning: cognitive skills (critical thinking, information literacy, reasoning and thinking logically, creativity, innovation), interpersonal skills (communication, collaboration, responsibility, conflict resolution, leadership) and intrapersonal skills (intellectual openness, conscience, positive self-esteem). In Singapore, the Ministry of Education, a country leading international PIRLS and PISA studies, has identified the following skills that will enable students to "succeed in school and beyond, in life, learning and working in a fast-changing, highly digital and interconnected world": critical, adaptive and inventive thinking;

communication, collaboration and information skills; civic, global and intercultural literacy. These skills are called "emerging 21st century skills." In Finland, the implementation of whose experience was much discussed last year, the National Curriculum defines the following “basic” skills (transversal skills) that must be developed within any academic discipline: thinking and the ability to learn; cultural competence, interaction and expression; self-care and managing daily life; multi-literacy; ICT competence; competence in working life and entrepreneurship; participation, engagement and building a sustainable future.

To develop 4K competencies in the Global Framework on Transferable Skills, the United Nations Children's Fund (UNICEF) focuses on the urgent need to expand, reimagine and transform education and educational systems so that they can provide children with quality education that includes the skills they need to succeed in school, work and life. The document notes that “transferable skills” (or “soft skills”, “21st century skills”, “life skills”) are central and serve as the basis for mastering other skills.

“Transferable skills” include cognitive skills (problem solving, informed decision making, planning, goal setting), social skills (communication, collaboration, conflict resolution, negotiation) and emotional skills (understanding one’s own and others’ emotions, empathy, coping skills). with stress). Based on these general criteria, general criteria “Formation of competencies “4K” (critical thinking, creativity, communication, collaboration) of students in professional educational organizations” were developed by the St. Petersburg Academy, which were announced on the Internet in 2021 (Figure 7).

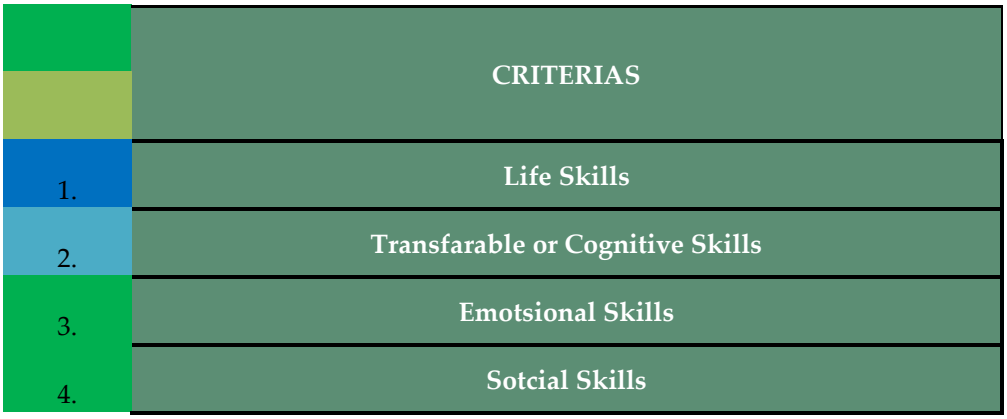

Figure 7.Criterias of 4k Teaching.

To identify the effectiveness of teaching, we accepted the H0 hypothesis that both of our samples of teaching children were from the same round. The second hypothesis states that the effectiveness of training depends on the use of ICT. We selected two groups, control and experimental, in which there were an equal number of students, and also applied to the control group a teaching methodology with a STEAM approach without the use of a computer. Conducted testing and received results. The training was traditional. Conducted statistical processing of the data (Table 1).

Table 1. Continious education of children in preschool education using information and computer means

Groups	Number of pupils in school	The level of assimilation of knowledge on the integration of several subjects in STEAM. The level of assimilation of knowledge on the integration of several subjects in STEAM with ICT		
		Low	Medium	High

Experimental	**100**	**11**	**31**	**59**

Table 2. Continious education of children in preschool education using information and computer means

Groups	**Number of pupils in school**	**The level of assimilation of knowledge on the integration of several subjects in STEAM with ICT**		
		Low	**Medium**	**High**
Total	**100**	**36**	**24**	**36**

Next, we conducted training using Lego Educatiion, Lego Mindstorms, TinCerCad, as well as a chain of programs we created. Scratch for Android, as well as a chain of computer programs created by us. The training was carried out in experimental groups. We conducted a survey, a survey, and then tested after training. We processed the obtained results using the method of mathematical statistics of Pearson and Student. According to Pearson, it turned out that our H0 hypothesis was not true, we refuted it and chose the H1 hypothesis. It turned out that when using ICT training, the effectiveness of training increases. 4K competencies also increase: creativity, critical thinking, collaboration, communication (Table 2).

$$\ddot{x} = \frac{1}{n}\sum_{i=1}^{C} ni * xi = \frac{1*11+2*31+3*59}{100} = \frac{73+177}{100} = \frac{250}{100} = 2{,}5$$

$$\ddot{y} = \frac{1}{n}\sum_{i=1}^{C} ni * xi = \frac{1*36+2*24+3*36}{100} = \frac{84+108}{100} = \frac{192}{100} = 1{,}92$$

In the experimental group, the efficiency increased, i.e.:

$$. \ddot{x} = \frac{2{,}5*100}{3} \cong 80\%$$

$$\ddot{y} = \frac{1{,}92 * 100}{3} \cong 64\%$$

In the experimental group, efficiency increased, i.e.

$$\ddot{x}\text{-}\ddot{y} \cong 80\% - 64 \cong 16\%$$

Training efficiency increased by

16%.

In STEAM education, it is necessary to form 4K competencies, which include scientific, technological, educational, creative, technical, technological and engineering, mathematical components that require training in the subjects included in them. Requiring to have competencies in creativity, critical and creative thinking, cooperation, ecommunication, collaboration.

We selected general cpmpetences of STEAM education, they are following::

Several basic elements of critical thinking can be identified:

1. Analysis. The ability to find connections between statements, questions, arguments.

2. Evaluation. The ability to evaluate the reliability of statements and the persuasiveness of arguments.

3. Explanation (argumentation). Ability to explain your thoughts/method,

defend your conclusions.

4. Deriving hypotheses (planning decisions). Ability to form hypotheses and draw conclusions yourself, discover a lack of information.

5. Self-regulation (control). Reflection, self-test and correction.

Creativity or creative thinking:

Curiosity (active interest in the task):

❖ interest in the surrounding world (task situation) and desire to learn more about the surrounding world (about various aspects of the task situation; pronouncing associations);

❖ independent search for answers to your own questions. Active search for a new information (including from unexpected sources).

2. Creating ideas (imagination). Producing your own ideas. Here

❖ Two aspects stand out: originality of the proposed ideas; flexibility or mobility, the ability to produce large quantities ideas.

3. Development of proposed ideas:

❖ assessment of proposed ideas from different positions and search for their strengths and weaknesses parties in order to improve the idea or abandon it;

❖ ability to quickly restructure one's activities in changing conditions and with the emergence of new information about the object of study.

The structure of cooperation criteria is as follows:

The structure of this competency/skill is presented as follows:

1. Willingness to communicate:

❖ lack of fear when entering into communication, initiation communication, willingness to answer someone else's question, willingness to ask a question.

2. Adaptation to the purpose and context of communication and to the partner:

❖ in various communication situations the ability to choose different verbal and nonverbal means of communication, focusing on the emotional status of the partner.

3. Persuasive Communication:

❖ use of verbal (vocabulary and knowledge of language rules) and non-verbal means (gestures, facial expressions, intonation) to achieve the goal of communication

Cooperation structure.

The structure of this competency/skill is presented as follows.

1. Acceptance of common goals:

❖ ability to share the goals of the team and put them above one's own goals, to work in a team, integrate the result of your work into a collective decision, manage your emotions in teamwork.

2. Social interaction:

❖ participation in discussion, ability to negotiate, interact respectfully, listen and accept other people's opinions, coordinate one's actions with those of other team members;

❖ willingness to help them; willingness to take responsibility for the general result.

3. Fulfillment of undertaken obligations:

❖ willingness to take such a position and accept such a role that is effective for teamwork;

❖ responsible performance of one's part of the work, achieving quality result.

4. Independence and initiative:

❖ ability to work independently and take initiative within the assigned task;

❖ ability to involve all team members in solving a problem, to provide them psychological support, motivation

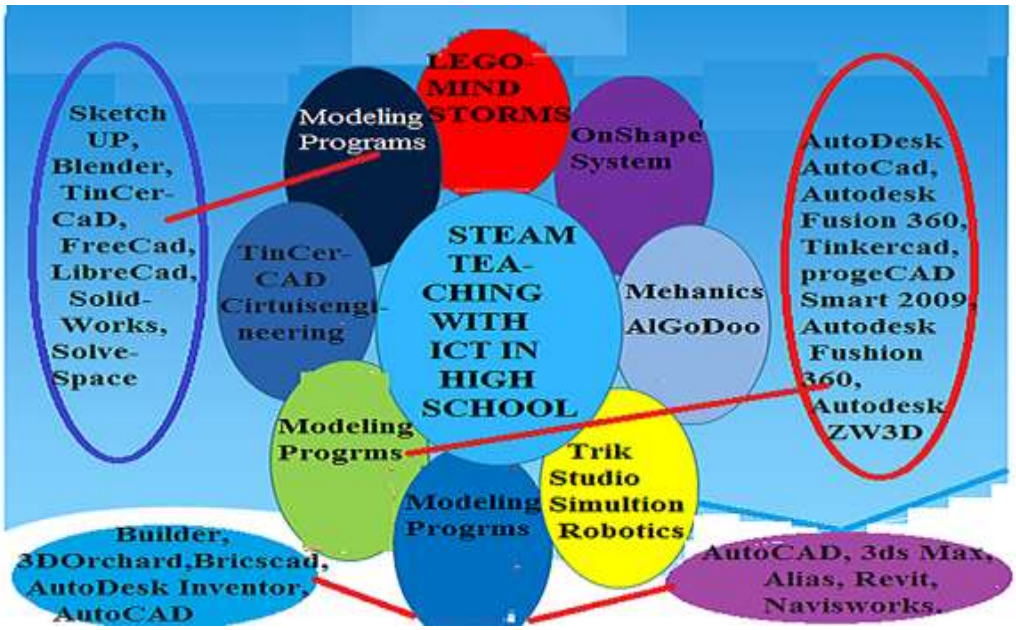

Figure 8. STEAM teaching with ICT in High school.

It should be noted that among these programs there are programs that work online. For example, ScetchUp. Training in CAD design technologies is also very popular; in today's age of programming and computer science, cloud-based uses of CAD technologies in education are already being used. Training in the field of five areas provides the formation of 4K competencies (Figure 8): communication, creativity STEAM thinking, critical thinking, collebrativity cognition teamwork, practical skills development, connections between science, and technology, as well as theory and practice in general [52].

One of the important criteria for learning STEAM is programming in C++, C#, Python.

Discussion

In the preschool period, it is necessary to create ICT computer programs for the following stages of child development:

1) to become familiar with the environment;

2) on the formation of logical thinking;

3) to prepare preschoolers for school.

STEAM education in preschool period, taught modules:

The preschool period is a critical stage in a child's cognitive, social, and emotional development, during which the foundations for lifelong learning are established. The integration of Information and Communication Technologies (ICT) into early childhood education offers significant opportunities to support developmentally appropriate learning experiences. In particular, the design of ICT-based computer programs should correspond to key stages of preschool child development, ensuring both pedagogical effectiveness and age appropriateness [53].

First, ICT programs aimed at familiarizing children with their environment play an essential role in developing basic perceptual and cognitive skills. Interactive digital content such as educational games, animations, and simulations can help preschoolers explore natural and social environments in a safe and engaging manner [54. Through visual and auditory stimuli, children learn to recognize objects, colors, shapes, animals, and everyday phenomena, thereby expanding their vocabulary and general knowledge. Such programs support experiential learning by allowing children to learn through observation, interaction, and exploration.

4. Conclusion

The creation and application of ICT in education has always been the most relevant point in IT science, which has always carried the essence of teaching subjects, but with the use of new and new types of information technologies and computer programs that enriched or even led to a change in its content, more conveniently presenting material to the user, during this difficult period of providing a greater flow of information to the person. In teaching models, the means, computer programs, their types, the type of information technology have changed from simple projectors to a multi-projector, from computer programs to online applications and so on to artificial intelligence, to virtual and augmented realities and other innovations of scientific analytics educational robotics computer science

Acknowledgments

We are grateful to our consultants for providing valuable advice, as well as ideas for connecting our work with government orders, requirements, etc. We are also grateful to the heads of universities and faculties who provided us with respondents from their preschool, school institutions, as well as universities and institutes. We are grateful to the respondents themselves, children, students, as well as their parents for giving permission to conduct experiments and for their participation with children.

REFERENCES

[1] S. L. J. M. Feola *et al.*, "STEM education institutional change projects: Examining enacted approaches through the lens of the Four Categories of Change Strategies Model," *Int. J. STEM Educ.*, vol. 10, no. 67, 2023, doi: 10.1186/s40594-023-00.

[2] G. Yunusova, "O'zbekiston Respublikasida axborot texnologiyalari va kompyuter dasturlari yordamida STEAM uzluksiz ta'limni shakllantirish," *Scientific Bulletin of Namangan State University*, 2023.

[3] G. N. Yunusova, "Programming and robotics in digital platforms of STEAM education," *Finland Int. Sci. J. Educ., Soc. Sci. & Human.*, vol. 10, no. 12, 2022.

[4] M. Akbar *et al.*, "Sol y Agua: A game-based learning platform to engage middle-school students in STEM," in *Proc. IEEE Frontiers in Education Conf. (FIE)*, 2018, pp. 1–9.

[5] M. Alhabri and S. Huang, "An augmentative system with facial and emotion recognition for improving social skills of children with autism spectrum disorders," in *Proc. IEEE Int. Systems Conf. (SysCon)*, 2020, pp. 1–6.

[6] L. Wang *et al.*, "Effects of digital game-based STEM education on students' learning achievement: A meta-analysis," *Int. J. STEM Educ.*, vol. 9, no. 26, 2023.

[7] G. N. Yunusova, *Scratchda Lego Konstruktsiyalash Asosidagi Muhandislik Dasturlashtirish va Zamonaviy Informatika O'qitish Metodikasi*, Namangan, Uzbekistan, 2022.

[8] G. Yunusova, "Scratch dasturida birinchi proyektini yaratish uslubiyoti," 2021.

[9] F. Aprin, P. Peters, and H. U. Hoppe, "The effectiveness of a virtual learning companion for supporting the critical judgment of social media content," *Educ. Inf. Technol.*, 2022.

[10] H. G. Cheng *et al.*, "DIRT: A deep learning theory of item response for cognitive diagnostics," in *Proc. 28th ACM Int. Conf. Information and Knowledge Management*, 2019, pp. 2397–2400.

[11] F. Chen, Q. Lu, Y. Cui, and Y. Gao, "Modeling learning outcomes in computer-based learning assessments: A sequential deep collaborative filtering approach," *IEEE Trans. Learn. Technol.*, vol. 16, no. 2, pp. 243–255, 2023, doi: 10.1109/TLT.

[12] D. Woo, "Central practitioners' developing legitimate peripheral participation in a community of practice for changing schools," *Australas. J. Educ. Technol.*, vol. 31, no. 2, 2015.

[13] C. L. Wu and H. Y. Wu, "The exploration of continuous learning intention in STEAM education through attitude, motivation, and cognitive load," *Int. J. STEM Educ.*, vol. 9, no. 35, 2022.

[14] Y. Bergner *et al.*, "Model-based collaborative filtering analysis of student response data," in *Proc. Int. Conf. Data Mining in Education*, 2012, pp. 95–102.

[15] D. Baidoo-Anu and L. Owusu Ansah, "Education in the era of generative artificial intelligence: Understanding the potential benefits of ChatGPT in promoting teaching and learning," 2023.

[16] H. A. Eidlin-Levy *et al.*, "Math anxiety affects career choices during development," n.d.

[17] D. Chaplot *et al.*, "Learning cognitive models using neural networks," in *Proc. Int. Conf. Artificial Intelligence in Education*, 2018, pp. 43–56.

[18] C. Chen *et al.*, "The role of media in influencing students' STEM career interest," *Int. J. STEM Educ.*, vol. 10, no. 56, 2023, doi: 10.1186/s40594-023-00448-1.
[19] A. Y. Wang, "Exploring the relationship of creative thinking to reading and writing," *Thinking Skills Creativity*, vol. 7, no. 1, pp. 38–47, 2012, doi: 10.1016/j.tsc.2011.09.001.
[20] E. Wenger, R. McDermott, and W. M. Snyder, *Cultivating Communities of Practice*, Boston, MA, USA: Harvard Business School Press, 2002.
[21] E. Wenger, B. Trayner, and M. de Laat, *Promoting and Assessing Value Creation in Communities and Networks*, 2011.
[22] M. Pfeifer *et al.*, "Forging a science researcher identity in the context of research training," *Int. J. STEM Educ.*, vol. 11, no. 18, 2024.
[23] I. Alkinj, A. Pereira, and P. C. Santos, "The effects of an educational program based on modeling and social stories on improvements in the social skills of students with autism," *Heliyon*, vol. 8, no. 5, e09289, 2022.
[24] M. A. Almaiah *et al.*, "Examining the impact of artificial intelligence and social and computer anxiety in e-learning settings," *Electronics*, vol. 11, no. 22, 2022.
[25] L. Alvarez *et al.*, "A socially relevant focused AI curriculum designed for female high school students," *Proc. AAAI Conf. Artificial Intelligence*, vol. 36, no. 11, pp. 12698–12705, 2022.
[26] R. Deng and S. Shen, "Correction to: Improving the effectiveness of video-based flipped classrooms with questioning embedding," *Educ. Inf. Technol.*, 2023.
[27] W. Xu *et al.*, "The application of AI technologies in STEM education: A systematic review from 2011 to 2021," *Int. J. STEM Educ.*, vol. 9, no. 59, 2022.
[28] G. N. Yunusova, "Fizikaning elektronikasi va amaliy matematikaning tadbig'i robototexnikaga kirish: Arduino platasi," *Namangan State University Bulletin*, 2019.
[29] G. Yunusova, "Python dasturlash tili," vol. 1, pp. 167–170, 2021.
[30] D. N. Beede *et al.*, "Women in STEM: A gender gap to innovation," *Economics and Statistics Administration Issue Brief*, 2011.
[31] L. Anderson and T. Ward, "Expectancy-value models for STEM persistence plans of ninth-grade students," *Science Education*, vol. 98, no. 2, pp. 216–242, 2023.
[32] B. Wu and X. Chen, "Intention to continue using MOOCs," *Comput. Human Behavior*, vol. 67, pp. 221–232, 2017.
[33] A. Kraft *et al.*, "Prior experiences and adoption of evidence-based instructional practices," *Int. J. STEM Educ.*, vol. 11, no. 18, 2024.
[34] U. Bergmark *et al.*, "Why become a teacher?" *Eur. J. Teacher Educ.*, vol. 41, no. 3, pp. 266–281, 2018.
[35] J. K. Alexander *et al.*, "Opportunities to learn science and interest development," *Science Education*, vol. 96, no. 5, pp. 763–786, 2012.
[36] L. Anderson and T. Ward, "Expectancy-value models for STEM persistence," *Science Education*, vol. 98, no. 2, pp. 216–242, 2023.
[37] L. Zeng and M. Z. Zeng, "Factor structure of website creativity," *Comput. Human Behavior*, vol. 25, no. 2, pp. 568–577, 2009.
[38] C. Dongam *et al.*, "Emergency remote teaching during COVID-19," *Int. J. STEM Educ.*, vol. 9, no. 19, 2022.
[39] Q. Khusanov *et al.*, "Improving electronic learning in interdisciplinary faculties," *NamDU Scientific Bulletin*, vol. 2, pp. 440–443, 2017.
[40] V. H. Van Daal and R. P. Van der Leij, "Computer-assisted learning to read and spell," *J. Res. Reading*, vol. 23, pp. 181–193, 2000.
[41] V. Videnovik *et al.*, "Game-based learning in computer science education," *Int. J. STEM Educ.*, vol. 10, no. 54, 2023.
[42] G. N. Yunusova, "Creating a website in WordPress for children aged 1–6," *Acta of Turin Polytechnic University in Tashkent*, pp. 72–78, 2022.
[43] G. N. Yunusova, "Programming and robotics by STEAM learning," 2022.
[44] G. N. Yunusova *et al.*, "Improving STEAM technologies by strengthening modeling, programming, and robotics," *JCHR*, vol. 14, no. 2, pp. 1244–1262, 2024.
[45] M. Dancy and A. K. Hodari, "How physicists maintain ignorance of inequity," *Int. J. STEM Educ.*, vol. 10, no. 45, 2023.
[46] G. N. Yunusova, "STEAM-based electronic boards and computer games," *Ta'lim Fidoiylari Jurnali*, vol. 1, 2021.
[47] G. N. Yunusova, "Modeling physical processes with Crocodile Physics," *Finland Int. Sci. J. Educ., Soc. Sci. & Human.*, vol. 11, pp. 825–839, 2023.
[48] M. Nalipay *et al.*, "Promoting STEM learning perseverance," *Int. J. STEM Educ.*, vol. 11, no. 17, 2024.

[49] Y. Zhai and L. Xu, "Science teacher identity research," *Int. J. STEM Educ.*, vol. 11, no. 20, 2024.
[50] X. Zhang, "Innovating students' learning through OER," *Educ. Inf. Technol.*, 2023.
[51] S. Gamage and B. M. Gamage, "Using Moodle for teaching and learning," *Int. J. STEM Educ.*, vol. 9, no. 9, 2022.
[52] S.-H. Yang, "Effective feedback practice in online communities," *Comput. Educ.*, vol. 94, pp. 162–177, 2016.
[53] D. Baidoo-Anu and L. Owusu Ansah, "Education in the era of generative AI," 2023, doi: 10.2139/ssrn.4337484.
[54] E. Wenger, N. White, and J. D. Smith, *Digital Habitats: Stewarding Technology for Communities*, 2009.