Integrating formative assessment into higher education learning environment

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Abstract

The article explores the aspects of integrating formative assessment into the design of the learning environment. A pedagogical experiment was conducted at the National University Zaporizhzhia Polytechnic during the 2023-2024 academic year, focusing on the graphic training of first-year Industrial Engineering students. The experiment, carried out in three phases (ascertaining, formative, and control), it involved 56 students in the experimental group from the educational programs "Operation, Testing and Maintenance of Automobiles and Tractors" and "Internal Combustion Engines". The control group consisted of 86 students from the programs "Metal-cutting Machines and Systems" and "Lifting and Transport, Road, Construction, Land Reclamation Machinery and Equipment". The study concluded that formative assessment fosters a culture of independent work among students. A pedagogical model was designed to integrate formative assessment into students' independent work, emphasizing a cyclical structure to enhance assessment skills. The main qualities developed through formative assessment include educational, personal, professional skills, and qualities related to cooperation and co-creation within the educational process. The article also highlights the role of digital technologies in the educational process. Key indicators of formative assessment identified are motivation to learn, self-analysis, self-assessment, mutual assessment, self-confidence, personal responsibility, and teamwork. The results demonstrate the positive impact of formative assessment on fostering a culture of independent work among students, supported by digital technologies.

Keywords

formative assessment, students' independent work culture, digital technologies, graphic training

1. Introduction

The higher education system is continually evolving, necessitating innovative approaches to assess both the process and outcomes of professional training. Modern skills for future specialists, such as goal-setting, process and result analysis, strategic learning adjustments, and the evaluation of personal and peer learning activities, are becoming increasingly relevant and promising.

Formative assessment plays a crucial role in the modernization of education. It is a significant element in the design of learning environments, uncovering students' potential and cognitive abilities for independent work while aiming to cultivate a culture of self-directed learning. We believe formative assessment is an analytical tool that enhances learning quality. In the context of personality-based and student-centred learning, its relevance and timeliness are evident.

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The scientific literature on learning environment design includes several synonymous pedagogical terms: Instructional Systems Design, Educational Design, Learning Environment Design, and Pedagogical Design. Educational design refers to the planning of educational activities aimed at achieving specific, predefined learning outcomes [1]. Learning design is a systematic approach to planning, developing, and implementing effective learning processes. It is grounded in scientific understanding of how people learn and utilizes various methods and tools to achieve well-defined learning goals.

From the authors' perspective, learning environment design, or pedagogical design, involves creating a learning environment that promotes a culture of independent student work. This design aims to foster students' independent mastery of knowledge, skills, and abilities to seek out and apply various methods and means of processing educational information. This process is supported by the scientific and methodological guidance of a teacher, enabling students to develop both personal and professional competencies.

The goal of pedagogical design is to develop effective strategies, methods, and techniques for educational processes while ensuring a supportive psychological and pedagogical environment that enables students to achieve the outcomes of their educational and professional programs.

In essence, learning environment design is the art of creating and implementing educational courses within an academic setting. Key components of pedagogical design include:

- Clear learning objectives: Well-defined goals that outline the competencies students should acquire by the end of the course.
- Effective learning content: Materials, including lectures, workshops, assignments, and other resources, that are engaging, understandable, and aligned with the learning objectives.
- Diverse learning methods: A variety of teaching and learning approaches to engage students and enhance their learning experience.
- Regular assessment: The inclusion of formative assessments throughout the learning process to gauge student progress and make necessary adjustments.

Integrating formative assessment with digital technologies into the learning environment design enhances the effectiveness of education in higher institutions. This approach aims to train qualified specialists while fostering their comprehensive development, considering each student's personal interests, needs, and abilities.

This article aims to identify the essential characteristics of formative assessment as a key element in learning environment design and to present the outcomes of its implementation in cultivating a culture of independent work among technical students.

2. Literature review

In 1967, Scriven [2] first proposed the distinction between formative and summative evaluation, highlighting their differing goals. Formative evaluation is aimed at developing and improving ongoing activities, whereas summative evaluation assesses learning outcomes [3]. Building on this foundation, Bloom et al. [4] further explored the essential characteristics of formative assessment in their 1971 work, "Handbook on Formative and Summative Evaluation of Student Learning". They emphasized its diagnostic function, arguing that students should master current material before progressing to the next stage of learning. Formative assessment involves final tests at each learning stage, administered by teachers to achieve learning goals for all students.

The concept of formative assessment gained official recognition abroad in the 2000s. Since then, various official documents and recommendations have been approved, reflecting this approach. In European countries, assessment has gradually evolved to involve learners actively in the educational process. The interaction between teachers and students, whose work is evaluated, provides opportunities to improve the educational situation by identifying students' strengths and weaknesses and their potential opportunities.

Over time, the main principles of formative assessment proposed by Bloom et al. [4] have evolved. Allal and Mottier Lopez [5] described this assessment as involving various technologies at all educational stages, regulating the learning process through feedback and adaptation, applying a differential approach to learning, and systematically improving the educational process.

Wiliam [6], and Earl [7] analyzed the impact of assessing students' practical activities on improving academic performance, and explored the definitions of "assessment for learning" and "assessment as learning". In their research, Ukrainian scientists expanded on these concepts, transforming them into primary assessment goals [8]:

- Assessment for learning: Teachers use insights from student progress to adjust the organization of learning.
- Assessment as learning: Students reflect on and monitor their progress to set learning goals.

The combined and systematic application of "assessment for learning" and "assessment as learning" can significantly enhance the educational process. Formative assessment involves various activities performed by educators and students to gather actual data on learning outcomes, which are then used to tailor teaching and learning methods to students' needs.

The Assessment Reform Group has developed a comprehensive "assessment for learning" framework aimed at enhancing the quality of learners' experiences and achieving educational goals. The basic principles of formative assessment include [9]:

- serving as a tool for effective teaching and learning planning,
- focusing on the ways students learn,
- being an integral part of daily practical activities,
- representing a key professional skill for teachers,
- providing a positive and constructive learning experience, considering the emotional impact of assessment,
- emphasizing the importance of learner motivation,
- aligning with learning goals and ensuring a clear understanding of assessment criteria,
- offering teachers' productive support to improve students' independent work skills,
- cultivating students' ability to self-assess, enabling autonomous work,
- recognizing each student's achievements and efforts.

The systematic application of formative assessment principles relies on constructive interaction between teachers and learners. This interaction helps future professionals develop the personal and professional qualities essential for an independent work culture.

A theoretical analysis of foreign experiences in implementing formative assessment has confirmed its high effectiveness in improving educational achievements, particularly among students who previously failed to meet expected outcomes [10, 11, 12].

Between 2002 and 2005, the Organization for Economic Co-operation and Development (OECD) studied the formative education model in institutions across eight countries: Australia, Canada, Denmark, Great Britain, Finland, Italy, New Zealand, and Scotland. This model demonstrated significant educational progress, coordinated teamwork, and the development of an independent work culture. The study identified six conditions for effective learning [13]:

- creating a supportive group culture that encourages the use of assessment tools,
- setting educational goals and monitoring individual progress,
- employing diverse teaching methods to address students' educational needs,
- using varied approaches to assess learners' understanding of the material,
- providing feedback to adapt the learning process to students' needs,
- actively involving students in the learning process.

A number of scholars and practitioners have devoted their work to exploring effective formative assessment in the design of learning environments [14, 15, 16, 17, 18, 19].

The achievements of foreign and Ukrainian scientists in the field of formative assessment have laid the groundwork for incorporating this approach into the development of an independent work culture among students in technical disciplines.

To fully understand the essence of formative assessment, it is essential to explore its content. Here, we present various interpretations of this concept as found in the scientific literature:

- The process of monitoring and assessing students' learning and understanding to adapt teaching methods to better address individual needs [20].
- Teacher and student activities that provide feedback to adjust the learning process [21].
- The process of finding and interpreting data that students and teachers can use to make decisions about current learning status, future goals, and the best path to achieve them [9].
- A two-way process between the teacher and the student to optimize the learning process [22].
- A tool that helps improve learning [23].
- Interactive assessment of student progress that enables teachers to identify student needs and adapt learning accordingly [24].
- Measurement and judgment of the quality of student achievements in relation to educational goals [25].
- Assessment of a student's progress in education, emphasizing strengths rather than mistakes, and adjusting the educational program and teaching methods according to individual needs. It includes teaching students to independently assess their achievements and progress, set goals, and choose the means to achieve them [26].

The provided definitions of "formative assessment" allow us to view this concept as a tool for measuring the quality of students' knowledge, abilities, and skills, as well as the realization of educational goals. It is aimed at identifying individual cognitive needs, facilitating independent assessment of educational achievements, monitoring progress, and fostering a culture of independent work.

We believe the main conceptual idea is that formative assessment is a purposeful, systematic process of monitoring the academic success of learners – active participants in educational activities. This process focuses on acquiring a comprehensive set of knowledge, skills, and abilities in their chosen specialty and provides constructive support. It is also a critical component in designing a learning environment that cultivates students' independent work culture in professional training.

The purpose of formative assessment is to enhance the effectiveness of students' cognitive activities, improve the learning process, and develop personal qualities essential for professional practice.

3. Methodology

The pedagogical experiment was conducted following a robust methodology to ensure the validity and reliability of the results. The study employed a quasi-experimental design, as the participants were not randomly assigned to the experimental and control groups due to the pre-existing class structures at the university.

3.1. Participants

The study involved 142 first-year students majoring in Industrial Engineering at the National University Zaporizhzhia Polytechnic during the 2023-2024 academic year. The experimental group (EG) consisted of 56 students enrolled in the programs "Operation, Testing and Maintenance of Automobiles and Tractors" and "Internal Combustion Engines". The control group (CG) comprised 86 students studying "Metal-Cutting Machines and Systems" and "Lifting and Transport, Road, Construction, and Land Reclamation Machinery and Equipment".

3.2. Procedure

The pedagogical experiment was carried out in three distinct stages:

1. Ascertaining stage: A pilot section was conducted using the graphic control method to investigate the state of formation of the students' independent work culture in both the EG and CG. The levels of formation were categorized as elementary (0-60 points), reproductive (61-75 points), productive (75-89 points), and creative (90-100 points).
2. Formative stage: Students in the EG incorporated formative assessment using digital technologies into the learning environment for the course "Descriptive Geometry, Engineering, and Computer Graphics", while students in the CG followed a traditional methodology without formative assessment.
3. Control stage: A graphic control method and statistical analysis were conducted to assess the levels of students' independent work culture in both groups. The non-parametric Chi-square test was used with an allowable error margin of ±5% to ensure the objectivity of the experimental data.

3.3. Data analysis

The chi-square test was selected for data analysis due to its appropriateness for sample sizes greater than 50. This statistical criterion assesses the difference between observed (empirical) and expected (theoretical) frequencies. The larger the deviation between the computed chi-square value and the critical value from the chi-square distribution table, the more substantial the differences between the distributions of the samples under consideration. These discrepancies enable the determination of whether there is a statistically significant difference in the distribution of the attribute under study, specifically the level of development of students' independent work culture [27].

4. Results and discussion

The implementation of formative assessment is grounded in the principles of systematic, personalized, and activity-based approaches. Key indicators of formative assessment include motivation to study, self-analysis, self-assessment, self-confidence, personal responsibility, and teamwork. In this context, students become active participants in the educational process, taking responsibility for their own progress, while the teacher acts as an organizer, mentor, and facilitator of students' educational, cognitive, and research activities, fostering a culture of independent work. The integration of digital tools in education further simplifies the evaluation process through automation.

Formative assessment incorporates new strategies in education, such as identifying students' needs, fostering independence and interaction, acquiring knowledge and skills, checking understanding and metacognition, and observing the educational process. Assessment strategies should be designed to support and promote the development of student independence, encouraging students to take greater responsibility for their learning, become more self-regulating, and achieve greater autonomy [28]. Therefore, the choice of assessment strategy depends on the stage of the educational activity, its purpose, desired outcomes, and the teacher's role in helping learners reflect on their academic success and build an individualized educational trajectory.

The purpose of using formative assessment in professional education is to ensure students' research-reflective independence. This approach enables all participants to monitor and timely adjust the educational process, ensuring it remains focused on achieving competency-based outcomes.

4.1. Implementing formative assessment in the learning environment design of the graphic discipline "Descriptive Geometry, Engineering, and Computer Graphics"

Our study adhered closely to the principles, which are essential for guiding the ethical dimensions of pedagogical experimentation, research, and the dissemination of findings [29]. By following these

principles, we aimed to ensure that our work maintains the highest standards of integrity and transparency, minimizing any potential negative impact on individuals, institutions, and the broader scientific community.

The effective formative assessment process consists of several key components and their associated tasks:

- Assessment of Students' Needs: This involves updating knowledge on the topic, tapping into students' subjective experiences, generating interest in the subject matter, and preventing misunderstandings.
- Motivating Self-Organization: Encouraging students to take initiative in their educational activities helps develop independent work culture and fosters collaboration. This includes systematic tracking of progress through feedback loops between students and teachers, enabling the identification of knowledge gaps and reinforcing strengths.
- Understanding Educational Content: Formative assessment also checks for comprehension of educational material while promoting metacognition, encouraging students to apply their knowledge in new contexts.

Formative assessment is a continuous collaborative process between teachers and learners, where each participant engages in specific actions aimed at enhancing the quality of education (as illustrated in figure 1).

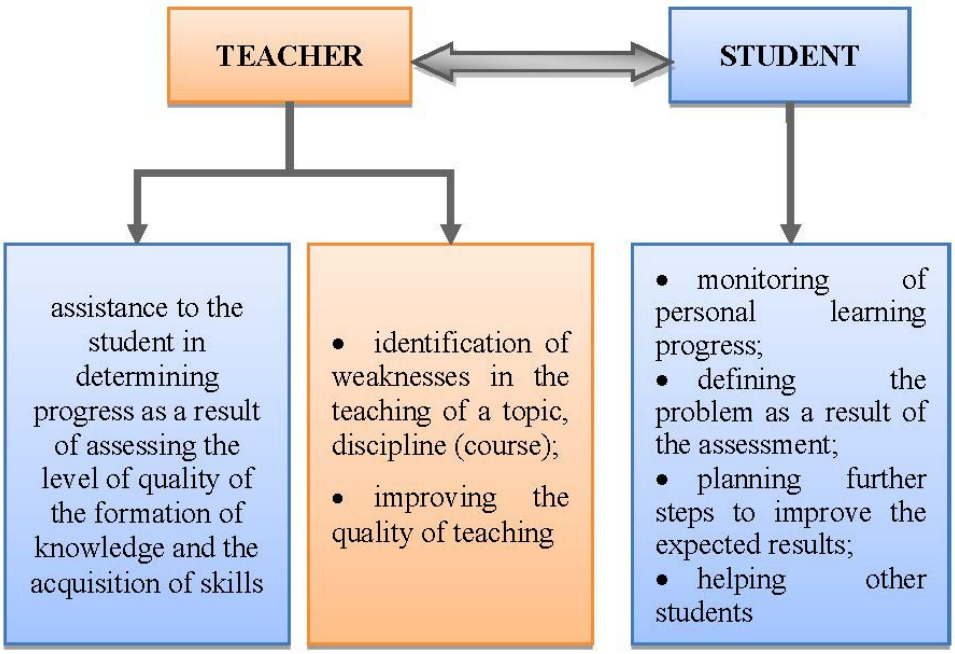


Figure 1: Interaction among participants in the educational process during formative assessment.

Formative assessment is conducted through a structured system involving consistent and systematic educational activities. These activities include observing students during independent work, asking questions to check their understanding, listening to explanations, and engaging in dialogue. Additionally, it involves examining the results of activities through various formats such as images, videos, and reports, as well as evaluating creative tasks that require innovation and creativity. The analysis extends to texts, tables, diagrams, mind maps, flowcharts, and interactive worksheets.

The assessment process employs methods such as observation, analysis, synthesis, comparison, generalization, and systematization. It also incorporates digital technologies to enhance the evaluation of educational activities. This approach allows students to develop a culture of independent learning and provides teachers with insights to adjust the educational process and address any difficulties encountered. Formative assessment aids learners in correcting their mistakes through innovative tasks

in both individual and team settings. If a student struggles with a particular question, they have the opportunity to revisit the material with the teacher's guidance.

Incorporating methods such as observation, analysis, synthesis, comparison, generalization, and systematization, along with digital technologies, significantly enhances the assessment of learning activities. This comprehensive approach enables students to cultivate a culture of independent learning and empowers teachers to adjust the educational process to address challenges effectively. Formative assessment plays a crucial role in helping students identify and correct their mistakes through innovative tasks in both individual and team settings. When students encounter difficulties, they have the opportunity to review and understand the material with the teacher's guidance, ensuring a more thorough grasp of the subject matter.

The integration of formative assessment in the learning environment offers significant benefits to both students and teachers:

- Students can evaluate their personal learning achievements, monitor their academic progress, and recognize the growth of their knowledge, skills, and abilities. They can also identify errors and gaps in their understanding and work to eliminate them.
- Teachers assist students in pinpointing their strengths and weaknesses, focusing on key areas of learning, and addressing problems promptly. They can also analyze and identify gaps in their teaching methods, which helps them improve their instructional skills.

This type of assessment fosters the development of critical and creative thinking skills, enhances students' ability to self-assess accurately, and promotes mastery of reflection and learning independence. Consequently, it is beneficial to implement formative assessment at all stages of a lesson: before it begins, during the lesson, and at its conclusion. The use of digital technologies simplifies the assessment process, making it more engaging and encouraging both learning and creativity. It also saves time, allowing for more constructive interaction between students and teachers in the classroom. The educational process incorporates various forms of formative assessment, including self-assessment, peer assessment, and teacher assessment of students' independent work (figure 2).

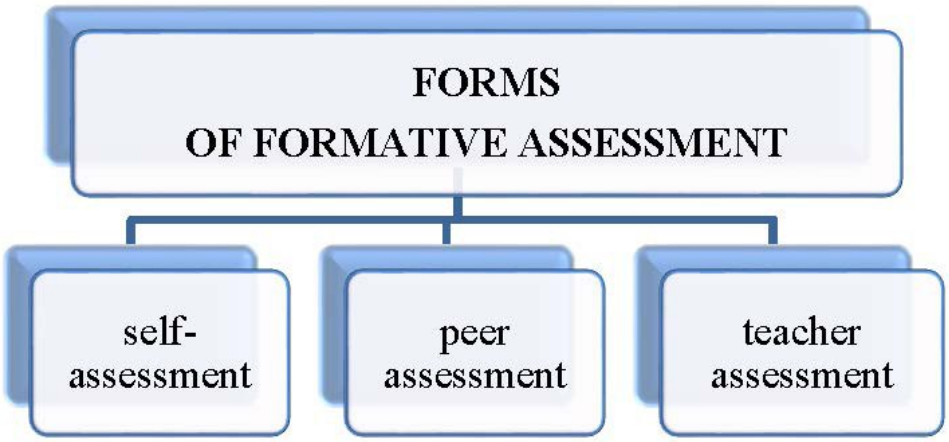


Figure 2: Forms of formative assessment of the learning process.

The development of self and peer assessment skills is a crucial aspect of education in the modern information society, as it enhances the learning capabilities of future professionals. The primary goal of self-assessment is to help students identify and rectify errors and gaps in their knowledge, evaluate their educational achievements, and determine the productivity of their work. This process fosters increased responsibility for their educational activities and a better understanding of educational goals and methods to achieve them.

Peer assessment skills enable students to analyze the quality of their peers' work based on clearly defined criteria, which they actively participate in developing and coordinating. This practice cultivates evaluative literacy and the culture of independent work, helping students understand tasks and

assessment standards. Evaluating each other in an atmosphere of trust and mutual respect allows for a thorough self-assessment and encourages future planning.

Teacher assessment of students' independent work, based on clear criteria, involves tracking academic progress, identifying difficulties in task completion, and providing personal support to each learner. The success of the assessment process hinges on creating a situation of success for the individual, fostering a subjective psychological state of satisfaction with their educational and cognitive activities, and promoting a personal culture of independent work.

Continuous tracking of students' progress is achieved through systematicity, represented as a cyclical structure in the formative assessment process. This involves repeatedly recording the results of specific actions within each cycle as part of the ongoing process (figure 3). The number of assessments within a lesson can vary depending on the students' progress towards set goals.

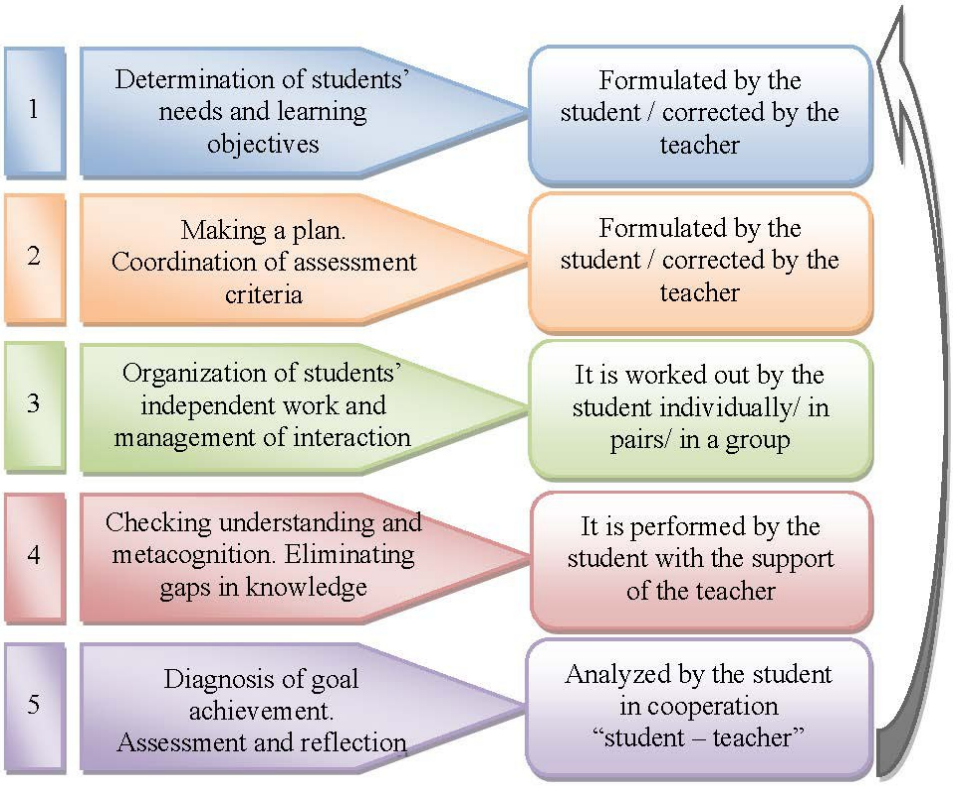


Figure 3: Cyclical structure of the formative assessment process.

When implementing formative assessment in the classroom, it is crucial for the teacher to systematically observe the process to:

- determine if students have mastered the topic,
- decide whether to proceed to the next topic,
- identify students with knowledge gaps and determine how to provide support,
- optimize teaching methods and adjust lesson planning.

The organization of students' independent work and the management of interactions occur within the systems of "teacher-student" and "student-student" relationships. Collaborative educational activities are reflected in the following actions:

- setting educational goals and establishing assessment criteria based on those goals,
- selecting methods for collecting data on student performance,
- observing the process of task completion and the personal achievements of each student in reaching specific goals,

- interpreting data to provide constructive assistance to students at various stages of their learning,
- making decisions on actions that can support students in the next stage of their independent work.

Based on these goals, we present our pedagogical design of the lesson, which includes the following structural elements: the purpose of formative assessment, methods, lesson stages, didactic tools, and assessment skills (figure 4). Depending on the goals of formative assessment, appropriate methods and tools for educational and cognitive activities are selected at each stage of the lesson.

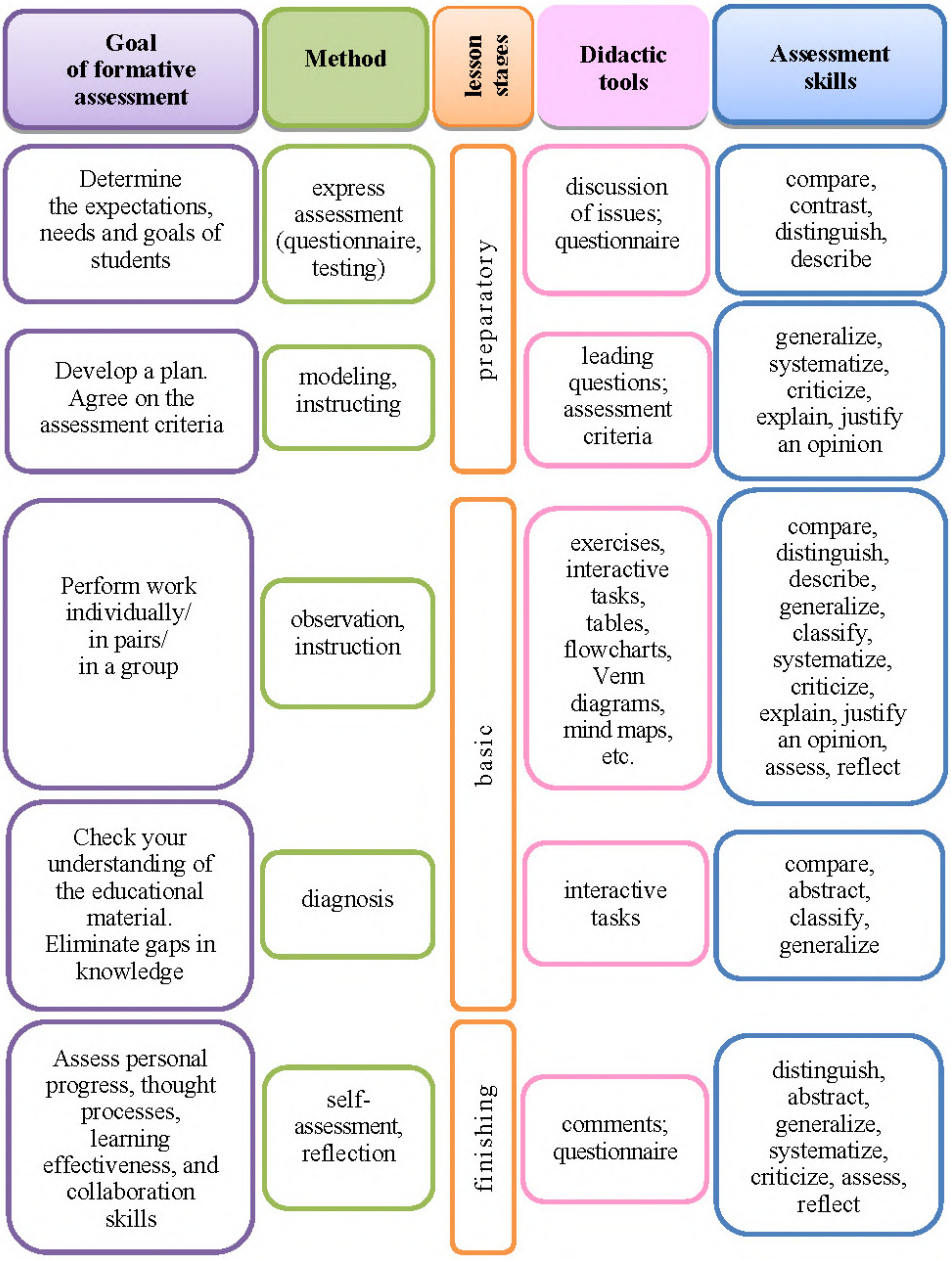


Figure 4: Pedagogical design of a lesson on the implementation of formative assessment.

Formative assessment in the process of students' independent work is systematically planned by the teacher and aims to develop the following:

- *Educational qualities*: These include motivation to succeed in educational activities, goal-orientation, independence, erudition, initiative, creativity, diligence, attentiveness, observation,

inquisitiveness, prudence, reflexivity, critical thinking, and responsibility for completed educational work.

- *Personal qualities*: These encompass motivation to achieve professional success, purposefulness, self-confidence, perseverance, independence, activity, diligence, erudition, discipline, self-organization, observation, attentiveness, inquisitiveness, tolerance, benevolence, objectivity, and principled behavior.
- *Professional qualities*: These qualities reflect the preparedness of future specialists to master and apply professional methods and tools effectively in practice.
- *Collaboration and co-creation in the educational process*: This includes tolerance, benevolence, attentiveness to others and their actions, sociability, communicativeness, objectivity, principled behavior, critical thinking, prudence, intelligence, and creativity.

The development of these qualities during the educational process is crucial for fostering a culture of independent work in each student. This includes cultivating skills in independent planning, modeling, self-assessment of educational activities, and enhancing analytical and reflective abilities.

Implementing the pedagogical design for formative assessment in the educational process ensures that students can evaluate their performance. This evaluation allows them to plan their work, operate autonomously, increase their motivation to learn, and improve their knowledge, skills, and abilities.

The integration of various formative assessment tools aligned with educational goals enables the discovery of new approaches to developing students' assessment skills through independent work and teamwork. At the preparatory stage of the lesson, students, with the teacher's guidance, identify their needs and learning goals and develop a work plan. Guiding questions help them understand the necessary actions to achieve their goals.

During the main stage of the lesson, students engage in tasks designed for individual independent work or collaboration in pairs/groups. Examples of didactic tools used include exercises, interactive tasks, tables, flowcharts, Venn diagrams, and mind maps (as shown in figure 4).

The organization of students' educational activities by the teacher was facilitated through the use of cloud services and web tools. A comprehensive set of digital technology tools was employed:

- For conducting video conferences: Zoom, Google Meet.
- For surveys and testing: Moodle, Google Forms, Mentimeter.
- For working with interactive online boards: Zoom, Canva, Padlet, Jamboard.
- For interactive communication: Google Blogger, Google Docs, Google Presentation, Google Drawings, LearningApps, YouTube, XMind, Word Cloud Generator, QR Code Generator.
- For professional study of the basics of mechanical engineering drawing and modeling: AutoCAD, SolidWorks.

We provide some examples of didactic tools used to implement formative assessment in the educational process for students studying "Descriptive Geometry, Engineering, and Computer Graphics".

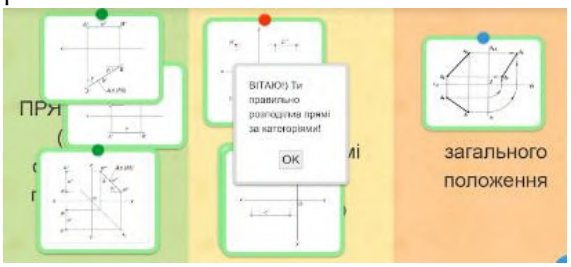
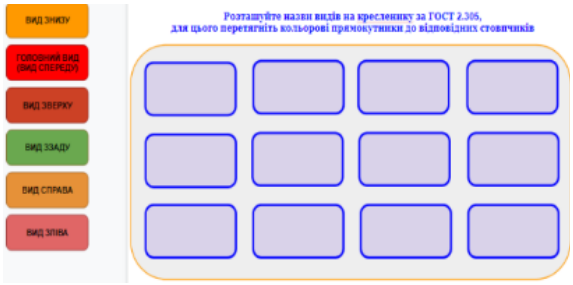
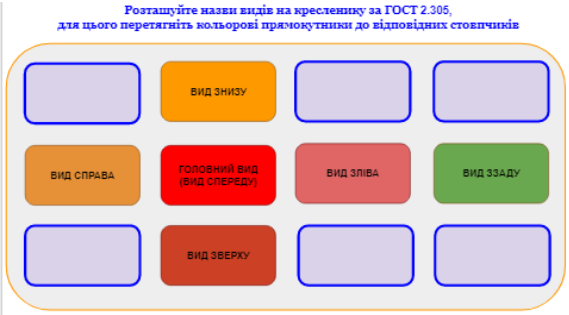
Interactive tests can be created on various web services and platforms. Examples of formative tests are presented in table 1.

The students employed various note-taking methods (such as Cornell's method, Bill Gates' method, mind maps, sentences, boxes, numbering, tables, indices, and thesis statements) to engage with the material and present their creative works in class.

Mind Maps and Note-Taking: Note-taking is a productive activity that involves reading the text (or listening to audio and watching videos), identifying key points, considering examples, and forming a summary by analyzing, synthesizing, and systematizing information. This process allows the teacher to assess the students' understanding and their ability to highlight main ideas and reproduce the structural and logical connections within the studied topic (as shown in figure 5).

The students in the EG actively participated in the scientific club "Geometric Modelling Using BYOD Technology: A Culture of Independent Work of Students". They showcased their educational and scientific achievements at both university and international conferences.

Table 1
Interactive tasks for self-control.

Test creation service, its condition	Purpose of the test, a sample of the task completed by the student
Test "Classification of straight lines" from the topic "Projection of a straight line"	
The test was created on the LearningApps.org web service. Task: Drag the image of the straight line on the epur in the right category	Purpose of the test: Identifying the level of knowledge of how to project a straight line onto three projection planes
	
Test "Location of the main views on the drawing" from the topic "Views. Projection of the main types on the drawing"	
The test was created in Google Presentation. Task: Place the names of views on the drawing according to state standard. Drag a specific view into the appropriate columns	Purpose of the test: Identifying the level of knowledge of how to project main views on the drawing
	

Tables: To implement this toolkit, the teacher determined the assessment criteria for a specific task in advance. These criteria were discussed with the participants in the educational process to ensure a clear understanding of the expected outcomes. If necessary, corrections and clarifications were made to the criteria, taking into account the levels of material awareness. Clearly defined and well-documented criteria enabled students to choose an individual educational trajectory for acquiring specific competencies and ensured an objective assessment of the process and outcomes.

As a result of the agreed-upon criteria, students learned to reflect, evaluated their peers' outcomes, and through peer assessment, evaluated their own personal and professional qualities and educational achievements.

To develop self and peer assessment skills, we present an example of the assessment criteria for understanding educational information on the topic "Threads" (table 2). Information can be presented in various ways: verbally, through videos, drawings, etc. Independent processing of the educational material according to the discussed task assessment criteria stimulates students to achieve better educational outcomes.

After completing the task, students compared the results of their work with the standard provided to them and evaluated the work verbally (table 3). The learners performed the same work in pairs during peer assessment.

Therefore, the data obtained from students' evaluation judgments represent a combination of predetermined and agreed-upon assessment criteria, previous educational experiences, and competencies (possession of knowledge and skills at a certain stage of education). This approach tracks their progress

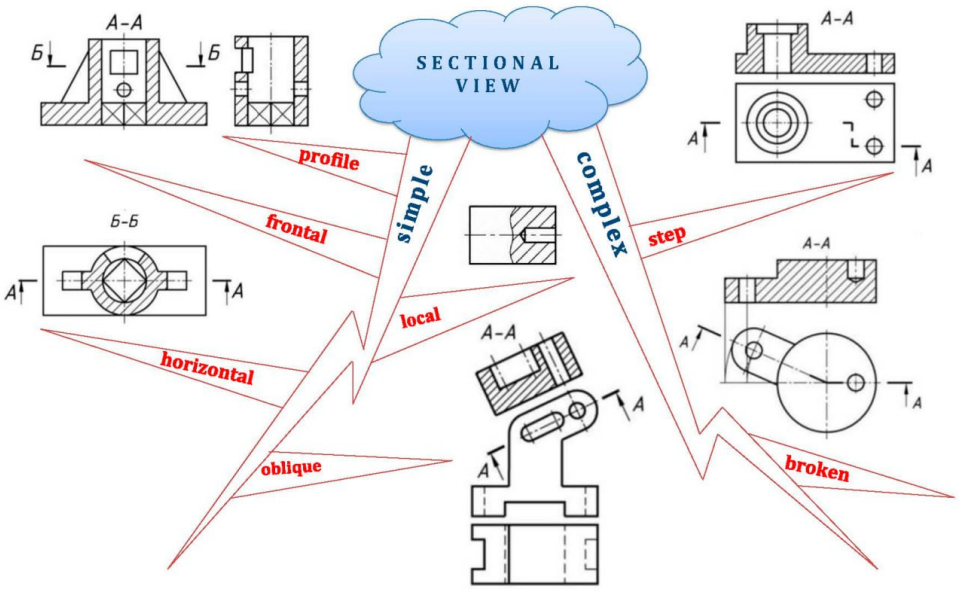


Figure 5: Mind map on the topic "Sections", created in Microsoft Word by student A. Matvienko.

Table 2
Assessment criteria for the task on the topic "Threads" to evaluate students' understanding of the educational material.

Criteria	The result of the student's work		
	full answer without mistakes	full answer with errors, incomplete answer	wrong answer/no response
Data analysis. Procedure completed	1. The thread profile is correctly defined	1. The profile is correctly defined in four threads out of six	1. The thread profile is represented correctly in fewer than four out of six threads
	2. The name of the thread corresponds to the defined profile	2. When determining the name of the thread: four out of six threads correspond to the state standard	2. The name of the thread does not correspond to the defined profile
	3. A sample of conventional notation of threads according to the state standard is provided	3. Some examples of conventional designations of various types of threads according to the state standard are given	3. Examples of conventional designations of various types of threads according to the state standard are not given or are partially given

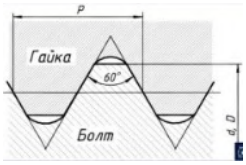
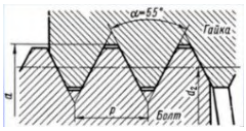
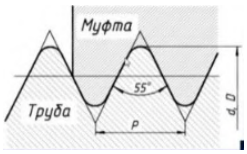
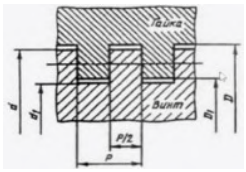
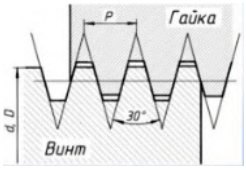
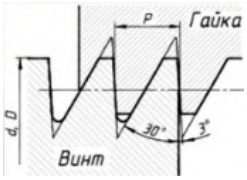
along the trajectory of independent work.

An important outcome of integrating formative assessment into the learning environment at the main and final stages of the lesson is the development of students' abilities to evaluate their own progress, intellectual growth, and the effectiveness of their personal learning and teamwork skills.

The integration of formative assessment into the learning environment of the graphic discipline "Descriptive Geometry, Engineering, and Computer Graphics" fosters the development of essential assessment skills in students, such as:

- the ability to compare, contrast, distinguish, and describe,
- the ability to abstract, generalize, classify, and systematize,
- the ability to criticize, explain, defend an opinion, evaluate, and reflect.

Table 3
The standard for task performance on the topic “Threads”.

Purpose of thread	Thread profile	Thread name	Example of designation
Fastener threads		Metric thread	M24, M 24x2, M 24 LH
		Inch thread	1/2”
		Pipe thread	G 1
		Rectangular thread	–
Motion threads		Trapezoidal thread	Tr 30x10
		Buttress thread	S 28x5

The development of these skills significantly contributes to students’ personal development and enhances their ability to independently manage their learning process. This, in turn, promotes a culture of independent work within the educational setting.

4.2. Dynamics of the formation levels of students’ independent work culture during the pedagogical experiment

At the control stage of the pedagogical experiment, a graphic control method and a statistical analysis were conducted to assess the levels of students’ independent work culture in both the experimental and control groups.

In the statistical comparison of the distributions of the samples under consideration, differences were identified in the levels of academic achievement between students in the experimental and control groups. Figure 6 illustrates the positive changes in the indicators of students’ independent work culture, measured at the beginning and end of the experiment. These changes are presented as percentages, categorized by elementary, reproductive, productive, and creative levels.

The data obtained from the pedagogical experiment demonstrate that the diagnostic results of the EG and CG at the ascertainment stage are nearly identical.

However, a comparison of the empirical values between the EG and CG at the ascertainment and control stages reveals an increase in the indicators of the students’ independent work culture formation

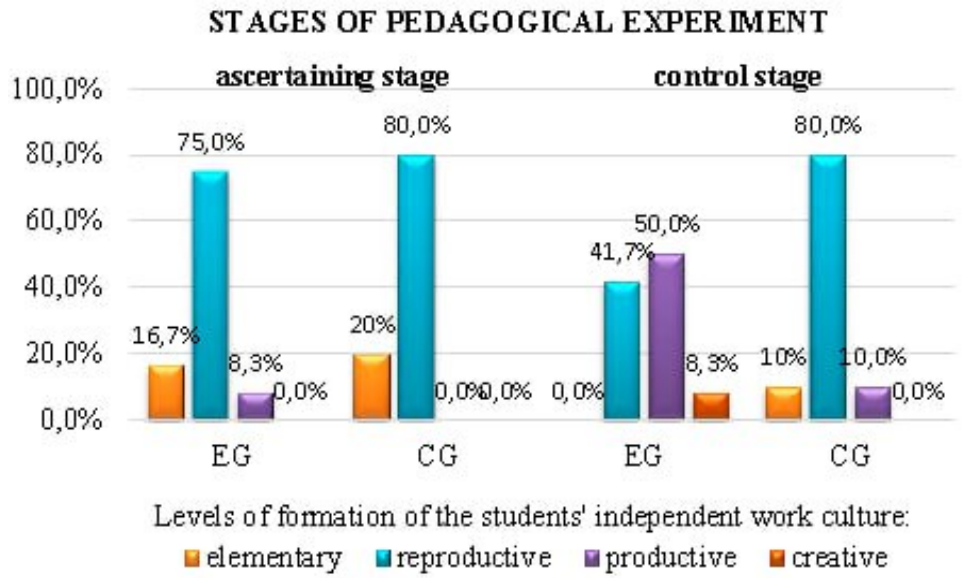


Figure 6: Dynamics of the formation levels of students' independent work culture during the pedagogical experiment.

in both groups. The distribution of students in the EG and CG varies significantly by level of work culture formation:

- In the EG, 8.3% of respondents reached a creative level, 50.0% achieved a productive level, 41.7% were at a reproductive level, and none were at an elementary level.
- In the CG, none of the respondents attained a creative level, 10.0% reached a productive level, 80.0% were at a reproductive level, and 10.0% remained at an elementary level.

These results underscore the effectiveness and feasibility of implementing formative assessment through digital technologies in the discipline "Descriptive Geometry, Engineering, and Computer Graphics". The pedagogical experiment confirms that such an approach significantly enhances the students' independent work culture.

5. Conclusions

Based on a comprehensive review of the scientific literature on formative assessment and the empirical data obtained from the pedagogical experiment, it is evident that formative assessment plays a crucial role in the modernization of education. It is a significant component in designing the learning environment, contributing to the development of higher education students' independent work culture in professional training and enhancing the overall quality of education.

The findings of this study support the systematic implementation of formative assessment using digital technologies in education. Key components of effective pedagogical design identified in this research include:

- adapting the learning process to meet the needs of students,
- increasing student motivation to learn,
- tracking and recording the development of each student at all stages of learning,
- encouraging students to form accurate self-assessments,
- developing assessment skills,
- cultivating self-assessment and peer evaluation skills,
- building self-confidence and responsibility for one's learning activities,
- fostering independent work culture.

Promising avenues for further research on this scientific problem include:

- Enhancing the methodological framework for developing self-education and self-assessment skills in future specialists in technical fields through graphic training.
- Expanding the scientific scope of formative assessment research to include other specialities and disciplines, in order to test the universality of the proposed approach.
- Exploring the adaptation of the model presented in this article within the context of distance and blended learning environments.
- Conducting a comparative analysis of the effectiveness of various digital tools used in formative assessment.
- Investigating the psychological impact of formative assessment on student motivation and self-esteem.

These proposed research directions highlight the potential for further advancements in the educational process and the professional training of future specialists.

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