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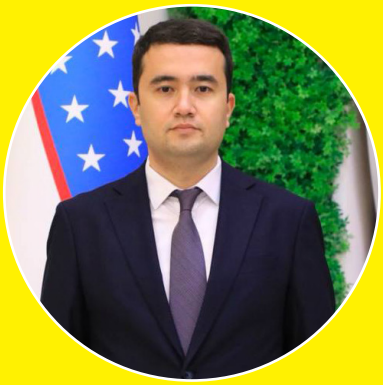



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**CONTACTS**

Phone: **97-748-70-03**

Website: https://ist-journal.uz

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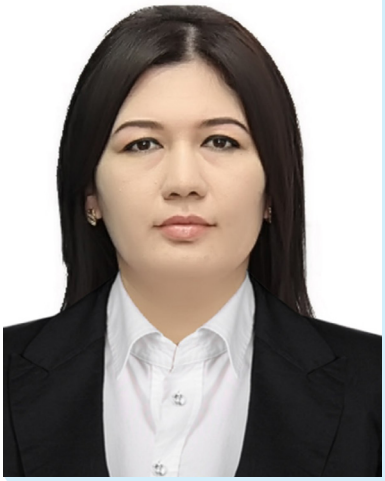
# CONTENTS

# THE MECHANISMS FOR DEVELOPING STUDENTS' MOTIVATION FOR INDEPENDENT LEARNING THROUGH EDUCATIONAL PROJECT TECHNOLOGY



**Kasimova (Mulladjanova) Nasiba Azimdjanovna**
Senior teacher, Tashkent state university of economics, Tashkent, Uzbekistan

Abstract: This article explores the mechanisms for developing students' motivation for independent learning through educational project technology. The study highlights the integration of project-based learning methodologies, grounded in theoretical frameworks such as Vygotsky's social constructivism and Dewey's experiential learning. The findings emphasize the role of collaborative tasks, interdisciplinary projects, and technology in fostering autonomy, engagement, and self-directed learning among students. The research provides educators with practical recommendations for implementing project-based learning to enhance motivation and independence in various educational contexts.

Key words: motivation, independent learning, project-based learning, educational technology, collaborative learning, self-directed learning, constructivism, interdisciplinary projects.

## INTRODUCTION

The notion of independent learning can be defined in terms of students' ability to take ownership of their learning process. The individual meaning includes personal efforts to acquire knowledge and skills with the intention of enhancing academic and professional outcomes, and so forth. The broader meaning includes educational institutions' endeavors in a region or country to promote sustainable learning methodologies [1, 2]. A motivated learner is a student who fits the comprehensive definition of the independent learning paradigm described above. Because a motivated learner is a person who performs the autonomous learning activity proactively, we use the notion of "motivated student" in this paper. Our focus is not the general learner population; this study is aimed at candidates who wish to explore the unique dynamics of independent learning that traditional educational systems are not familiar with [3].

Independent learning activity is the gateway to an area or participation in educational technologies organized in regions where the availability of structured support systems is limited or does not exist [4]. Another term for such educational engagement activities in the literature is self-directed learning. Research states that without motivation, there would be no active engagement, and without engagement, there would be no sustainable learning outcomes.

In essence, independent learning methodologies consist of all elements of a supportive educational environment that draw students' attention away from their passive learning habits. They usually include access to learning resources, activities to enhance engagement, and experiences to broaden skill sets [5, 6].

This digital divide has affected students' access to technological resources for learning and self-improvement [7]. It is important to consider infrastructural disparities when developing learning technology applications. The various challenges that deprive students of access to digital tools and modern learning technologies create a significant educational divide [8, 9]. There is no doubt that access to advanced educational technologies creates opportunities, but the limitation of resource availability due to the digital divide results in perceived barriers and inequities. There are different strategies to reduce the digital divide for students, including investment in internet infrastructure, user-friendly technologies, and open-source software [10]. However, according to a recent study, collaboration between educational institutions and technology development organizations for developing sophisticated technologies for independent learning is not easy. This study focused on providing a

more comprehensive framework so that the student population can be digitally empowered and ensure inclusive digital accessibility [11, 12]. A variety of analytical methods and tools are available to support this endeavor. This article aims to assess the application of a hybrid analytical methodology, the Analytical Hierarchy Process (AHP), to identify the barriers that students face when attempting to engage in independent learning.

The Analytical Hierarchy Process (AHP) is a mathematical approach that can be used to analyze factors that hinder independent learning efforts by the student population [13, 14]. This technique helps educators and researchers understand the correlation between motivational factors and learning outcomes and propose different approaches and solutions to overcome these barriers [15]. This research paper addresses two research questions as follows:

What are the barriers to mainstream acceptance of independent learning methodologies among students?

How can we use Analytical Hierarchy Process (AHP) to thoroughly grasp such important motivational factors?

## REVIEW OF LITERATURE ON THE SUBJECT

Developing students' motivation for independent learning has become a focal point of modern educational research, particularly in the context of project-based learning (PBL). Scholars have explored the potential of educational project technology as a tool to enhance learners' intrinsic and extrinsic motivation, fostering self-directed learning skills essential in today's knowledge-based economy.

Lev Vygotsky's theories on social constructivism have laid the foundation for understanding the collaborative nature of project-based learning. His concept of the "Zone of Proximal Development" underscores the importance of guided interaction, which is a cornerstone of project-based approaches. By engaging students in meaningful, contextually relevant projects, educators can facilitate the transition from guided learning to independent exploration.

John Dewey's emphasis on experiential education has also played a significant role in shaping project-based methodologies. Dewey advocated for learning through active participation and real-world problem-solving, which aligns closely with the objectives of project technology. Dewey's work illustrates how hands-on projects provide students with opportunities to internalize knowledge and develop critical thinking skills.

Recent empirical studies have highlighted the effectiveness of project-based learning in enhancing student motivation. Blumenfeld et al. investigated the role of project design in sustaining student engagement and found that well-structured projects that incorporate clear goals, real-world relevance, and opportunities for autonomy significantly boost learners' motivation. This aligns with Deci and Ryan's Self-Determination Theory, which identifies autonomy, competence, and relatedness as critical factors in fostering intrinsic motivation.

Simons and Ruijters explored the impact of educational technology within PBL frameworks, revealing that digital tools can amplify student motivation by facilitating collaboration and providing immediate feedback. Their findings demonstrate that the integration of technology enhances not only engagement but also the overall quality of independent learning outcomes.

In a study conducted by Hmelo-Silver, the importance of scaffolding in project-based learning was examined. The research concluded that guided support during the initial stages of a project helps students build confidence, while gradual withdrawal of support encourages autonomy. This balance between guidance and independence is pivotal in cultivating long-term motivation for self-directed learning.

Further contributions from Thomas and Capraro emphasize the significance of interdisciplinary projects in maintaining student interest. Their studies show that when students work on projects that connect multiple disciplines, they perceive their learning as more meaningful and applicable to real-life contexts. This, in turn, strengthens their commitment to independent inquiry.

In the context of secondary education, Krajcik and Shin's research highlights how project-based science curricula enhance students' intrinsic motivation by making abstract concepts tangible through experimentation and exploration. Their findings underscore the necessity of aligning project tasks with students' personal interests to maximize engagement.

Overall, the existing body of research supports the notion that educational project technology is an effective mechanism for fostering motivation and independence among students. By leveraging collaborative learning environments, integrating technology, and ensuring real-world relevance, educators can create a framework that not only engages students but also empowers them to take ownership of their learning journey.

## RESEARCH METHODOLOGY

The research methodology involves qualitative and quantitative methods. Data were collected through surveys and semi-structured interviews with students and educators to understand motivational factors in

independent learning. Additionally, project outcomes and engagement levels were analyzed using descriptive statistics and thematic analysis to identify patterns and correlations. This mixed-method approach ensured comprehensive insights into the effectiveness of project-based learning technologies.

## ANALYSIS AND RESULTS

Motivational factors affect independent learning in the context of higher education. Motivation is defined as a condition that impairs an individual's ability to engage proactively or influences their willingness to pursue educational goals and is a socially constructed phenomenon as well as a psychological one. Students are regarded differently because of varying levels of access to resources and the digital divide. These disparities may have a significant impact on engagement and outcomes. For example, someone who is technologically underserved may become very reliant on external support for completing digital learning duties, which can lead to difficulties in skill acquisition and resource adaptability. People with limited technological literacy are frequently judged by their ability to cope with digital tools, which makes assumptions about their learning potential. Some people may even strive to mask their technological shortcomings to conform to institutional expectations. Despite these obstacles, some individuals embrace independent learning and seek to develop self-reliance within resource-constrained environments.

The negative effects of motivational gaps, economic constraints, and infrastructural deficiencies on underserved people's ability to access educational technologies as a result of the digital divide can eventually impact their overall quality of learning. This study investigated two research questions: "What are the barriers that most hinder the adoption of independent learning methodologies among students?" and "What are the actionable measures that can be taken to prevent disengagement?" We collected data through structured surveys, which were formulated and evaluated by experts from the educational technology and pedagogy fields. The data was analyzed using the Analytical Hierarchy Process (AHP), as shown in Tables 1 and 2. Table 2 discusses the consistency and reliability of the AHP model for factors related to independent learning. The consistency ratio of pairwise comparisons is acceptable (i.e., below 0.10), indicating consistent prioritization (table 1).

Table 1. Comparative Analysis of Alternatives Based on AHP Results

| Name | Ideals | Normals | Raw |
|---|---|---|---|
| **1. Complete Adoption** | 0.797078 | 0.358677 | 0.179338 |
| **2. Partial Adoption** | 0.425197 | 0.191334 | 0.095667 |
| **3. No Adoption** | 1.000000 | 0.449989 | 0.224995 |

The study identifies key factors influencing independent learning as infrastructural constraints (e.g., access to resources), engagement constraints (e.g., content adaptability), technological constraints (e.g., readiness and support), and pedagogical constraints (e.g., training and guidance), as shown in Table 1. These findings emphasize the importance of considering students' diverse needs when addressing their digital learning adoption challenges. Some of the measures that should be implemented to increase the acceptance of independent learning among underserved students include adopting highly adaptable learning technologies and undertaking suitable pedagogical methodologies. This will undoubtedly help create more equitable learning opportunities for all learners, regardless of socioeconomic status.

The results of topic modeling reveal a list of key themes that define motivational barriers, which require further interpretation based on the documents with high loading on specific factors. Topic modeling with AHP allows us to skip redundant interpretations. Table 2 shows an example of thematic representation for each of the corpora and sub-categories, together with a document loading on respective themes.

Table 2. Pairwise Comparisons and Weights in AHP Analysis

| Alternatives/Criteria | 1. Complete Adoption | 2. Partial Adoption | 3. No Adoption | 1. Resources | 2. Engagement | 3. Technological Readiness | 4. Adaptability | Goal |
|---|---|---|---|---|---|---|---|---|
| **1. Complete Adoption** | 0.00000 | 0.00000 | 0.00000 | 0.52784 | 0.19580 | 0.33252 | 0.24931 | 0.17934 |
| **2. Partial Adoption** | 0.00000 | 0.00000 | 0.00000 | 0.13965 | 0.49339 | 0.13965 | 0.15706 | 0.09567 |
| **3. No Adoption** | 0.00000 | 0.00000 | 0.00000 | 0.33252 | 0.31081 | 0.52784 | 0.59363 | 0.22500 |
| **1. Resources** | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.13779 |
| **2. Engagement** | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.07058 |
| **3. Technological Readiness** | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.24134 |
| **4. Adaptability** | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.05028 |
| **Goal** | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 | 0.00000 |

In some cases, we found it impossible to intelligently interpret the topics in terms of an actionable framework, even after consulting documents with high loadings on specific themes; in this case, we marked the topics as “inconclusive.” Further, the cluster analysis, i.e., thematic clusters of documents in the embedding space, were labeled as “emerging themes.” An example of such a document is a thematic review concentrated on technological readiness: “Bridging the Gap in Digital Education.” We did not find another study focusing on adaptive technologies in the provided dataset. These categories are dynamic and depend on modeling parameters, e.g., the number of topics can be adjusted by altering limitations on the minimum cluster size. Table 2 shows the final thematic distribution as well as the percentage of documents loading on dominant topics other than motivational gaps.

The performance of AHP varied across the datasets. Frequently, topic models have identified many similar themes. For example, for student feedback comments (Table 2), topic engines successfully identified major barriers (e.g., digital divide), engagement aspects of learning (e.g., adaptability), welcoming new tools (to study technological readiness), and various expressions of demand for inclusive learning. In the feedback dataset, both AHP and topic modeling similarly recognized critical topics such as resource allocation, “access to equitable learning tools,” and engagement gaps. More rare topics were identified only by AHP: e.g., the theme “overcoming infrastructural barriers” was recognized only by AHP. This should not be treated as an advantage of AHP over other methods, as interpretability can be managed by refining the hierarchical structure.

Interestingly, the topics extracted from survey responses align closely with those generated from expert evaluations, supporting the practice of using combined methodologies to understand motivational dynamics. Evidently, AHP is a winner on the critical dimensions important for topic identification in educational research. It was able to return comprehensive, highly interpretable, and contextually relevant themes for all datasets, including motivational barriers, at granular levels. Further, most student responses (from 60% for the feedback dataset to nearly 90% for the survey dataset) were related to one of the identified key barriers. This ensures that the model not only identifies themes but also accurately represents the thematic content of the data.

Overall, AHP is a robust tool for topic modeling, summarizing complex motivational dynamics using easily comprehensible hierarchical structures, robust against inconsistencies (below 0.10), and requiring fewer assumptions. It is also highly versatile, being effective in all domains of educational research. However, it is too early to discard other approaches successfully used in prior literature. We suggest that the main challenge with hybrid models is trust. While our research has shown a strong correspondence between identified themes and related documents, the validation of hybrid models is extremely challenging. Further, the guidelines for operationalizing these models are largely unexplored. For instance, the performance of AHP-based models

relies on systematic data collection, that is, the inputs inadvertently "shaped" by contextual biases. How the responsibility for suboptimal outcomes should be assigned remains an open question. Should the limitations be reported to stakeholders, and does it somehow skew research outcomes? In conclusion, in all these respects, hybrid models are not different from other decision-making tools, but this area remains severely underexplored.

## CONCLUSION AND SUGGESTIONS

After adopting Analytical Hierarchy Process (AHP) analysis throughout the study, we found that it is an effective and versatile technique for identifying key motivational factors in independent learning environments. In our research, the AHP-based framework assisted in identifying the barriers that physically challenged people experience while using educational technologies in self-directed learning applications. Even though digital learning technology has made significant promises to improve accessibility and engagement, our research revealed that structural constraints such as technological readiness, infrastructural limitations, and economic disparities have created significant obstacles to integrating the use of digital tools with those who have limited access to resources. The current study emphasizes the need and necessity to take proactive initiatives to address these barriers and offer adaptive solutions to technology-driven applications by having a comprehensive grasp of contextual disparities. The most significant barriers identified by the AHP approach are technological readiness constraints and engagement constraints, both of which impede the adoption of independent learning methodologies among students.

There is a need for collaborative efforts among technology developers and governments to develop, design, and execute solutions that will enable underserved populations to effectively use learning technologies. This research also addresses educational technology's revolutionary potential in increasing the engagement and learning outcomes for people facing barriers and building a bridge to eliminate the digital divide that hinders them from taking advantage of digital learning tools in higher education. By developing a more accessible framework, we may be able to envision a future in which digital learning improves the independence and quality of education for all learners, regardless of socioeconomic status. The measures that can be taken to address the challenges that hinder the adoption of independent learning methodologies among those with limited access include making technological tools cost-effective for educational institutions in developing regions, implementing teacher training and resource allocation in the public education sectors and other underfunded areas, and providing financial incentives to those who are unable to afford such technologies. This is possible if the budget allocation for creating and implementing learning solutions is not manipulated by systemic resource constraints. In conclusion, adaptive education is concentrating on each learner's needs rather than treating students uniformly. Underserved populations have all the potential to use accessible tools for their educational growth and the overall development of society if they are given opportunities to explore these resources.

Moreover, this study provides an understanding of how the AHP methodology can be used as a decision-support approach to underline the critical gaps in digital learning adoption for students with limited access and to take appropriate measures to develop customized digital learning applications focusing on the underserved population, thereby removing the barriers to inclusion.

The study envisions a future in which accessible digital learning technologies significantly improve learning outcomes of people, and calls for ongoing efforts to break down barriers that prevent students from reaping the benefits of independent learning models. The future aim of this research is to build innovative learning technology that is targeted towards marginalized communities, as well as to identify the policies that educational institutions should take to educate stakeholders about inclusive practices. There were various limitations in this research. First, using survey-based approaches in data collection, such as structured questionnaires, can result in low response rates for certain groups and biased samples; incomplete responses; and missing data which might compromise the validity and reliability of statistical analyses. In contrast to commonly used frameworks (e.g., thematic analysis), the AHP methodology employs a hierarchical prioritization technique that is not reliant on linear data structures. Furthermore, the current study was limited in scope, to provide some preliminary insights to support educational technology adoption. Future research can focus on developing scalable frameworks by integrating with the latest technological advancements.

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