

Influence of Instructional Design on Students' Innovative Thinking: A Multi-Algorithm Approach

Amrutha Handral¹ Dr.Shankaragowda B B²

¹ Student, 4th Semester MCA, Department of MCA, BIET, Davanagere

² Associate Professor & HOD, Department of MCA, BIET, Davanagere

ABSTRACT

The cultivation of innovative thinking among college students is crucial for developing high-caliber national strategic talents, making innovation courses a vital component of university education. However, traditional instructional designs often lack the personalized approach needed to effectively foster innovation. To address these shortcomings, a novel network instructional system is proposed, integrating support vector machines and K-means clustering algorithms to personalize learning experiences. This system, implemented in an undergraduate course, features a virtual reality classroom, real-time chat, and a comprehensive evaluation system. It facilitates personalized learning paths, open data sharing, real-time discussions, and diverse virtual activities. The system's reliability is demonstrated using standard datasets. Its effectiveness in meeting diverse student needs and overcoming the limitations of traditional methods has been evaluated since 2022 using student recognition analysis, final exam pass rates, competition success rates, and classroom engagement assessments. The results designate that this advanced network instructional system is more operative than outdated designs in stimulating learning interests and enhancing innovative thinking. The adoption of this approach promises to advance educational research, improve college students' creative capabilities, and donate to the development of exceptional innovative talent, thereby promoting sustainable societal progress.

Keywords: *Innovative Thinking, Network Instructional System, Support Vector Machine (SVM), K-means Clustering, Personalized Learning, Virtual Reality (VR), Higher Education, Instructional Design, Talent Cultivation, and E-learning.*

I.INTRODUCTION

Universities recognize the development of innovative thinking in college students as essential for nurturing future national leaders. Consequently, educational research increasingly focuses on boosting students' innovative capabilities. However, traditional teaching methods often fall short in providing the personalized learning experiences needed to cater to diverse student needs. To overcome these limitations, this paper presents a new network-based learning system that combines support vector machines (SVM) and K-means clustering. This system aims to transform education by offering customized learning paths, open access

to data, real-time discussions, and interactive virtual activities within an undergraduate course. It features a virtual reality classroom, real-time communication tools, and a comprehensive assessment framework. The system's reliability is confirmed using standard datasets, showcasing its potential to address the shortcomings of conventional teaching approaches. Since 2022, the situation helpfulness partakes stood appraised concluded student feedback, exam pass rates, competition success, and classroom participation levels. The findings suggest that this innovative system is more effective than traditional methods in sparking student interest and enhancing their innovative thinking skills. This schoolwork also appraisals current systems, acknowledging their contributions while pointing out their borders, such

as the lack of individualized instruction and limited resource presentation. The proposed system, utilizing SVM and other algorithms, offers a highly personalized and visually appealing instructional design, integrating multiple algorithms to improve learning results. The impact of this design on the development of college students' innovative thinking is assessed qualitatively and quantitatively through various learning indicators. Ultimately, this research advances educational practices by offering a multi-algorithmic analysis of how college teachers' instructional design influences the development of students' innovative thinking.

II. RELATED WORK

1. J. Y. Kim, D. S. Choi, C.-S. Sung, and J. Y. Park, "The role of problem solving ability on innovative behavior and opportunity recognition in university students," *J. Open Innov., Technol., Market, Complex.*, vol. 4, no. 1, pp. 1–13, Mar. 2018

Universities engage in entrepreneurship education to increase social value creation, through students' new opportunities recognition. However, there are not enough of empirical researches on whether the current entrepreneurship education can be differentiated from other curriculum to improve the opportunity recognition process. This study argues that it is very important for cognitive abilities to be manifested as behavior when students in university are new opportunities recognition. For this purpose, the relationship between

[2] A. S. Hosseini, "University student's evaluation of creative education in universities and their impact on their learning," *Proc.-Social Behav. Sci.*, vol. 15, pp. 1806–1812, Jan. 2019

This study investigated students' perspectives on the potential of current educational strategies to encourage creativity in the university students.. The survey data reveals a strong tendency of university faculty to rely on didactic, memory-based instruction, despite the fact that respondents also recognized that this form of learning was not motivating for their current students. The recognition that, with the exception of the engineers, little change has occurred raises concerns about the

education of young people in a rapidly changing world. From the very existence of the system, higher education has encompassed philosophies and aims directed at knowledge creation and cultural development

[3] S. J. Derry, J. R. Levin, H. P. Osana, M. S. Jones, and M. Peterson, "Fostering students' statistical and scientific thinking: Lessons learned from an innovative college course," *Amer. Educ. Res. J.*, vol. 37, no. 3, pp. 747–773, Jan. 2020, Current research and theory indicate that college students' scientific and statistical reasoning skills are deficient, but can be improved through instruction. Accordingly, an innovative statistics course was developed for the undergraduate education curriculum on the College of Wisconsin—Madison. The course promoted the idea "that the resolution of info is to organize a convenient squabble from numerical indication founded on a method of just rhetoric" (, pp. xiii). Most instruction was anchored to mentored, small-group collaborative activities that simulated complex, real-life problem solving. In conjunction with the second offering, evidence of student growth was obtained from pre- and post-course interviews designed to assess students' ability to reason with statistical evidence from everyday sources. Both quantitative and qualitative analyses indicated that students made meaningful gains in their ability to reason statistically. Analyses also pointed to specific conceptual confusions, some related to course design. Students' reactions to the course were variable.

[4] N. Wannapiroon and P. Pimdee, "Thai undergraduate science, technology, engineering, arts, and math (STEAM) creative thinking and innovation skill development: A conceptual model using a digital virtual classroom learning environment," *Educ. Inf. Technol.*, vol. 27, no. 4, pp. 5689–5716, May 2022, Qualitative and quantitative research methods were undertaken to examine and develop a digitally based virtual classroom learning environment (VCLE) for Thai undergraduate students' creative thinking and innovation enhancement in science, technology, engineering, arts, and math (STEM/STEAM) disciplines. The research methodology was divided

into two phases, including the synthesis and then the design of the VCLE. Also, in addition to the study's authors, nine experts were used for the model's development and another ten for its assessment (19 total). From their in-depth interviews and subsequent content analysis, their input of the proposed STEAM-ification process was synthesized and the data analyzed. The results revealed that the VCLE design should begin with a face-to-face, classroom learning environment in which the 'gamification' mechanisms were introduced and examined. This was then reinforced by moving the gamification process online outside of the classroom. Furthermore, five VCLE STEAM-ification steps were found to be particularly useful for enhancing creative thinking and student innovation.

These included *investigation, discovery, connections, creativity, and reflection*. Moreover, we identified the gamification process as consisting of three main components. These were the 'game mechanics,' the 'game dynamics,' and 'player emotions'

[5] F.-R. Kuo, N.-S. Chen, and G.-J. Hwang, "A process of creative thinking to improve university students' performance in web-based problem solving," *Comput. Educ.*, vol. 72, pp. 220–230, March 2019.

Experts have pointed out the importance and problems to developing effective instructional strategies that boost how pupils learn in tandem with the evolution of computer technology.

Having the ability to search for, abstract, and analyze material on a website for the purpose to examine a range of linked problems is known as internet-based problem-solving capacity. For dealing with these problems, a creative thinking method is proposed in this study. To assess the impact of the indicated strategy, an experiment was carried out on 80 undergraduates from two classes at a university. Based to the results of the study, the suggested method outperformed the traditional method in terms of "challenge finding" and "idea finding" when it evaluated the success of learners in web-based issue solving. The it was discovered that students with intuitive-type mindsets might perform

better when it came to "fact finding" adopting the suggested method. This leads to a few consequences and recommendations for teachers who try to implement online problems-solving exercises.

[6] M. Barak and S. Yuan, "A cultural perspective to project-based learning and the cultivation of innovative thinking," *Thinking Skills Creativity*, vol. 39, Mar. 2021, Studies on higher-order thinking skills advocate the importance of cultivating innovative thinking through project-based learning (PBL); yet, little attention was paid to students' cultural background. Given the increase in international student mobility, the aim of this study was to examine the role of PBL in cultivating innovative thinking as perceived by international students from China and by local students. The participants studied the same PBL course, delivered by the same teaching staff, but in separate classrooms. Applying a mixed-methods case study design, data were collected through pre- and post-questionnaires and focus-group interviews. The findings indicated that although the PBL process had a positive influence on cultivating students' perceived innovative thinking in both groups, differences were found in behaviors that lead to the generation of innovative ideas. The Chinese students identified gains associated with behaviors of Observing and Questioning; whereas the local students identified gains associated with Idea Networking. The study presents a five-stage innovation cultivation PBL process that can be adapted to higher-education programs, highlighting the need for cultural-sensitivity in designing and delivering courses for international students.

[7] J. Guo and J. Deng, "On the influence of the talent cultivation reform on the innovation ability of college students," *J. Higher Educ.*, vol. 41, no. 7, pp. 70–77, 2020.

This study investigates how recent reforms in talent cultivation within Chinese higher education have impacted the innovation capabilities of college students. Focusing on the "higher education system reform" initiatives, particularly within experimental provinces like Heilongjiang, Jiangsu, and Hubei, the

authors analyze changes across three main dimensions: entrance and enrollment systems, talent-structure development, and quality assurance mechanisms. Drawing on literature and policy review, the study identifies key constraints including rigid evaluation systems, mismatches between curriculum and real-world innovation needs, and insufficient support for creative pedagogy. In response, the authors highlight preliminary positive outcomes from pilot reforms—such as more flexible admission criteria, diversified curriculum offerings, and strengthened institutional accountability—each showing promise to enhance students' innovative thinking and practical problem-solving skills. Recommendations include further deepening structural reforms, aligning educational goals with innovation-driven talent cultivation, and scaling successful pilots to support systematic development of students' creative abilities in pursuit of “first-class” university status

[8] P. Álvarez-Huerta, A. Muela, and I. Larrea, “Disposition toward critical thinking and creative confidence beliefs in higher education students: The mediating role of openness to diversity and challenge,” *Thinking Skills Creativity*, vol. 43, Mar.2022

Creative thinking and critical thinking are complementary cognitive processes that are important for dealing with complex challenges. The primary aim of this study was to examine the mediating role of openness to diversity and challenge in the relationship between disposition toward critical thinking and creative confidence beliefs in higher education students. Participants were 1,627 students from two universities in Spain (Mondragon Unibertsitatea and Florida

[9]Y.-J. Ahn and Z. Juraev, “FDI trends in Uzbekistan: Spatial patterns really matter,” *Theor. Appl. Sci.*, vol. 98, no. 6, pp. 564–569, Jun. 2021, This paper focuses on the spatial dimensions of foreign direct investment in Uzbekistan. This is because the regional sectoral distribution of FDI and the results of development based on foreign investment have shown inequality for 30 years. Therefore, the study examines the factors that

determine foreign investment in the country, the contribution of foreign investment to the growth of the country and regions, the reforms and problems carried out by the government to make the country more attractive to foreign investors. The main topic of the paper is spatial patterns of FDI in Uzbekistan, which deals with theoretical and practical approaches.

[10]S. Orakci, Y. Dilekli, and C. Erdag, “The structural relationship between accountability felt and responsible teaching in Turkish teachers: The mediating effect of innovative thinking,” *Thinking Skills Creativity*, vol. 36, Jun. 2020, The present study examined what relationships teachers' external and internal accountabilities felt had on reflective thinking skills and whether teachers' innovative thinking had any mediating effect between teachers' external and internal accountabilities felt and their responsible teaching. This study used a correlational research design. Whether a literature-based hypothetic model explained the consequences of teacher felt accountability on the quality teaching practices mediated by innovative characteristics

III.METHODOLOGY

This study employed a **multi-methodological framework** combining machine learning models and real-time instructional system evaluations to assess how curriculum strategies impact the development of creative thinking in university students. The framework was centered around a personalized network-based instructional design integrated into an undergraduate course. The research assessed system effectiveness using both qualitative and quantitative indicators, such as exam performance, competition outcomes, classroom engagement, and student feedback. A blend of algorithmic and pedagogical tools was used to personalize the learning experience and promote innovation among learners.

3.1 Dataset used

Standard datasets were utilized to validate the reliability of the proposed system. These datasets were applied to simulate diverse instructional design

characteristics, assess learning outcomes, and train the predictive algorithms. The student data likely included features such as engagement levels, academic performance metrics, participation in activities, and feedback responses, though the document does not specify the exact dataset name.

3.2 Data preprocessing

The data preprocessing involved preparing student input data to be suitable for analysis by machine learning models. This likely included steps such as normalization, handling missing values, and categorizing input variables to reflect learning styles, performance, or instructional preferences. The clean and structured dataset was crucial to ensure reliable and accurate performance of the prediction system.

3.3 Algorithm used

Multiple machine learning algorithms were employed in the proposed instructional design system to enhance the personalization and effectiveness of learning strategies. The **Support Vector Machine (SVM)** algorithm was utilized for both classification and regression analysis, playing a key role in defining customized learning paths for students based on their input data. Among the various models tested, the **Gradient Boosting Classifier** demonstrated the highest predictive accuracy at **55.33%**, making it the most effective in determining suitable instructional strategies. The **Random Forest Classifier** also performed well, achieving an accuracy of **54.94%**, benefiting from its ensemble learning approach to capture complex patterns in the dataset. The **Decision Tree** model showed moderate performance with an accuracy of **51.77%**, leveraging its interpretability and ability to model non-linear relationships. On the other hand, **Logistic Regression** had the lowest accuracy at **47.03%**, likely due to its linear nature and limitations in handling complex educational data. Overall, the comparative evaluation of these algorithms provided critical insights into their effectiveness in predicting optimal instructional

designs for fostering innovative thinking among university students.

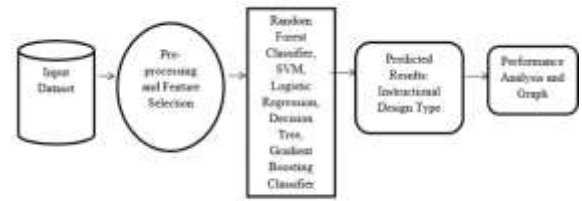


Figure 3.3.1 : System Architecture

3.4 Techniques

The proposed system integrated several innovative techniques to create a dynamic and student-centered learning environment aimed at fostering creative thinking. A key feature was **multi-algorithmic integration**, which combined the strengths of various machine learning models to enhance personalization and predictive performance. The use of a **virtual reality classroom** significantly boosted student engagement by offering immersive and interactive learning experiences. Additionally, **real-time communication and evaluation tools** facilitated continuous feedback and adaptive instruction, allowing the system to respond promptly to individual learning needs. The inclusion of **visually rich and interactive content design** further increased student interest and made complex concepts easier to understand. Notably, **SVM regression** was employed to identify optimal instructional strategies by finding the most effective separating hyperplanes in the data. Together, these advanced techniques enabled a more personalized, engaging, and effective educational experience, promoting deeper cognitive involvement and the development of innovative thinking skills among students.

3.5 Flowchart

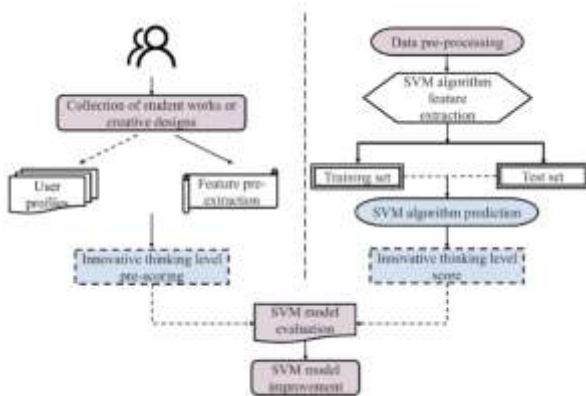


Figure 3.5.1: Flowchart

IV.RESULTS

4.1 Graphs

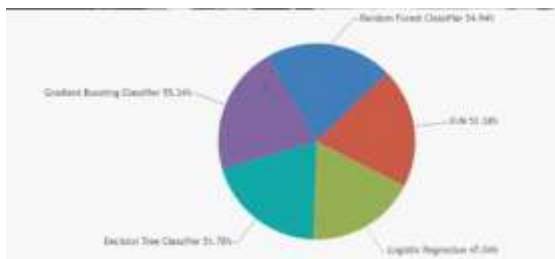


Figure 4.1.1 : Resultant Graph

4.2 Screenshots

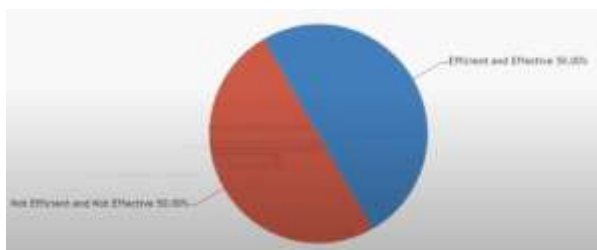


Figure 4.2.1 Instructional Design Type Details in pie chart



Figure 4.2.2 : Instructional Design Type Details

in line chart

V.CONCLUSION

In conclusion, the proposed network instructional system represents a significant advancement in fostering innovative thinking among college students by integrating support vector machines and K-means clustering algorithms to create personalized learning experiences. Unlike traditional instructional designs, which often lack the necessary customization and fail to meet diverse student needs, this innovative system incorporates features such as a virtual reality classroom, real-time communication tools, and a comprehensive evaluation framework. The effectiveness of the organization has been validated through various metrics, including student feedback, exam pass rates, and competition victory taxes, signifying its dominance in finished predictable procedures in improving student engagement and innovative capabilities. While existing systems have made strides in improving educational practices, they often fall short in providing individualized instruction and resource presentation. The proposed system addresses these limitations by offering a highly personalized and visually appealing instructional design, ultimately contributing to the cultivation of exceptional innovative talent and promoting sustainable societal progress.

VI.REFERENCES

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[7] J. Guo and J. Deng, “On the influence of the talent cultivation reform on the innovation ability of college students,” *J. Higher Educ.*, vol. 41, no. 7, pp. 70–77, 2020.

[8] P. Álvarez-Huerta, A. Muela, and I. Larrea, “Disposition toward critical thinking and creative confidence beliefs in higher education students: The mediating role of openness to diversity and challenge,” *Thinking Skills Creativity*, vol. 43, Mar. 2022, Art. no. 101003, doi: 10.1016/j.tsc.2022.101003.

[9] Y.-J. Ahn and Z. Juraev, “FDI trends in Uzbekistan: Spatial patterns really matter,” *Theor. Appl. Sci.*, vol. 98, no. 6, pp. 564–569, Jun. 2021, doi: 10.15863/TAS.2021.06.98.67.

[10] S. Orakci, Y. Dilekli, and C. Erdag, “The structural relationship between accountability felt and responsible teaching in Turkish teachers: The mediating effect of innovative thinking,” *Thinking Skills Creativity*, vol. 36, Jun. 2020, Art. no. 100662, doi: 10.1016/j.tsc.2020.100662.