EXPERIENTIAL LEARNING TO CULTIVATE MEDICAL STUDENTS' SCIENTIFIC RESEARCH SKILLS

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Abstract

This study explores experiential learning in self-directed learning, students' innovative abilities, teaching methodology, practical activities, and the scientific research skills of medical students, and analyzes the significant influence of experiential learning on these skills. The sample group consists of 425 students selected by purposive sampling from second- and third-year medical majors at Kunming Health Vocational College. The questionnaire was distributed to students, who generated a QR code and survey link on the Wenjuanxing platform and shared them with participants through institutional communication channels. The data analysis included mean and standard deviation, t-tests, one-way ANOVA, and multiple linear regression. The results of the study showed that (1) The average mean of experiential learning is at a high level. (2) The significant influence of experiential learning is only 2 variables, these are self-directed learning (SDL) and students' innovative abilities (SIA), toward the medical students' scientific research skills (SRA) at the 0.01 level. The scientific research skills of medical students are essential to promote medical progress and innovation in clinical practice.

Keywords: *Medical students, experiential learning, scientific research skills*

PEMBELAJARAN BERDASARKAN PENGALAMAN UNTUK MENGEMBANGKAN KETERAMPILAN PENELITIAN ILMIAH MAHASISWA KEDOKTERAN

Abstrak

Studi ini mengeksplorasi pembelajaran berbasis pengalaman dalam pembelajaran mandiri, kemampuan inovatif siswa, metodologi pengajaran, kegiatan praktis, dan keterampilan penelitian ilmiah mahasiswa kedokteran, serta menganalisis pengaruh signifikan pembelajaran berbasis pengalaman terhadap keterampilan-keterampilan ini. Kelompok sampel terdiri dari 425 siswa yang dipilih secara purposive sampling dari jurusan kedokteran tahun kedua dan ketiga di Kunming Health Vocational College. Kuesioner dibagikan kepada siswa, yang menghasilkan kode QR dan tautan survei di platform Wenjuanxing dan membagikannya kepada peserta melalui saluran komunikasi institusional. Analisis data meliputi rata-rata dan simpangan baku, uji-t, ANOVA satu arah, dan regresi linier berganda. Hasil penelitian menunjukkan bahwa (1) Rata-rata nilai tengah pembelajaran pengalaman berada pada tingkat tinggi. (2) Pengaruh signifikan pembelajaran pengalaman hanya pada 2 variabel, yaitu pembelajaran mandiri (SDL) dan kemampuan inovatif siswa (SIA), terhadap keterampilan penelitian ilmiah (SRA) mahasiswa kedokteran pada tingkat 0,01. Keterampilan penelitian ilmiah mahasiswa kedokteran sangat penting untuk memajukan kemajuan medis dan inovasi dalam praktik klinis.

Kata kunci: *Mahsiswa kedokteran*; Pembelajaran lampau; Keahlian penelitian

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1. Introduction

Innovation is the soul of a nation's progress. It is the responsibility of those leading scientific research at colleges and universities to improve student quality and cultivate innovative talent through scientific research activities. How to train innovative talent at the undergraduate level of higher medical education has long been a concern for medical educators. Yet, the quality of scientific research training in higher medical education in China has not received sufficient attention [1]. The medical students we teach today will become the doctors of tomorrow, carrying our values, skills, and hopes for the profession into the future. Therefore, it is no exaggeration to say that medical education represents the future of medicine [2]. The progress of medicine relies on continuous innovation, in-depth scientific research and exploration. As the main force of the future medical field, medical students' innovative abilities and scientific research skills are directly related to whether the medical field can overcome bottlenecks and solve complex clinical problems.

Education is a dynamic process that has to be refined periodically. The lack of innovative teaching techniques in academia makes medical curricula inadequate for making a significant stride towards the future [3]. The traditional medical teaching mode focuses on the transmission of knowledge. It is insufficient for stimulating students' innovative thinking and cultivating their scientific research literacy, so it is of urgent practical significance to study how to improve these two abilities in the teaching process effectively. Self–directed learning is a model of instruction for medical students to motivate and direct the students' learning experience, foster critical thinking, problem solving and other valuable skills to lead to scientific research skills

1.1. Definition of Key Terms

1.1.1. Medical students

Although medical students gain some experience examining and interviewing patients in the first or second year of medical school, clinical clerkships usually begin in the third year. Third-year medical students, known as junior medical students, spend part of the year in the patient care environment through month-long rotations in internal medicine, surgery, obstetrics and gynecology, and pediatric services.

1.1.2. Experiential learning

Medical students have mastered theoretical knowledge through classroom learning, but transforming this knowledge into practical operational capabilities is inseparable from experiential learning through laboratory and clinical internships and participation in scientific research projects. This thesis covers experiential learning of medical students, including self-directed learning, Students' innovative abilities, Teaching methodology, and Practical activities that affect scientific research skills.

1.1.3. Self-directed learning

Self-directed learning (SDL) competencies are students' skills to continuously monitor and adjust their cognitive state, observe and apply a variety of learning strategies, adjust their learning behaviors, and take ownership of their learning, including understanding and managing their own learning process. It includes self-awareness and the skills to learn and subjectively control their own learning process.

1.1.4. Students' innovative abilities

Students' innovation abilities are the creative and knowledge-application skills you need to generate new ideas and solutions. These skills enable you to conduct in-depth analysis of situations and explore perspectives that differ from existing knowledge or ways of thinking.

1.1.5. Teaching methodology

Teaching methodology comprises the general principles, pedagogical approaches, and management strategies used in the classroom. The choice of teaching methodology depends on the appropriate educational philosophy and the classroom population. Teaching methodology is the teacher's skills in making judgments about students' understanding and in changing the teaching methodology at any time.

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1.1.6. Practical activities

Practical activities are designed to enhance hands-on experience, critical thinking and self-efficacy. These activities move beyond traditional lectures to include direct participation in tasks such as molecular biology techniques, ethical research practices, and data analysis through methods such as peer-assisted learning and project-based work.

2. Literature Review

2.1. Self-directed learning

The concept of self-directed learning emerged from the humanistic tradition of adult education in the second half of the twentieth century [4]. Based on a belief in human beings' capacity for responsibility, choice, positive direction, and self-actualization, self-directed learning is defined as "a process in which individuals take the initiative, with or without the help of others, in diagnosing their learning needs, formulating learning goals, identifying human and material resources for learning, choosing and implementing appropriate learning strategies, and evaluating learning outcomes" [5]. For self-directed learning to take place, an appropriate environment is needed in which learners are supported by others, such as instructors, mentors, resource people, and peers [6]. In summary, self-directed learning (SDL) is a teaching model in which learners take initiative in the learning process, working at their own pace and based on pre-defined content by the teacher. This approach emphasizes personal autonomy, self-management and learner control, enabling individuals to diagnose their own learning needs, set goals and evaluate learning outcomes.

2.2.Students' innovative abilities

The ability to develop new solutions to daily workplace challenges is an important component of adaptive expertise. Exploring how to develop this skill optimally is therefore of paramount importance to education researchers. This is certainly no less true in health care, where optimal patient care depends on the continuous efforts of doctors and other health care workers to deliver the best possible care through the development and incorporation of new knowledge. Medical education programmes must therefore foster the skills and attitudes necessary to engage future doctors in the systematic development of innovative problem-solving [7, 8]. The innovative abilities of medical students refer to the skills to discover new problems, propose new ideas, explore new methods, and create new results through unique ways of thinking during medical learning and practice. It is not only limited to the simple application of existing medical knowledge, but also the active exploration and breakthrough of unknown problems in the medical field [9]. Thinking innovation requires medical students to have critical thinking and divergent thinking, dare to question the traditional concepts and existing theories, and think about medical problems from different perspectives; technological innovation focuses on the skills of medical students to apply new science and technology in the field of medicine; practical innovation emphasizes the skills of medical students to formulate personalized treatment plans according to the specific conditions of patients, optimize the process of healthcare services, and improve the quality of healthcare in clinical practice.

2.3.Teaching methodology

Teaching methodology plays a crucial role in integrating humanistic education into technical programs. Research has shown that interactive and experiential teaching methods are most effective in fostering the development of humanistic competencies [10]. Appropriate teaching styles help students to absorb better and understand knowledge. Effective teaching methods can improve students' learning efficiency [11]. For example, multimedia teaching and the presentation of content through pictures, videos, and other forms can convey a large amount of information in a short period, attracting students' attention and enabling them to learn more in a limited time. Diversified teaching methods can stimulate students' interest in learning and help them shift from passive to active learning.

2.4. Practical activities

The practical exploration was to examine how medical students' self-learning skills were developed during the course of teaching, mainly in English disciplines. But such studies

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are mostly summaries of experiences with specific problems in a particular course and do not apply to all courses [12]. Although educational institutions and teachers have recognized the importance of cultivating self-learning skills, they are still in the exploratory stage, and practical, effective teaching methods are urgently needed [13]. Therefore, providing a platform for integrated analysis to explore ways to cultivate students' self-learning skills and to construct the corresponding teaching model is an essential issue at present. To achieve this, the recently developed "Learning Analysis" technology provided a viable solution [14, 15]. Practical activities help medical students develop good professionalism and a sense of social responsibility. At the same time, by participating in social practice activities, such as community clinics and health missions, medical students can apply the medical knowledge they have learned in real life, provide medical services to the general public, and enhance their sense of social responsibility. This cultivation of professionalism and social responsibility is of great significance to the future career development and social contribution of medical students.

2.5.Scientific Research Skills

The cultivation of learners' scientific research skills is an important element in training learners in higher education institutions. In recent years, this research topic has received much attention in China [16]. Focusing on current learners' scientific research skills, this paper first analyzes the key areas of this topic and the trends in the research. Then, it outlines the factors that influence learners' scientific research skills [17]. By adopting interpretive paradigms, the paper constructs a multi-level hierarchical model of the factors influencing learners' scientific research skills [18]. Scientific research skills encompass a range of abilities required to conduct effective, rigorous research. These skills include information gathering, critical thinking, data analysis, communication, and ethical considerations. They are essential for students, academics, and professionals across various fields who need to investigate, analyze, and interpret information to solve problems and generate new knowledge.

3. Method

This study utilized quantitative research and a survey research design with different students, including differences in academic year, gender, and experiential learning. The objective research conducted to explore experiential learning among medical students, the independent variable in this study, includes self-directed learning, students' innovative abilities, the teacher's teaching methodology, and practical activities in education. The research analyzed the influence of experiential learning on the dependent variable, namely, scientific research skills, of medical students in vocational colleges.

This study focuses on medical students, who are an essential group in the future healthcare field. They are receiving systematic training and are committed to becoming proficient professionals in diagnosis. The reason for choosing this group as the research object is that vocational education institutions play a key role in cultivating technical professionals. Purposive sampling was used to select 425 research participants from the current students enrolled in the medical program at the vocational college. Through this sampling method, the researcher was able to precisely focus on a specific subgroup of students whose educational and training experiences were directly related to the objectives of this study, thus providing a highly fitted sample base for the study.

The questionnaire was distributed to 425 students majoring in medicine at vocational colleges. The questionnaire generated a QR code and a survey link via the Wenjuanxing platform and was shared with participants via institutional communication channels such as email, student groups, and online class forums. The platform enabled the researchers to design a comprehensive questionnaire comprising closed-ended Likert-scale questions to measure participants' perceptions, behaviors, and abilities that would be integrated into the medical professional curriculum. The questionnaires consist of 5 topics. There are 10 items on each topic: Self-directed learning, Students' innovative abilities, Teaching methodology from the teacher, Practical activities in learning, and Scientific research skills of the students. The data analysis included mean and standard deviation, t-tests, one-way ANOVA, and multiple linear regression.

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4. Analysis Result

The sample group consists of student personnel selected from universities, and a total of 425 samples were selected. Based on advanced statistical procedures, the data analysis is as follows:

Table 1 Mean, standard deviation, interpretation, and mean rank

TOPIC	Mean	Standard deviation	Interpret	Mean rank
Independent variable (experiential learning)				
1. Self-directed learning (SDL)	3.60	1.11	high	4
2. Innovative skills (SIA)	4.45	0.56	high	1
3. Teaching methodology (TM)	3.81	1.14	high	3
4. Practical activities (PA)	4.12	0.93	high	2
Dependent variable				
5. Scientific research skills (SRA)	4.45	0.56	high	1

Table 1: The mean result of experiential learning found that the most value is Innovative skills (SIA) ($\bar{X}$ 4.45, S.D. 0.56) and decreasing in order Practical activities (PA) ($\bar{X}$ 4.12, S.D. 0.93), Teaching methodology (TM) ($\bar{X}$ 3.81, S.D. 1.14), Self-directed learning (SDL) ($\bar{X}$ 3.60, S.D. 1.11). The Scientific research skills (SRA) ($\bar{X}$ 4.45, S.D. 0.56) is the essential dependent variable that shows the most value in the medical students' replies in the questionnaire of this study. The average of each variable is high. Thus, it is consistent with the hypothesis.

Correlation analysis can test whether variables are correlated, and the presence of a correlation provides a basis for follow-up studies of the variables' impact. If the correlation between variables is significant, it indicates a relationship among the variables. Generally speaking, correlation analysis can only assess the strength and direction of correlation among variables. But it is impossible to judge the direction of causation between independent and dependent variables; that is, it is impossible to distinguish which variable affects which.

Table 2 Correlations between variables: SDL, SIA, TM, PA and SRA

	1	2	3	4	5
Variable	SDL	SIA	TM	PA	SRA
SDL	1				
SIA	-0.094	1			
TM	0.609**	-0.065	1		
PA	0.572**	0.110*	0.598**	1	
SRA	-0.178**	0.511**	-0.058	0.049	1

** Correlation is significant at the 0.01 level (2-tailed).
* Correlation is significant at the 0.05 level (2-tailed).

Table 2 shows the summary correlation coefficient between the independent and dependent variables. Correlation coefficient and significance: The correlation coefficient reflects the strength and direction of the linear relationship between two variables. The results confirm that the correlation coefficient between SRA and SDL is -0.178 and is significant ($p<0.01$). The correlation coefficient between SRA and SIA is 0.511 and is significant ($p<0.01$). Others are not significant ($p > 0.05$). Possible explanation: A stronger self-directed learning ability is associated with lower scientific research ability. This finding requires further contextual analysis, as it may be related to sample characteristics or variable definitions.

Model Summary

Model	R	R Square	Adjusted R-Square	Std. Error of the Estimate
1	0.527[a]	0.278	0.274	0.1956

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a. Predictors: (Constant), SDL, SIA

Table 3: Multiple regression was conducted and achieved an R2 value of 0.278, which means that the Dependent Variable was explained by 27.8%. Therefore, this clearly shows that the model is generally fit.

Table 4 Analysis of variance (SRA, predictors: SDL, SLA)

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	6.203	2	3.101	**81.089**	**0.000[b]**
	Residual	16.140	422	0.038		
	Total	22.343	424			

a. Dependent Variable: SRA
b. Predictors: (Constant), SDL, SIA

Table 4: The sum of squares is 6.203, the degrees of freedom are 2, the mean square is 3.101, the F-statistic is 81.089, and the significance level is 0.000[b], which is less than 0.01. This indicates that the predictors (SDL and SIA) can significantly predict the dependent variable (SRA).

Table 5 Multiple regression of SRA

Coefficients[a]

		Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
Model		B	Std. Error	Beta	t	Sig.	Tolerance	VIF
1	(Constant)	2.354	0.198		11.895	**0.000**		
	SDL	0.042	0.013	-0.131	-3.143	**0.002**	0.991	1.009
	SIA	0.505	0.042	0.498	11.991	**0.000**	0.991	1.009

a. Dependent Variable: SRA

Table 5 shows the results: the *P*-value is 0.000, which is less than 0.01. Therefore, this means the statistical significance of the model. The VIF values for all 5 factors are less than 10, indicating slight multicollinearity. SDL has a negative, significant influence on the dependent variable SRA (beta < 0, *p*-value < 0.01). SIA has a positive, significant influence on the dependent variable SRA (beta > 0, *p*-value < 0.01).

5. Discussion

The scientific research skills of medical students are not only related to their academic development but also an important guarantee for promoting medical progress and innovation in clinical practice. Among them, self-directed learning and students' innovative abilities are the two core factors that affect medical students' scientific research skills. On the one hand, self-directed learning is the foundation for medical students to learn effectively and integrate information in a complex, constantly evolving medical knowledge system. Students with strong self-directed learning can take the initiative to obtain the information required for scientific research, master scientific research methods, and improve their independent thinking and problem- solving skills. Self-directed learning is one of the most critical abilities for medical students in their future clinical practice. During the blended teaching process, teachers can design a variety of learning activities to cultivate students' Self-directed learning abilities. This study aimed to assess differences in the Self-directed learning abilities of medical students using blended and traditional didactic teaching [19].

Self-directed learning (SDL) is a process in which individuals take the primary initiative and responsibility for their own learning. This involves diagnosing personal learning needs, formulating goals, identifying resources, choosing and implementing learning strategies, and evaluating outcomes. Fundamentally, it shifts the learner's role from a passive recipient to an active manager of knowledge. However, its effectiveness depends heavily on the individual's inherent motivation, metacognitive skills, and the specific context in which it is applied. In certain scenarios, a lack of structure or feedback in SDL can lead to knowledge

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gaps, underscoring that it is a powerful yet nuanced approach that requires careful facilitation to reach its full potential.

The observed significant negative relationship between self-directed learning (SDL) and scientific research ability (SRA) can be theoretically explained through two primary lenses [20]. Firstly, if SDL is conceptualized as a "lone learner" trait emphasizing highly independent, unstructured learning without external feedback, it may directly hinder the development of collaborative research skills essential to modern science, such as teamwork and peer review [21]. Secondly, from a resource-allocation perspective, the substantial time and cognitive effort invested in self-directed activities (e.g., reading textbooks) could compete with and potentially displace time dedicated to hands-on, research-specific training, such as laboratory work or data analysis practice. Beyond theoretical explanations, methodological issues in measurement offer another compelling rationale [22]. The negative correlation could be an artifact of how the constructs were defined and measured. For instance, if the SDL scale emphasized items related to learning in isolation (e.g., "I prefer studying alone"), it would inherently conflict with SRA items that assess socially-embedded skills (e.g., "I seek mentorship for research"). Similarly, a disconnect could exist if the SRA measurement focused narrowly on technical proficiencies (e.g., statistical analysis). At the same time, the SDL scale captured general learning habits that do not directly translate into these specific research competencies.

Students' innovative abilities are the soul of scientific research, directly affecting the formulation of research questions, the design of research methods, and the originality of research results. If medical students have a strong sense of innovation and strong thinking skills, they can go beyond the traditional framework and propose forward-looking, realistic research directions, thereby deepening and broadening scientific research. Therefore, self-directed learning and students' innovative abilities complement each other and play a decisive role in improving medical students' scientific research skills. Strengthening the cultivation of these two skill sets should become an important goal of medical education. The regression results show that SDL and SIA are significant predictors of SRA. SIA has a more substantial positive impact on SRA compared to SDL's negative impact. The model has good statistical properties with no multicollinearity issues.

6. Conclusion

This research is quantitative, aimed at exploring experiential learning in self-directed learning, students' innovative abilities, teaching methodology, practical activities, and the scientific research skills of medical students, and analyzing the significant influence of experiential learning on medical students' scientific research skills. The sample group consists of 425 students selected by purposive sampling from second- and third-year medical majors at Kunming Health Vocational College. The questionnaire was distributed to 425 students, who generated a QR code and survey link through the Wenjuanxing platform and shared them with participants through institutional communication channels such as email, student groups, and online class forums. The average mean of experiential learning in self-directed learning, students' innovative abilities, teaching methodology, practical activities and scientific research skills of the medical students is at a high level. The significant influence of experiential learning is only 2 variables, these are self-directed learning and students' innovative abilities, toward the medical students' scientific research skills at the 0.01 level.

References

1. Guixian, Z., & Mingfeng, F. (2021). A Study of the Factors that Influence Learners' Scientific Research Skills and the Strategies for Promoting It. Forest Chemicals Review, 83-91.
2. Cruess, R., & Cruess, S., & Steinert, Y. (2018). Medicine as a community of practice implications for medical education. Acad Med.; 93(2):185–191. doi: 10.1097/ACM.0000000000001826
3. Millar, R. (2009). Analysing practical activities to assess and improve effectiveness: The Practical Activity Analysis Inventory (PAAI). York: Centre for Innovation and Research in Science Education, University of York.

4. Yan, P., Lei, L., Baochao, C., Zheng, C., Weidong, C., Huijuan, Y., & Peng, X. (2022). Analysis of the Present Situation of the Cultivation of Scientific Research and Innovation Skills in Medical Students and Exploration of the Scientific Research Training Mode
5. Kolb, D,A., Boyatzis, R.E., & Mainemelis, C. (2001). Experiential Learning Theory: Previous Research And New Directions. In: Sternberg RJ, Zhang LG, Editors. Perspectives On Thinking, Learning, And Cognitive Styles. Mahwah, NJ: Erlbaum; Pp. 227–247.
6. Challa, K.T., Sayed, A., & Acharya, Y. (2016). Modern techniques of teaching and learning in medical education: a descriptive literature review.
7. Que, Y., & Hu, X. (2025). Exploring background music for studying in virtual reality learning environments. *Interactive Learning Environments*, *33*(9), 5516–5529. https://doi.org/10.1080/10494820.2025.2483412
8. Ngo, T.T.A., Tran, T.T., An, G.K., & Nguyen, P.T. (2025). Investigating the influence of augmented reality marketing application on consumer purchase intentions: A study in the E-commerce sector. *Computer in Human Behavior Reports*, *18*, 100648. https://doi.org/10.1016/j.chbr.2025.100648
9. Ling, Y., Chung, S.J. & Wang, L. (2023). Research on the reform of management system of higher vocational education in China based on personality standard. *Current Psychology, 42*, 1225–1237. https://doi.org/10.1007/s12144-021-01480-6
10. Liu, Y., Zhan, Q., & Zhao, W. (2023). A systematic review of VR/AR applications in vocational education: models, affects, and performances. *Interactive Learning Environments*, *32*(10), 6375–6392. https://doi.org/10.1080/10494820.2023.2263043
11. Long, Y., Zhang, X. & Zeng, X. (2025). Application and effect analysis of virtual reality technology in vocational education practical training. *Education and Information Technologies, 30*, 9755–9786. https://doi.org/10.1007/s10639-024-13197-7
12. Mansour, N., Aras, C., Staarman, J.K., & Alotaibi, S.B.M. (2025). Embodied learning of science concepts through augmented reality technology. *Education and Information Technologies*, *30*, 8245–8275. https://doi.org/10.1007/s10639-024-13120-0
13. Hao, T., Wang, W., Wang, G., Yang, W., & Ma, K. (2025). From “chosen ones” to “leftovers”: a historical analysis of China's vocational education and training system, 1949–2023. *Education + Training*, *67*(3), 436-456. https://doi.org/10.1108/ET-09-2023-0412
14. Cha, W., Anderman, E.M., & Kim, M. (2025). How to promote intrinsically versus extrinsically motivated teachers’ job satisfaction: Exploring individual and school factors. *Teaching and Teacher Education*, *166*, 105179. https://doi.org/10.1016/j.tate.2025.105179
15. Alam, A., & Mohanty, A. (2023). Educational technology: Exploring the convergence of technology and pedagogy through mobility, interactivity, AI, and learning tools. *Cogent Engineering*, *10*(2). https://doi.org/10.1080/23311916.2023.2283282
16. Rohayati, Y., & Abdillah, A. (2024). Digital Transformation for Era Society 5.0 and Resilience: Urgent Issues from Indonesia. *Societies*, *14*(12), 266. https://doi.org/10.3390/soc14120266
17. Serrano-Ausejo, E., & Mårell-Olsson, E. (2024). Opportunities and challenges of using immersive technologies to support students’ spatial ability and 21st-century skills in K-12 education. *Education and Information Technologies*, *29*, 5571–5597. https://doi.org/10.1007/s10639-023-11981-5
18. Shamad, M. I., Sari, H., Suti, M., Junaidi, J., & Nurjannah, N. (2023). The effects of cognitive- and affective-based trust on students’ knowledge sharing and learning performance during the Covid-19 pandemic. *Knowledge Management & E-Learning*, *15*(2), 303–321. https://doi.org/10.34105/j.kmel.2023.15.017
19. Yang, J., Liu, Y., Arifani, Y., & Junaidi, J. (2024). The Influence of Entrepreneurial Education on Students’ Business Innovation and Motivation. *International Journal of Learning, Teaching and Educational Research, 23*(11), 268-286. https://doi.org/10.26803/ijlter.23.11.14

20. Zhao, X., Ren, Y., & Cheah, K. S. L. (2023). Leading Virtual Reality (VR) and Augmented Reality (AR) in Education: Bibliometric and Content Analysis from the Web of Science (2018–2022). *SAGE Open*, *13*(3). https://doi.org/10.1177/21582440231190821

21. Zuo, H., Zhang, M., & Huang, W. (2025). Lifelong learning in vocational education: A game-theoretical exploration of innovation, entrepreneurial spirit, and strategic challenges. *Journal of Innovation & Knowledge*, *10*(3), 100694. https://doi.org/10.1016/j.jik.2025.100694

22. Ulmanen, S., Tikkanen, L. & Pyhältö, K. (2024). Sense of relatedness and study engagement as mediators between students' peer support and life satisfaction. *European Journal of Psychology of Education, 39*, 2603–2617 (2024). https://doi.org/10.1007/s10212-024-00858-x