Exploring the Integration of Phenomenon-based Learning Approach in Programming and Critical Thinking Intent

Meng-Chun Tsai[1*[0000-0003-1719-2806]] and Hao-Chiang Koong Lin[2[0000-0001-9824-6938]]

[1] General Competency Center, National Penghu University of Science and Technology, Penghu, Taiwan
[2] Department of Information and Learning Technology, National University of Tainan, Tainan, Taiwan
cherrybearpipi@gmail.com, koonglin@gmail.com

Abstract. Students who are not information technology (non-IT) majors (*N*=63) mostly appear to be frightened and bored when it comes to programming. In this study, the phenomenon-based learning (PhBL) approach would be applied to programming to focus the pedagogical process on students so that they could be inspired through thinking about daily issues. Then, cross-disciplinary integration would take place to apply the acquired programming techniques to visual inventions to generate the creative word cloud. It was indicated in this study that the whole process contributed to significantly enhanced systematic analytical capabilities, open-mindedness, intellectual curiosity, overall and reflective thinking, critical thinking intent and growth needs, with all applicable coefficients greater than 0.7, demonstrating significant high levels of correlation. Both critical thinking intent and interest in the course among students with high growth needs were greater than students with low growth needs and were highly significant with $p < .001$. The correlation with interest in the course and growth needs was nearly highly relevant ($.69^{**}$), proving that the growth needs among students could be reinforced if they have abundant pleasant learning experience.

Keywords: Critical thinking, Phenomenon-based learning, PhBL, Growth needs

1 Introduction

Critical thinking has become one of important educational goals, particularly for university students, because of its diverse nature, that is, multi-dimensional perspectives and the attempt to solve problems and the fact that it is also part of fundamental core competencies. Research has revealed that the programming learning process helps boost the development of critical thinking and advanced train of thought [1]. As such, such capability has been included in the center of the educational framework in many countries and made a paramount task to be fulfilled in education [2]. Programming education is believed to be an important route to the development of advanced thinking in students [3]. In fact, it helps students analyze, organize, express, and evaluate their

thoughts while solving problems [4]. Meanwhile, programming is a form of exploratory learning where students constantly get boosted in their computing and creative thinking capabilities while they try to fulfill the exploratory programming task and create a bond between old and new knowledge [5][6]. Moreover, programming is a learning process where students need to try and error repeatedly in order to realize self-reflection and to accordingly boost critical thinking [7][8]. For most teachers or researchers, however, it remains quite challenging to develop advanced thinking capability in students through programming education [9]. Research has revealed that, with abundant and pleasant learning experience in activities, it helps reinforce students' learning behavior in terms of participation and persistence, such as concentration and perseverance. Once the creative train of thought is inspired in students, they can solve problems more effectively and clearly applying the programming technique. However, non-IT majors mostly appear to be frightened and bored while dealing with programming. In light of this, the PhBL approach will be applied to programming through this study to focus the pedagogical process on students. Students will be inspired through thinking about daily issues. Then, the programming technique acquired in class is applied to visual inventions to generate the creative word cloud. Hopefully, students will be fond of programming and enjoy it.

2 Literature review

2.1 Critical thinking (CT)

Boosting critical thinking is an important goal in many fields in society, especially in education, and particularly in higher education. In as early as 1987, JH MacMillan[10] pointed out that critical thinking should be a main goal of education, particularly during the university stage, as it aims to inspire students' capabilities, such as critical thinking, making inferences, and making judgment that help them make better decisions. Many ideas about critical thinking have been introduced [11]. It means, for example, the internal motivation of a person in the face of problems to be solved, ideas to be evaluated, or decisions to be made [12]. In other words, critical thinking is a "required" occupational skill in terms of problem-solving, evidence collection, and information assessment, which is even more important for a vocational university. Research has revealed that critical thinking is paramount to the promotion of deep learning among students [7][6] as it helps them reflect and generate corresponding ideas and approaches making the best use of evidence and evaluating the materials provided. As a result, enhancing students' critical thinking is set as a paramount educational goal by many schools; they want to nurture independent critical thinkers [13][14]. Education of the 21st century aims to prepare students with the capability to solve problems and critical thinking. By supporting this process with scientific and technical attainments, students are able to think and thinking becomes a skill that contributes the nurturing of individuals that possess originality and are more educated and open-minded [15].

2.2 Phenomenon-based learning, PhBL

PhBL was first developed in the late 1990s. During the 1990s, Maijaliisa Rauste-von Wright [16], in charge of educational psychology in normal education, developed PhBL accordingly. Learning was believed to be "a context-based and situated interaction process" and also "a self-correcting model of curriculum" [16] and aim at minimizing the distance between theory and practice by emphasizing the capability of students to apply what they learned in class to daily life. In other words, learning is a dynamic process and is yet also cognitive, sensitive, responsive, individual, and collective [17]. It contributes to the generation of ethical awareness in learners so that they reflect upon their prior assumptions about themselves, each other, and the world they live in and share the goal to link the learning topic to their living environment and experience. This will accordingly free them from restrictions in the field of learning [18] and reach out wherever possible with the existing pedagogical approach while at the same time retaining the depth integral of the specific discipline [19]. This is why PhBL can be referred to as a cross-disciplinary learning approach.

2.3 Growth needs

Hackman and Lawler [20] indicated that growth needs are desires of individuals to learn and take challenges in the pursuit of self-fulfillment and growth needs vary from one person to another in extent. In other words, growth needs are individualized. Research has revealed that people's mindset is crucial to accomplishments in many aspects of life. Those who believe that capability can be developed (with a growth mindset) are more determined and passionate in realizing long-term goals [21][22]. If students know that they can fortify their belief in growth (new and even stronger neural links take shape while they strive to learn difficult things), they are even more motivated to learn and can render higher scores and reap better learning efficacy [21]. Fundamental psychological needs and relevant characteristics of personal and academic growths have gained quite some prominence [23][24][25]. The satisfaction of psychological needs in students are positively related to respective development outcomes [26][27][28][29]. Besides, the satisfaction of psychological needs also contributes to spontaneous involvement [30] and the search for more assistance [23]. Based on literature review, the following questions are raised for the study: What are the effects of integrating the PhBL approach into programming courses for non-IT majors on their systematic analytical capabilities, open-mindedness, intellectual curiosity, reflective and critical thinking, and overall growth needs, including any differences observed between students with low and high growth needs?

3 Methods

3.1 Participants

The study subjects were non-IT majors, 63 in total, from a national university in Taiwan. They chose "Emerging Technology and Logical Thinking" as their elective

course. Each student spent a semester in finishing the "Emerging Technology and Logical Thinking" course.

3.2 Experimental Design

The 18-week "single group pre-test and post-test design" was adopted for the curriculum. There was one class session a week that lasted for 2 hours. Students completed the "Critical Thinking Intent Questionnaire" in the beginning and at the end of the semester. A total of 63 valid copies of the questionnaire were recovered. The steps taken to apply the PhBL approach to the programming course are as follows Fig. 1, students' class work creative word cloud works as follows Fig. 2.

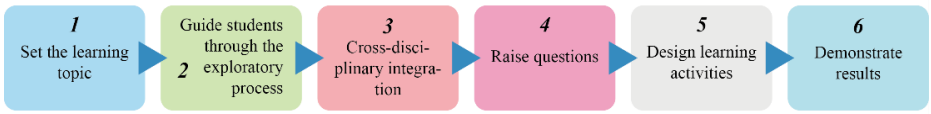

Fig. 1. PhBL course flow chart

The foregoing steps enable students to learn programming knowledge and skills and also to understand in depth daily life issues and phenomena and to develop important skills such as problem-solving and creative thinking.

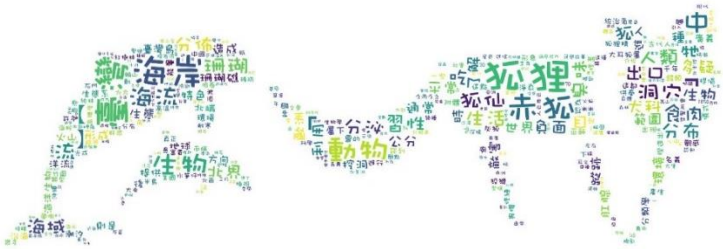

Fig. 2. Creative word cloud works (Source: From students' class work)

3.3 Research tool

Critical thinking intent scale. The critical thinking intent scale of Yeh [31] is divided to four sub-constructs in total, namely, systematic analytical capabilities, open-mindedness, intellectual curiosity, and overall and reflective thinking. The overall critical thinking scale consists of 20 questions that are rated by the Likert 5-point scale of 1 (highly disagree) to 5 (highly agree). A higher score means a higher level of consent to what is described for the specific question. Reliability analysis was performed as part of the pre-test and post-test of each scale for this study. Analysis results showed that the pre-test and post-test Cronbach's α of internal consistency coefficient are .938 and .883 respectively for the 9 questions under systematic analytical capabilities, .868 and .750 respectively for the 4 questions under open-mindedness, .829 and 794 respectively for the 3 questions under intellectual curiosity, .860 and .840 respectively for the 4 questions under overall and reflective thinking, and .969 and .934 respectively for the

20 questions of the critical thinking intent scale. The reliability appeared to be optimal, as is shown in Table 1.

Growth demand scale. In the Job Diagnostic Survey (JDS) introduced by Hackman and Oldham [32], personal growth needs were meant mainly to weigh the individual needs in the pursuit of a higher level and consisted a total of 5 questions that were measured by the Likert 5-point scale of 1 (highly disagree) to 5 (highly agree). A higher score means a higher level of consent to what is described for the specific question. In this study, the pre-test Cronbach's α of internal consistency was .943 and the post-test one was .935; the reliability was quite desirable. See Table 1.

Table 1. Reliability of respective constructs of the critical thinking intent, growth needs and the interesting nature of course scale

-	Cronbach's α		Number of items
	pre-test	post-test	
Systematic analytical capabilities	.938	.883	9
Open-mindedness	.868	.750	4
Intellectual curiosity	.829	.794	3
Overall and reflective thinking	.860	.840	4
Critical thinking intent	.969	.934	20
Growth Needs	.943	.935	5
Interesting nature of course	.945	.958	6

4 Results

This study mainly explores the correlation between the integration of the PhBL approach in the programming course of non-IT majors and systematic analytical capabilities, open-mindedness, intellectual curiosity, overall and reflective thinking, critical thinking intent and growth needs? Are their capabilities enhanced? Are there differences between students with low growth needs and those with high ones in their critical thinking intent and the interesting nature of course? For this sake, SPSS is applied in this study for Pearson's correlation analysis, paired sample T-test, and independent sample T-test. Detailed results are provided below.

4.1 Analysis of Correlation of Respective Constructs

The Pearson's correlation analysis results revealed that the correlation coefficients among systematic analytical capabilities [$r(61) = .97$, $p<.01$], open-mindedness [$r(61) = .77$, $p<.01$], intellectual curiosity [$r(61) = .80$, $p<.01$], overall and reflective thinking [$r(61) = .91$, $p<.01$], and critical thinking intent were consistently greater than 0.7, indicating significantly high positive correlation; those among systematic analytical capabilities [$r(61) = .50$, $p<.01$], intellectual curiosity [$r(61) = .46$, $p<.01$], overall and reflective thinking [$r(61) = .43$, $p<.01$], critical thinking intent [$r(61) = .50$, $p<.01$], and

growth needs were between 0.4 and 0.7, indicating significantly moderate positive correlation; that with open-mindedness [$r(61) = .30$, $p<.05$] was smaller than 0.4, indicating significantly low positive correlation; those among systematic analytical capabilities [$r(61) = .44$, $p<.01$], intellectual curiosity [$r(61) = .41$, $p<.01$], overall and reflective thinking [$r(61) = .41$, $p<.01$], critical thinking intent [$r(61) = .46$, $p<.01$], growth needs [$r(61) = .69$, $p<.01$], and interesting nature of course were between 0.4 and 0.7, indicating significantly moderate positive correlation while that with open-mindedness [$r(61) = .35$, $p<.05$] was smaller than 0.4, indicating significantly low positive correlation. See Table 2.

Table 2. Correlation matrix of respective constructs upon Pearson's correlation analysis (N = 63) after the course

	1	2	3	4	5	6
1. Systematic analytical capabilities	-					
2. Open-mindedness	.69**	-				
3. Intellectual curiosity	.71**	.50**	-			
4. Overall and reflective thinking	.84**	.60**	.67**	-		
5. Critical thinking intent	.97**	.77**	.80**	.91**	-	
6. Growth needs	.50**	.30*	.46**	.43**	.50**	-
7. Interesting nature of course	.44**	.35**	.41**	.41**	.46**	.69**

*$p<.05$ ** $p<.01$ *** $p<.001$

4.2 Analysis of Related Competencies After Participation in Course

In order to know if students' applicable competencies were enhanced after the course, the paired sample T-test was adopted for analysis and it revealed significant differences between pre-test and post-test means in systematic analytical capabilities ($t(62) = 2.13$, $p = .04$, $d = 0.27$). The post-test systematic analytical capabilities (M = 4.15, SD = 0.60) were significantly greater than the pre-test ones (M = 3.88, SD = 0.75). Open-mindedness differed significantly between pre-test and post-test means ($t(62) = 2.57$, $p = .01$, $d = .32$). The post-test open-mindedness (M = 4.28, SD = 0.50) was significantly greater than the pre-test one (M = 3.97, SD = 0.73). Intellectual curiosity differed significantly between pre-test and post-test means ($t(62) = 3.77$, $p = .00$, $d = .48$). The post-test intellectual curiosity (M = 4.25, SD = 0.66) was significantly greater than the pre-test one (M = 3.74, SD = 0.79). Overall and reflective thinking differed significantly between pre-test and post-test means ($t(62) = 2.16$, $p = .03$, $d = .27$). The post-test overall and reflective thinking (M = 4.09, SD = 0.72) was significantly greater than the pre-test one (M = 3.79, SD = 0.78). Critical thinking intent differed significantly between pre-test and post-test means ($t(62) = 2.65$, $p = .01$, $d = .33$). The post-test critical thinking intent (M = 4.18, SD = 0.55) was significantly greater than the pre-test one (M = 3.85, SD = 0.72). Growth needs differed significantly between pre-test and post-test means ($t(62) = 2.41$, $p = .02$, $d = .30$). The post-test growth needs (M = 3.99, SD = 0.88) were significantly greater than the pre-test ones (M = 3.62, SD = 0.84). They indicate that stu-

dents' systematic analytical capabilities, open-mindedness, intellectual curiosity, overall and reflective thinking, critical thinking intent, and growth needs were all significant. See Table 3. In other words, the integration of the PhBL approach in the programming course of non-IT majors did significantly enhance the systematic analytical capabilities, open-mindedness, intellectual curiosity, overall and reflective thinking, critical thinking intent and growth needs.

Table 3. T-test of pre-test and post-test differences (N = 63)

Dimension	*M(SD)*		*df*	*t-value*	*p*	*d*
	pre-test	post-test				
Systematic analytical capabilities	3.87(0.75)	4.15(0.60)	62	2.13	.04*	0.27
Open-mindedness	3.97(0.73)	4.28(0.50)	62	2.57	.01*	0.32
Intellectual curiosity	3.74(0.79)	4.25(0.66)	62	3.77	.00***	0.48
Overall and reflective thinking	3.79(0.78)	4.09(0.72)	62	2.16	.03*	0.27
Critical thinking intent	3.85(0.72)	4.18(0.55)	62	2.65	.01**	0.33
Growth needs	3.62(0.84)	3.99(0.88)	62	2.41	.02*	0.30

*p<.05 ** p <. 01 *** p< .001

4.3 Analysis of Low and High Growth Needs

In order to know the differences, if any, between low growth needs and high ones in terms of critical thinking intent and interesting nature of course, the independent sample *t* test was adopted for analysis in this study. Results are shown in Table 4. The results showed significant differences between low growth needs and high ones in critical thinking intent ($t(31) = -4.26$, $p = .000$, d=0.75). Low growth needs ($M = 3.89$, $SD = 0.55$) were smaller than high ones ($M = 4.61$, $SD = 0.40$), with significant correlation. Significant differences were found in interesting nature of course ($t(31) = -6.33$, $p = .000$, d=1.12). Low growth needs ($M = 2.72$, $SD = 0.57$) were smaller than high ones ($M = 4.35$, $SD = 0.89$), with significant correlation.

Table 4. Independent sample t-test of low and high growth needs

Dimension	*M (SD)*		*df*	*t-value*	*p*	*d*
	Low growth needs ($N = 17$)	High growth needs ($N = 16$)				
Critical thinking intent	3.89(0.55)	4.61(0.40)	31	-4.26	.000***	0.75
Interesting nature of course	2.72(0.57)	4.35(0.89)	31	-6.33	.000***	1.12

*p<.05 ** p <. 01 *** p< .001

5 Conclusion

What are the effects of integrating the PhBL approach into programming courses for non-IT majors on their systematic analytical capabilities, open-mindedness, intellectual

curiosity, reflective and critical thinking, and overall growth needs, including any differences observed between students with low and high growth needs? We will answer questions about this study in more details below.

Through Table 2, we know that correlation coefficients of respective constructs with the overall scale were consistently greater than 0.7, indicating significantly high positive correlation. This answers to the research findings of Yeh [31]. In terms of growth needs and interesting nature of course, except for the correlation coefficient of open-mindedness, which was smaller than 0.4 and demonstrated significantly low positive correlation, the remainder was between 0.4 and 0.7, indicating significantly moderate positive correlation. This answers to the research findings of Marcos-Vílchez et al. [13]. Throughout critical thinking, competency and character are complementary to each other because they help students take advantage of evidence and evaluate the provided materials and reflect upon ideas. As far as interesting nature of course is concerned, its correlation with growth needs is close to highly relevant (.69**), which proves that it helps reinforce students' motivation for growth needs if they have enriched and pleasant learning experience and it will convert to participation and persistence of learning behavior [9].

Through Table 3, we know that, in terms of pre-test and post-test means, post-test ones were consistently greater than pre-test ones, indicating that the integration of the PhBL approach in the programming course of non-IT majors did significantly enhance the systematic analytical capabilities, open-mindedness, intellectual curiosity, overall and reflective thinking, critical thinking intent and growth needs. The sub-construct of intellectual curiosity reached significance ($p < .001$), indicating that the integration of PhBL approach allowed the students to begin with daily life issues and link their living environment and experience [18] and the combination of programming and visual design and it contributed to enhanced intellectual curiosity of the students. Such an exploratory learning process enhanced the critical thinking intent [18].

Through Table 4, we know that the critical thinking intent and interesting nature of course among students with high growth needs were both greater than those among students with low ones and highly significant ($p < .001$). This is because high growth needs are associated with the pursuit of self-fulfillment and the desire to take challenges [20] and growth needs vary from one person to another in extent. In other words, growth needs are individualized. Learners with high growth needs will reinforce the positive correlation between the characteristics of the task and their key psychological states. In addition, they will strengthen the correlation between their psychological states and satisfaction as well as efficacy. This falls in line with the findings of related studies. As such, learners with high growth needs reinforce the scenario of curricular design and curricular innovation and create positive correlation with their mindset. Such a mindset can exercise an important effect on their accomplishments in many aspects of life. Those who believe that capability can be developed (with a growth mindset) are more determined and passionate in realizing long-term goals [21][22]. Once students fortify their belief in growth (new and even stronger neural links take shape while they strive to learn difficult things), they are even more motivated to learn and will have even greater learning accomplishments.

Disclosure of Interests. It is now necessary to declare any competing interests or to specifically state that the authors have no competing interests.

References

1. Almerich, G., Suárez-Rodríguez, J., Díaz-García, I., & Cebrián-Cifuentes, S. 21st-century competences: The relation of ICT competences with higher-order thinking capacities and teamwork competences in university students. *Journal of Computer Assisted Learning, 36*(4), 468-479 (2020)
2. Assaly, I., & Jabarin, A. Arab Israeli EFL teachers' perceptions and practices vis-à-vis teaching higher-order thinking skills: A complicated relationship. *Language Teaching Research*, 13621688211032426 (2021)
3. Liu, D., & Zhang, H. Improving students' higher order thinking skills and achievement using WeChat based flipped classroom in higher education. *Education and Information Technologies, 27*(5), 7281-7302 (2022)
4. Buitrago Flórez, F., Casallas, R., Hernández, M., Reyes, A., Restrepo, S., & Danies, G. Changing a generation's way of thinking: Teaching computational thinking through programming. *Review of Educational Research, 87*(4), 834-860 (2017)
5. Garcia, M. B. Cooperative learning in computer programming: A quasi-experimental evaluation of Jigsaw teaching strategy with novice programmers. *Education and Information Technologies, 26*(4), 4839-4856 (2021)
6. Wu, T. T., & Chen, J. M. Combining Webduino programming with situated learning to promote computational thinking, motivation, and satisfaction among high school students. *Journal of Educational Computing Research, 60*(3), 631-660 (2022)
7. Liu, C. Y., Li, W., Huang, J. Y., Lei, L. Y., & Zhang, P. R. Collaborative programming based on social shared regulation: An approach to improving students' programming achievements and group metacognition. *Journal of Computer Assisted Learning, 39*(5), 1714-1731 (2023)
8. Psycharis, S., & Kallia, M. The effects of computer programming on high school students' reasoning skills and mathematical self-efficacy and problem solving. *Instructional science, 45*(5), 583-602 (2017)
9. Popat, S., & Starkey, L. Learning to code or coding to learn? A systematic review. *Computers & Education, 128*, 365-376 (2019)
10. McMillan, J. H. Enhancing college students' critical thinking: A review of studies. *Research in higher education, 26*, 3-29 (1987)
11. Rui, W., Jian, L., Xinwen, B., Xiaoying, M., Yan, L., Lihong, M., ... & Guanxing, X. The research design of the 5Cs framework for twenty-first century key competences. *Journal of East China Normal University (Educational Sciences), 38*(2), 20 (2020)
12. Facione, P. A., Facione, N. C., & Giancarlo, C. A. Professional judgment and the disposition toward critical thinking. *Retrieved Nov, 21*, 2020 (1997)
13. Marcos-Vílchez, J. M., Sánchez-Martín, M., & Muñiz-Velázquez, J. A. Effectiveness of training actions aimed at improving critical thinking in the face of disinformation: A systematic review protocol. *Thinking Skills and Creativity*, 101474 (2024)
14. Halpern, D. F. Thought and knowledge: An introduction to critical thinking. Psychology press (2013)
15. Altun, E., & Yildirim, N. What does critical thinking mean? Examination of pre-service teachers' cognitive structures and definitions for critical thinking. *Thinking Skills and Creativity, 49*, 101367 (2023)

16. Rauste-von Wright, M. The function of curriculum and the concept of learning. *Curriculum approaches. Readings and activities for educational studies*, 21-34 (2001)
17. Küpers, W. Phenomenology of learning. Encyclopedia of the Sciences of Learning; Seel, NB, Ed.; Springer: Cham, Switzerland, 2611-2615 (2012)
18. Tian, M., & Risku, M. A distributed leadership perspective on the Finnish curriculum reform 2014. *Journal of Curriculum Studies*, *51(*2), 229-244 (2019)
19. Wolff, L. A. Phenomenon-based learning. In *Encyclopedia of Sustainable Management* (pp. 1-9). Cham: Springer International Publishing (2022)
20. Hackman, J. R., & Lawler, E. E. Employee reactions to job characteristics. *Journal of applied psychology*, *55*(3), 259 (1971)
21. Toding, M., Mädamürk, K., Venesaar, U., & Malleus, E. Teachers' mindset and attitudes towards learners and learning environment to support students' entrepreneurial attitudes in universities. *The International Journal of Management Education*, *21*(1), 100769 (2023)
22. Hochanadel, A., & Finamore, D. Fixed and growth mindset in education and how grit helps students persist in the face of adversity. *Journal of International Education Research (JIER)*, *11*(1), 47-50 (2015)
23. Earl, S. R., Taylor, I. M., Meijen, C., & Passfield, L. Trajectories in cognitive engagement, fatigue, and school achievement: The role of young adolescents' psychological need satisfaction. *Learning and Individual Differences*, *101*, 102248 (2023)
24. Guay, F. Applying self-determination theory to education: Regulations types, psychological needs, and autonomy supporting behaviors. *Canadian Journal of School Psychology*, *37*(1), 75-92 (2022)
25. Howard, J. L., Bureau, J. S., Guay, F., Chong, J. X., & Ryan, R. M. Student motivation and associated outcomes: A meta-analysis from self-determination theory. *Perspectives on Psychological Science*, *16*(6), 1300-1323 (2021)
26. Tian, L., Chen, H., & Huebner, E. S. The longitudinal relationships between basic psychological needs satisfaction at school and school-related subjective well-being in adolescents. *Social indicators research*, *119*, 353-372 (2014)
27. Huhtiniemi, M., Sääkslahti, A., Watt, A., & Jaakkola, T. Associations among basic psychological needs, motivation and enjoyment within finnish physical education students. *Journal of sports science & medicine*, *18*(2), 239 (2019)
28. Carmona-Halty, M., Schaufeli, W. B., Llorens, S., & Salanova, M. Satisfaction of basic psychological needs leads to better academic performance via increased psychological capital: A three-wave longitudinal study among high school students. *Frontiers in psychology*, *10*, 474273 (2019)
29. Alivernini, F., Bianchi, D., Cavicchiolo, E., Manganelli, S., Cozzolino, M., Lucidi, F., & Park, N. Positive youth development among youth living in poverty: *The role of psychological needs satisfaction. Youth & Society*, *55*(5), 947-969 (2023)
30. Bureau, J. S., Howard, J. L., Chong, J. X., & Guay, F. Pathways to student motivation: A meta-analysis of antecedents of autonomous and controlled motivations. *Review of Educational Research*, *92*(1), 46-72 (2022)
31. Yeh, Y. C. A study of substitute teachers' professional knowledge, personal teaching efficacy, and teaching behavior in critical-thinking instruction. *Journal of Chengchi University*, *78*, 55-84 (1999)
32. Hackman, J. R., & Oldham, G. R. Development of the job diagnostic survey. *Journal of Applied psychology*, *60*(2), 159 (1975).