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The impact of inquiry-based learning on problem-solving skills and conceptual knowledge building

Dr. Majlinda Hala[1*], Assoc. Prof. Dr. Nazmi Xhomara[2]
[1]Lecturer, Department of Picture, Faculty of Arts, University of Arts, Tirana, Albania.
[2] Lecturer, Department of Mathematics and Statistics, Faculty of Information Technology and Innovation, Luarasi University, Albania.
*majlindahala@gmail.com
nazmixhomara@hotmail.com

ABSTRACT

The study aims to examine the implementation of an inquiry-based learning approach to improving problem-solving skills and conceptual knowledge building at university. Analysis of Variance (ANOVA) was used to test the impact of inquiry-based learning in problem-solving skills and conceptual knowledge building. The study found that that variance of the inquiry-based learning is different, revealing that different levels of inquiry-based learning influence problem- solving. It is also found that approximately 88.5% of the variance in problem- solving can be explained or accounted for by inquiry-based learning differences. It is confirmed that that variance of the inquiry-based learning is different, revealing that different levels of inquiry-based learning influence conceptual knowledge building. The study also found that approximately 31.5% of the variance in conceptual knowledge building can be explained or accounted for by inquiry-based learning differences.

Keywords
Inquiry-based learning, problem-solving, conceptual knowledge building

Introduction

The inquiry-based learning approach used by lecturers is supposed to be one of the important variables that influence problem-solving skills and conceptual knowledge building in the university. Inquiry-based learning is associated with some educational philosophies or paradigms; fostering communities of learning, learning by design, central conceptual structures, direct instruction, higher-order thinking skills, and knowledge building (van den Broek, 2012). It has often been found that students appreciate hands-on work, and find that they learn more with courses that include a project than those relying solely on conventional lectures and tests (Auerbach, Concordel, Kornatowski & Floreano, 2019). Attention to inquiry-based teaching practices has surfaced as one vehicle for supporting the development of critical thinking skills in science classrooms (Achieve Inc., 2013, cited by Franco, 2013). In science education, inquiry-based approaches to teaching and learning provide a framework for students to building critical-thinking and problem-solving skills (Roehrig, Michlin, Schmitt, MacNabb & Dubinsky, 2012). Inquiry-based teaching is at the heart of several pedagogical initiatives including project-based instruction, maker-centered learning, and the 5E learning cycle: engagement, exploration, explanation, elaboration, and evaluation (Bybee et al., 2006, cited by Rodriguez, Allen, Harron & Qadri, 2019). Inquiry-based teaching aims to increase student engagement through the development of hands-on, minds-on skills, such as critical thinking, collaboration, and communication, needed for the 21st century (The Partnership for 21st Century Skills, 2015). This approach respects the complexities of the learning process, values the knowledge and experience students bring to the classroom, and prioritizes active problem-solving communication of findings, and the shared construction of new ideas (Rodriguez, Allen, Harron & Qadri, 2019).

At the same time, students' academic gain and learning performance are affected by teaching faculty, students schooling, family social status, residential area of students, the medium of instructions in schools, and daily study hour (Xhomara, 2018). To compete globally in the 21st Century, students must have the skills to design their projects and understand how to navigate the wealth of information available at their fingertips.

One of the most important tools is to be able to investigate ideas and implement a plan of action to answer questions that have not been explored. These creative problem-solving skills are essential when students design problems and projects during the student-driven inquiry (Doss, 2018). Kraut (2015) pointed out that the inverted classroom allows more in-class time for inquiry-based learning and for working through more advanced problem-solving activities than does the traditional lecture class. Developing problem-solving skills is often accepted as a desirable goal in many educational settings. However, there is little evidence to support that students are better problem-solvers after graduating. The students can solve routine problems, but they confronted difficulties when adapting their prior knowledge for the solution of new problems (Fadzil, 2017).

The study aims to investigate the implementation of an inquiry-based learning approach to improving problem-solving skills and conceptual knowledge building at university level. The research questions are as follows: (1) Do different levels of inquiry-based learning differ in terms of problem-solving skills? Are inquiry-based learning higher levels better adjusted than lower levels in terms of problem-solving skills? (2) Do different levels of inquiry-based learning differ in terms of conceptual knowledge building? Are inquiry-based learning higher levels better adjusted than lower levels in terms of conceptual knowledge building?

Theoretical framework and Literature review

The most important factors in the teaching and learning process are an immature, undeveloped being; and certain social aims, meanings, values incarnate in the matured experience of the adult. The educative process is the due interaction of these forces. The current standpoint of the students and the facts and truths of studies define instruction. (Dewey, 1902). Constructivism theory is used as a basis of the theoretical framework. Constructivism is an instruction paradigm posits that learning is an active, constructive process, and where the learner is a constructor, and actively create their subjective representations of reality (David, 2015).

Conceptual framework

The conceptual framework for the study, as shown in figure 1, is developed from a review of existing evidence about the relationship between the interested variables. The review including a search for relevant empirical research through Sage, ERIC, and EBSCO, using the keywords inquiry-based learning, problem-skills, and conceptual knowledge building. The results of the study were interpreted in terms of constructivist theory and research conducted in the field.

Figure 1. Conceptual framework

Literature review

The impact of inquiry-based learning on problem-solving skills

Inquiry-based learning in university education is thought to be one of the most important variables to increase problem-solving skills in university studies. Many authors have done a lot of research to investigate the relationship between inquiry-based learning and problem-solving skills in university studies.

O'Neill, Adams, Bandelt, Chester, Cai, & Nadimpalli (2019) pointed out that conventional methods and methodologies may function as starting points, but they lack a focus on the metacognition and inquiry-based thinking required to analyze, evaluate, and synthesize diverse problems; meanwhile, Fadzil (2017) confirmed that when students are engaged in the inquiry-based learning process, the knowledge can be generated more meaningfully than in other perceived passive mode of learning. The inquiry-based learning that is based on the cognitive approach and student-centered teaching impact high-level cognitive skills, such as critical-creative thinking and problem-solving rather than conventional teacher-centered teaching (Akman & Alagöz, 2018; Yu, 2015); and Hassi and Laursen (2015) revealed that learning in classroom situations that use student activity, deep engagement, and collaboration not only enhance students' thinking and problem-solving skills, but it also significantly promotes self-perceptions, and social skills.

The problem-solving skills are influenced by the inquiry-based learning approach (Yuliati, Riantoni, & Mufti, 2018; Turnip, Wahyuni &

Tanjung, 2016); and Davis (2018), as well as Xhomara (2019) found out that inquiry-based learning approach influence higher ratings in problem-solving skills, life skills and students'achievements compared with the lecture-based approach. Roehrig, Michlin, Schmitt, MacNabb, & Dubinsky (2012) found out that combined content and knowledge of learning with inquiry-based pedagogy impact students' inquiry-based practices; and Thang, & Koh (2017) showed that the integrated science module deepened students' confidence with self-directed learning and authentic problem-solving whereas students' confidence with critical thinking positively predicted students' end-of-year results. The use of inquiry-based activities might have helped learners improve their level (Bozkurt & Koc, 2020); and including project-based instruction, maker-centered learning, and the 5E learning cycle: engagement, exploration, explanation, elaboration, and evaluation impact concept learning (Rodriguez, Allen, Harron, & Qadri, 2019).

Großmann & Wilde (2019) shows that inquiry-based experimentation influence knowledge acquisition on students with low prior knowledge; meanwhile, Zhang & Li (2019) found out that the inquiry-based investigation as an instructional approach was associated with students' overall science achievement and achievement in cognitive domains, including knowing science facts, applying scientific principles, and reasoning with scientific concepts to solve problems. In the inquiry-based learning, and where students become completely engaged, they work logically and systematically and learn to use problem-solving and communication skills, such as scientific practices of hypothesizing, investigating, observing, explaining, and evaluating (Cherif, Siuda, Kassem, Gialamas & Movahedzadeh, 2017; Doss, 2018). The prior knowledge, problem-based teaching, the comprehensive learning approach and assessment explained 50% of the variance in the levels of basic-learning skills (Xhomara, 2020); at the same time, Rapanta (2018) shows that the Socratic method of inquiry, collaborative problem solving, and debate-based deliberation establishing the relationship with the strategic promotion of argumentative reasoning; but from the other point of view, McRae-Jones (2017) revealed that there was no impact between the inquiry-based instructional strategies and student achievement in social studies.

Inquiry-based learning approach support reflective skills of the pre-service teachers (Østergaard, 2019); as well as cognitive development, higher motivation to learn, and increased self-efficacy of students (McElvain & Smith, 2016). Inquiry-based projects develop a natural curiosity of students that will lead them on the path toward solving problems (Cook, Hartman, Pierce & Seaders, 2017; LaBanca & Ritchie, 2011); meanwhile, Méndez & Pérez Gómez (2017) pointed out that inquiry-based practicum in the education of future teachers has been identified as a key component to foster student-teachers'abilities to face problems, try to solve them. Worthington (2018) emphasized that the student-centered teaching and learning opportunities can improve students' critical thinking, problem-solving, and collaborative skills; meanwhile, Falloon (2017) found out that student thinking, problem-solving and collaboration were increased when using digital tablets for a range of conventional curriculum-related purposes, and problem and inquiry-based learning programs.

Inquiry-based learning through robotics applications and virtual learning system offers multiple possibilities for students to implement their ideas, and influence problem-solving and improve the effectiveness of online learning (Auerbach, Concordel, Kornatowski, & Floreano (2019; Chanprasitchai & Khlaisang, 2016; Avsec & Kocijancic, 2016). Gupta (2012) found out that an inquiry-based approach to learning and teaching and student-centered active learning approach may be the effective way to enhance student understanding of concepts; and Gillies, Nichols, Burgh & Haynes (2012) shows that teaching students to ask and answer questions is critically important if they are to engage in reasoned argumentation, problem-solving, and learning. The student-centered construction of learning and knowledge, and inquiry-based teaching approaches support students to solve authentic problems by thinking critically, and actively create content (Jansen, 2011; Drake & Long, 2009); and Nehring, Nowak, zu Belzen & Tiemann (2015) show that students' characteristics predict their inquiry skills to a large extent (55%), whereas 9 out of 12 variables contribute significantly on a multivariate level. Thus, it is evidenced that inquiry-based learning impacts problem-solving skills at university. In conclusion, the investigation of the relationship between inquiry-based learning and problem-solving skills, as resulted in previous research, is important. Therefore, based on the above literature review it is hypothesized that:

H # 1: Problem-solving is a function of inquiry-based learning

The impact of inquiry-based learning on conceptual knowledge building

Inquiry-based learning in university education is thought to be one of the most important variables to increase conceptual knowledge building in university studies. Many authors have done a lot of research to investigate the relationship between inquiry-based learning and conceptual knowledge building in university studies.

Inquiry projects and extensive in-service professional development had positive effects on students' understanding of the complexity of educational concepts (Byker, Coffey, Harden, Good, Heafner, Brown & Holzberg, 2017); and Arslan Buyruk & Ogan Bekiroglu (2018) indicated that model-based inquiry on pre-service teachers' conceptual understanding of concepts facilitates conceptual learning; meanwhile, the observation and analysis of scientific data can be used as a scaffold to build conceptual understanding in science through inductive reasoning (Nichol, Szymczyk & Hutchinson, 2014; Levy & Petrulis, 2012). Xhomara (2020) demonstrated that students' academic success has been explained strongly by individual study work and lecturer support; at the same time, Lai (2017) indicate that a supportive online learning environment entails teachers using effective pedagogical practices to meet the needs of their students and to foster learner motivation and engagement; and Vokatis & Zhang (2016) found out that engaged in inquiry-based classroom practice using knowledge building pedagogy and knowledge forum, a collaborative online environment influence on deep and lasting change requires teacher transformation and capacity building. Project-based learning offers teachers a model for students to develop and enact inquiry-based projects that reflect positive, and active, civic dispositions (LeCompte & Blevins, 2015); meanwhile, Salsabila, Wijaya & Winarno, 2019) found out that argument-driven inquiry impact students' sustainability awareness in learning.

Tezcan-Unal, Winston & Qualter (2018) pointed out that supportive learning environment, learning practices, and leadership supports learning; and Kiss & Wang (2017) found out that the implementation of knowledge building pedagogy has a positive impact on teacher questioning and contributes to creating an effective learning environment. Kovanovic, Gaševic & Hatala (2014) shows that inquiry-based learning and the specifics of communication through asynchronous discussions support the student interactions with information and technology; meanwhile, Williams, Pringle & Kilgore (2019) revealed that engaging in practitioner inquiry, tapped into the potential of deliberate cognate instruction support the learning of science within the context of inquiry-based science teaching. Inquiry-based instruction, as well as team teaching support students to construct knowledge (Musanti, 2017; Bierenstiel & Snow, 2019); meanwhile, Arce, Bodner & Hutchinson (2014) point out that extensive in-service professional development can produce a substantive change in teachers' beliefs about optimum teaching practice. Xhomara (2022) found out that there is a strong positive correlation between student-centred teaching and critical thinking skills; meanwhile, Van Booven (2015) shows that the fixed nature of authoritatively oriented questioning can dramatically limit students' opportunities to demonstrate higher-order scientific understanding; and Reeves, Fostvedt, Laugerman, Baenziger, Shelley, Hand & Therrien, 2013) indicate that inquiry-based approach increases cognitive abilities such as critical thinking. Nilssen & Solheim (2015) confirmed that bridging theory and practice is depended by commuting between field practice and coursework, the authenticity of the tasks and future relevance for the teaching; meanwhile, Herczog (2014) showed that inquiry-based teaching impact building the critical thinking, problem-solving, and participatory skills of students. Thus, it is evidenced that inquiry-based learning impacts conceptual knowledge building at university. In conclusion, the investigation of the relationship between inquiry-based learning and conceptual knowledge building, as resulted in previous research, is important. Therefore, based on the above literature review it is hypothesized that:

H # 2: Conceptual knowledge building is a function of inquiry-based learning.

Methodology

Method and design

The quantitative approach was the method used in the research. The design of the study employed a sample of 132 law students. Inquiry-based learning was selected to be used as an independent variable; meanwhile, problem-solving and conceptual knowledge building were selected as dependent variables. Inquiry-based learning, as an independent variable has five levels: 1=very low level, 2= low level, 3= medium level, 4= high level, 5= very high level. Problem-solving skills, as dependent variable has five levels: 1= 0-40 scores, 2= 41-60 scores, 3= 61-80 scores, 4= 81-90 scores, 5= 91-100 scores. Conceptual knowledge building, as the dependent variable has also five levels: 1=very low level, 2= low level, 3= medium level, 4= high level, 5= very high level.

Sample and data collection

A non-random sample of 132 law students was selected to be investigated in the research. Regarding the study program, 76 respondents (57.6%) study in the Civil Law program, meanwhile, 56 of the experimental group (42.4%) study in the Criminal Law program. The sample of respondents is composed of 80 females (60.6%), and 52 (39.4%) males. A structured questionnaire was used to gather the primary data from the students in the 2019-2020 academic year. The questionnaire is based on academic self-efficacy, achievement motivation, engagement online survey (Huang, 2011) and is modified, piloted, and validated by the author. The questionnaire used in the research is compounded by three main dimensions: (1) inquiry-based learning, (2) problem-solving, and (3) conceptual knowledge building. Alfa Cronbach's values of questionnaire scales vary from .83 to .95 confirming a very good value of reliability, as follows.

Table 1.

Cronbach's alpha values

Table 1.

Cronbach's alpha values

N0.	Variables	Alpha Cronbach value	Evaluation
1	Inquiry-based learning	.95	Excellent
2	Problem-solving skills	.88	Good
3	Conceptual knowledge building	.83	Good

Analysis

Central tendency values, as well as frequency values, were used to describe the inquiry-based learning, problem-solving, and conceptual knowledge building. A one-way fixed effects between-subjects analysis of variance (ANOVA) was conducted to evaluate the null hypothesis that problem- solving, and conceptual knowledge building population means were equal across five inquiry-based learning levels. Preliminary assumption testing was conducted to check for normality, linearity, univariate outliers, homogeneity of variance, and multicollinearity, with no violations noted.

Results and Discussion

Descriptive statistics

Table 2.

Inquiry-based learning frequencies

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Inquiry-based learning frequencies

Inquiry-based learning

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very low level	16	12.1	12.1	12.1
	Low level	24	18.2	18.2	30.3
	Medium level	20	15.2	15.2	45.5
	High level	40	30.3	30.3	75.8
	Very high level	32	24.2	24.2	100.0
	Total	132	100.0	100.0	

Inquiry-based learning' frequencies indicate that 30.3% of the respondents report very low and low level in inquiry-based learning; 15.2% of them medium level; meanwhile, 54.5% of the respondents report high and very high level. Central tendency values for experimental groups (M= 3.3636, SD = 1.34943), indicate the same tendency for values as measured by frequencies. Therefore, the most of respondents report high and very high levels; meanwhile, approximately one-third of them report the very low and low level in inquiry-based learning.

Table 3.

Problem- solving frequencies

Table 3.
Problem- solving frequencies

Problem- solving

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very low level	8	6.1	6.1	6.1
	Low level	32	24.2	24.2	30.3
	Medium level	24	18.2	18.2	48.5
	High level	52	39.4	39.4	87.9
	Very high level	16	12.1	12.1	100.0
	Total	132	100.0	100.0	

Problem-solving' frequencies indicate that 6.1% of the respondents report 0-40 scores in problem-solving; 24.2% of them 41-60 scores; 18.2% of them 61-80 scores; 39.4% of them 81-90 scores; meanwhile, 12.1% of the respondents report 91- 100 scores. Central tendency values for experimental groups (M= 3.2727, SD = 1.34978), indicate the same tendency for values as measured by frequencies. Therefore, the most of respondents report high and very high levels; meanwhile, approximately one-third of them report the very low and low level in problem-solving.

Table 4.

Conceptual knowledge building frequencies

Table 4.
Conceptual knowledge building frequencies

Conceptual knowledge building

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Very low level	16	12.1	12.1	12.1
	Low level	20	15.2	15.2	27.3
	Medium level	40	30.3	30.3	57.6
	High level	32	24.2	24.2	81.8
	Very high level	24	18.2	18.2	100.0
	Total	132	100.0	100.0	

Conceptual knowledge-building' frequencies indicate that 27.3% of the respondents report very low and low level in conceptual knowledge building; 30.3% of them are medium level, meanwhile, 42.4% of the respondents high and very high level of conceptual knowledge building. Central tendency values for experimental groups (M= 3.2121, SD = 1.25419), indicate the same tendency for values as measured by frequencies. Therefore, less than half of respondents report high and very high level;

meanwhile, approximately one-third of them report the very low and low level in conceptual knowledge building.

Inferential statistics

Test of Hypothesis

H # 1: *Problem- solving is a function of inquiry-based learning*

Table 5.

Levene's Test of Equality of Error' outputs

Table 5.
Levene's Test of Equality of Error' outputs

Levene's Test of Equality of Error Variances

Dependent Variable: PS

F	df1	df2	Sig.
24.734	4	127	.000

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + IBL

Since the Levene's Test of Equality of Error Variances is statistically significant (p = .000), as shown in table 5, there is evidence to reject the null hypothesis of equality of variance across groups of the inquiry-based learning' independent variable. This result suggests that somewhere among the variances in the population, there is an inequality. Therefore, different levels of inquiry-based learning influence problem-solving.

Table 6.

Tests of Between-Subjects Effects' outputs

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Tests of Between-Subjects Effects' outputs

Tests of Between-Subjects Effects

Dependent Variable: PS

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	150.682[a]	4	37.670	245.341	.000	.885
Intercept	1051.559	1	1051.559	6848.618	.000	.982
IBL	150.682	4	37.670	245.341	.000	.885
Error	19.500	127	.154			
Total	1584.000	132				
Corrected Total	170.182	131				

a. R Squared = .885 (Adjusted R Squared = .882)

As shown in table 6, a statistically significant difference was found (F = 37.670 on 4 and 127 df, p < 0.001), with an estimated effect size of 0.885 (Eta squared). This result suggesting that approximately 88.5% of the variance in problem- solving can be explained or accounted for by inquiry-based learning differences. Therefore, based on ANOVA outputs, *H # 1: Problem- solving is a function of inquiry-based learning,* is supported. The result was consistent with some previously reported works, who argued that problem- solving is a function of inquiry-based learning scores (Fadzil, 2017; Akman & Alagöz, 2018; Yu, 2015; Hassi & Laursen, 2015; Yuliati, Riantoni, & Mufti, 2018; Turnip, Wahyuni & Tanjung, 2016; Davis, 2018; Thang, & Koh, 2017; Großmann & Wilde, 2019; Zhang & Li, 2019; Cherif, Siuda, Kassem, Gialamas & Movahedzadeh, 2017; Doss, 2018; Cook, Hartman, Pierce & Seaders, 2017; LaBanca & Ritchie, 2011; Méndez & Pérez Gómez, 2017; Worthington, 2018; Auerbach, Concordel, Kornatowski, & Floreano, 2019; Chanprasitchai & Khlaisang, 2016; Avsec & Kocijancic, 2016; Jansen, 2011; Drake & Long, 2009). As a conclusion, different levels of inquiry-based learning influence problem- solving.

H # 2: *Conceptual knowledge building is a function of inquiry-based learning*

Table 7.

Levene's Test of Equality of Error'ouputs

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Levene's Test of Equality of Error'ouputs

Levene's Test of Equality of Error Variances

Dependent Variable: CKB

F	df1	df2	Sig.
5.247	4	127	.001

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + IBL

Since the Levene's Test of Equality of Error Variances is statistically significant (p = .001), as shown in table 7, there is evidence to reject the null hypothesis of equality of variance across groups of the inquiry-based learning' independent variable. This result suggests that somewhere among the variances in the population, there is an inequality. Therefore, different levels of inquiry-based learning influence conceptual knowledge building.

Table 8.

Tests of Between-Subjects Effects'outputs

Tests of Between-Subjects Effects

Dependent Variable: CKB

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	64.927[a]	4	16.232	14.606	.000	.315
Intercept	1110.084	1	1110.084	998.919	.000	.887
IBL	64.927	4	16.232	14.606	.000	.315
Error	141.133	127	1.111			
Total	1568.000	132				
Corrected Total	206.061	131				

a. R Squared = .315 (Adjusted R Squared = .294)

As shown in table 8, a statistically significant difference was found (F = 16.232 on 4 and 127 df, p < 0.001), with an estimated effect size of .315 (Eta squared). This result suggesting that approximately 31.5% of the variance in conceptual knowledge building can be explained or accounted for by inquiry-based learning differences. Therefore, based on ANOVA outputs, *H # 2: Conceptual knowledge building is a function of inquiry-based learning,* is supported. The result was consistent with some previously reported works, who argued that conceptual knowledge building is a function of inquiry-based learning scores (Arslan Buyruk & Ogan Bekiroglu, 2018; Nichol, Szymczyk & Hutchinson, 2014; Levy & Petrulis, 2012; Vokatis & Zhang, 2016; LeCompte & Blevins, 2015; Tezcan-Unal, Winston & Qualter, 2018; Williams, Pringle & Kilgore, 2019; Musanti, 2017; Bierenstiel & Snow, 2019; Reeves, Fostvedt, Laugerman, Baenziger, Shelley, Hand & Therrien, 2013; Herczog, 2014). As a conclusion, different levels of inquiry-based learning influence problem- solving.

Conclusion and Implication

Several limitations of the study should be acknowledged as part of the conclusion. First, the measurement of inquiry-based learning, as well as problem-solving skills and conceptual knowledge building are made through using self- reported instruments. The study aimed to examine the implementation of inquiry-based learning to improving problem-solving skills and conceptual knowledge building at university. The prior assumption was that problem-solving skills and conceptual knowledge building are a function of inquiry-based learning.

It is found that the most of respondents reported the high and very high level of inquiry-based learning, as well as problem-solving skills, meanwhile, approximately one-third of them reported very low and low level. The study showed that less than half of the respondents reported the high and very high level of conceptual knowledge building; meanwhile, approximately one-third of them report the very low and low level. The study found that that variance of the inquiry-based learning is different, revealing that different levels of inquiry-based learning influence problem- solving. It is found that approximately 88.5% of the variance in problem- solving can be explained or accounted for by inquiry-based learning differences. The other variance may be explained by hidden or unknown variables. It is confirmed that that variance of the inquiry-based learning is different, revealing that different levels of inquiry-based learning influence conceptual knowledge building. It is found that approximately 31.5% of the variance in conceptual knowledge building can be explained or accounted for by inquiry-based learning differences. The other variance may be explained by hidden or unknown variables.

The other variance may be explained by hidden or unknown variables. The study confirmed that inquiry-based learning makes the strongest unique contribution to explaining problem- solving skills. The study's results, supported by other investigators about the influence of inquiry-based learning on the improving of problem-solving, and conceptual knowledge building have implications for future research. Future studies should investigate the impact of other variables on the improving of problem-solving, and conceptual knowledge building. The results of this study also have key implications in practice. The important support should design to empower lecturers and students because it is confirmed by this study that inquiry-based learning influences the improving of problem-solving, and conceptual knowledge building. In all, the finding of this study support theoretical and practical understanding as inquiry-based learning is an important variable that supports the improving of problem-solving, and conceptual knowledge building.

References

[1] Akman, Ö., & Alagöz, B. (2018). Relation between Metacognitive Awareness and Participation to Class Discussion of University Students. *Universal Journal of Educational Research*, *6*(1), 11-24.

[2] Arce, J., Bodner, G. M., & Hutchinson, K. (2014). A Study of the Impact of Inquiry-Based Professional Development Experiences on the Beliefs of Intermediate Science Teachers about "Best Practices" for Classroom Teaching. *Online Submission*, International Journal of Education in Mathematics, Science, and Technology *2*(2), 85-95.

[3] Arce, J., Bodner, G. M., & Hutchinson, K. (2014). A Study of the Impact of Inquiry-Based Professional Development Experiences on the Beliefs of Intermediate Science Teachers about "Best Practices" for Classroom Teaching. *Online Submission*, International Journal of Education in Mathematics, Science, and Technology *2*(2), 85-95.

[4] Arslan Buyruk, A., & Ogan Bekiroglu, F. (2018). Comparison of Pre-Service Physics Teachers' Conceptual Understanding of Dynamics in Model-Based Scientific Inquiry and Scientific Inquiry Environments. *Journal of Education in Science, Environment and Health*, *4*(1), 93-109.

[5] Auerbach, J. E., Concordel, A., Kornatowski, P. M., & Floreano, D. (2019). Inquiry-Based Learning With RoboGen: An Open-Source Software and Hardware Platform for Robotics and Artificial Intelligence. *IEEE Transactions on Learning Technologies*, *12*(3), 356-369.

[6] Avsec, S., & Kocijancic, S. (2016). A Path Model of Effective Technology-Intensive

Inquiry-Based Learning. *Educational Technology & Society*, *19*(1), 308-320.

[7] Bierenstiel, M., & Snow, K. (2019). Periodic Universe: A Teaching Model for Understanding the Periodic Table of the Elements. *Journal of Chemical Education*, *96*(7), 1367-1376.

[8] Bozkurt, A., & Koc, Y. (2020). Effects of Different Learning Environments on Pre-Service Teachers' Justification. *Malaysian Online Journal of Educational Sciences*, *8*(1), 38-49.

[9] Byker, E. J., Coffey, H., Harden, S., Good, A., Heafner, T. L., Brown, K. E., & Holzberg, D. (2017). Hoping to Teach Someday? Inquire Within: Examining Inquiry-Based Learning with First-Semester Undergrads. *Journal of Inquiry and Action in Education*, *8*(2), 54-80.

[10] Chanprasitchai, O., & Khlaisang, J. (2016). Inquiry-Based Learning for a Virtual Learning Community to Enhance Problem-Solving Ability of Applied Thai Traditional Medicine Students. *Turkish Online Journal of Educational Technology - TOJET*, *15*(4), 77-87.

[11] Cherif, A. H., Siuda, J. E., Kassem, S., Gialamas, S., & Movahedzadeh, F. (2017). Which Sweetener Is Best for Yeast? An Inquiry-Based Learning for Conceptual Change. *Journal of Education and Practice*, *8*(2), 11-30.

[12] Cook, S. A., Hartman, J., Pierce, P. B., & Seaders, N. S. (2017). To Each Their Own: Students Asking Questions through Individualized Projects. *PRIMUS*, *27*(2), 235-257.

[13] Davis, D. (2018). Inquiry-Based Learning in a First-Year Honors Course. *PRIMUS*, *2*(5), 387-408.

[14] Doss, K. K. (2018). Providing Opportunities for "Flow" Experiences and Creative Problem-Solving through Inquiry-Based Instruction. *Global Education Review*, *5*(1), 108-122.

[15] Drake, K. N., & Long, D. (2009). Rebecca's in the Dark: A Comparative Study of Problem-Based Learning and Direct Instruction/Experiential Learning in Two 4th-Grade Classrooms. *Journal of Elementary Science Education*, *21*(1), 1-16.

[16] Fadzil, H. M. (2017). Exploring Early Childhood Preservice Teachers' Problem-Solving Skills through Socioscientific Inquiry Approach. *Asia-Pacific Forum on Science Learning and Teaching*, *18*(1).

[17] Falloon, G. (2017). Exploring Student Thinking, Problem Solving, and Collaboration in iPad-Supported Learning Environments. *Teaching and Learning Research Initiative.*

[18] Franco, Y. (2013). Building a Community of Inquirers in Your Classroom: Learning from Our Global Colleagues. *Electronic Journal of Science Education*, *17*(4).

[19] Gillies, R. M., Nichols, K., Burgh, G., & Haynes, M. (2012). The Effects of Two Strategic and Meta-Cognitive Questioning Approaches on Children's Explanatory Behaviour, Problem-Solving, and Learning during Cooperative, Inquiry-Based Science. *International Journal of Educational Research*, *53*, 93-106.

[20] Großmann, N., & Wilde, M. (2019). Experimentation in Biology Lessons: Guided Discovery through Incremental Scaffolds. *International Journal of Science Education*, *41*(6), 759-781.

[21] Gupta, T. (2012). Guided-Inquiry Based Laboratory Instruction: Investigation of Critical Thinking Skills, Problem Solving Skills, and Implementing Student Roles in Chemistry. *ProQuest LLC*, Ph.D. [Doctoral Dissertation, Iowa State University].

[22] Hassi, M. L., & Laursen, S. L. (2015). Transformative Learning: Personal Empowerment in Learning Mathematics. *Journal of Transformative Education*, *13*(4), 316-340.

[23] Herczog, M. M. (2014). Implementing the C3 Framework: Monitoring the Instructional Shifts. *Social Education*, *78*(4), 165-169.

[24] Jansen, B. A. (2011). Inquiry Unpacked: An Introduction to Inquiry-Based Learning. *Library Media Connection*, *29*(5), 10-12.
[25] Kiss, T., & Wang, A. (2017). Investigating Teacher Questions within the Framework of Knowledge Building Pedagogy. *Journal of International Social Studies*, *7*(1), 55-69.
[26] Kovanovic, V., Gaševic, D., & Hatala, M. (2014). Learning Analytics for Communities of Inquiry. *Journal of Learning Analytics*, *1*(3), 195-198.
[27] Kraut, G. L. (2015). Inverting an Introductory Statistics Classroom. *PRIMUS*, *25*(8), 683-693.
[28] LaBanca, F., & Ritchie, K. C. (2011). The Art of Scientific Ideas: Teaching and Learning Strategies that Promote Creative Problem Finding. *Science Teacher*, *78*(8), 48-51.
[29] Lai, K. W. (2017). Pedagogical Practices of NetNZ Teachers for Supporting Online Distance Learners. *Distance Education*, *38*(3), 321-335.
[30] LeCompte, K., & Blevins, B. (2015). Building Civic Bridges: Community-Centered Action Civics. *Social Studies*, *106*(5), 209-217.
[31] Levy, P., & Petrulis, R. (2012). How Do First-Year University Students Experience Inquiry and Research, and What Are the Implications for the Practice of Inquiry-Based Learning?. *Studies in Higher Education*, *37*(1), 85-101.
[32] McElvain, C. M., & Smith, H. A. (2016). Curiosité: Inquiry-Based Instruction and Bilingual Learning. *Journal of Curriculum and Teaching*, *5*(2), 63-75.
[33] McRae-Jones, W. J. (2017). Using Inquiry-Based Instructional Strategies to Increase Student Achievement in 3rd Grade Social Studies. *ProQuest LLC*, Ed.S. [Doctoral Dissertation, Brenau University].
[34] Méndez, R. P., & Pérez Gómez, F. (2017). Understanding Student-Teachers' Performances within an Inquiry-Based Practicum. *English Language Teaching*, *10*(4), 127-139.
[35] Musanti, S. I. (2017). Challenging Inquiry and Building Community: Analyzing ESL and Bilingual Teachers' Narratives. *Action in Teacher Education*, *39*(3), 292-306.
[36] Nehring, A., Nowak, K. H., zu Belzen, A. U., & Tiemann, R. (2015). Predicting Students' Skills in the Context of Scientific Inquiry with Cognitive, Motivational, and Sociodemographic Variables. *International Journal of Science Education*, *37*(9), 1343-1363.
[37] Nichol, C. A., Szymczyk, A. J., & Hutchinson, J. S. (2014). Data First: Building Scientific Reasoning in AP Chemistry via the Concept Development Study Approach. *Journal of Chemical Education*, *91*(9), 1318-1325.
[38] Nilssen, V., & Solheim, R. (2015). "I See What I See from the Theory I Have Read." Student Teachers Learning through Theory in Practice. *Journal of Education for Teaching: International Research and Pedagogy*, *41*(4), 404-416.
[39] O'Neill, M., Adams, M. P., Bandelt, M. J., Chester, S. A., Cai, W., & Nadimpalli, S. P. V. (2019). Cohort Learning: Supporting Transdisciplinary Communication and Problem-Solving Skills in Graduate STEM Researchers. *International Journal of Teaching and Learning in Higher Education*, *31*(1), 166-175.
[40] Østergaard, L. D. (2019). Creation of New Routines in Physical Education: Second-Order Reflection as a Tradition-Challenging Form of Reflection Stimulated by Inquiry-Based Learning. *Sport, Education, and Society*, *24*(9), 981-993.
[41] Rapanta, C. (2018). Potentially Argumentative Teaching Strategies--And How to Empower Them. *Journal of Philosophy of Education*, *52*(3), 451-464.
[42] Reeves, C. G., Fostvedt, L., Laugerman, M., Baenziger, J., Shelley, M., Hand, B., & Therrien, W. (2013).

Structural Equation Modeling of Knowledge Content Improvement Using Inquiry-Based Instruction. *Society for Research on Educational Effectiveness.*

[43] Rodriguez, S., Allen, K., Harron, J., & Qadri, S. A. (2019). Making and the 5E Learning Cycle. *Science Teacher*, *86*(5), 48-55.

[44] Roehrig, G. H., Michlin, M., Schmitt, L., MacNabb, C., & Dubinsky, J. M. (2012). Teaching Neuroscience to Science Teachers: Facilitating the Translation of Inquiry-Based Teaching Instruction to the Classroom. *CBE - Life Sciences Education*, *11*(4), 413-424.

[45] Salsabila, E. R., Wijaya, A. F. C., & Winarno, N. (2019). Improving Students' Sustainability Awareness through Argument-Driven Inquiry. *Journal of Science Learning*, *2*(2), 58-64.

[46] Tezcan-Unal, B., Winston, K., & Qualter, A. (2018). Learning-Oriented Quality Assurance in Higher Education Institutions. *Quality in Higher Education*, *24*(3), 221-237.

[47] Thang, F. K., & Koh, J. H. L. (2017). Deepening and Transferring Twenty-First Century Learning through a Lower Secondary Integrated Science Module. *Learning: Research and Practice*, *3*(2), 148-162.

[48] Turnip, Wahyuni, & Tanjung (2016). The Effect of Inquiry Training Learning Model Based on Just in Time Teaching for Problem Solving Skill. *Journal of Education and Practice*, *7*(15), 177-181.

[49] Van Booven, C. D. (2015). Revisiting the Authoritative-Dialogic Tension in Inquiry-Based Elementary Science Teacher Questioning. *International Journal of Science Education*, *37*(8), 1182-1201.

[50] van den Broek, G. S. E. (2012). Innovative Research-Based Approaches to Learning and Teaching. OECD Education Working Papers, No. 79. *OECD Publishing (NJ1).*

[51] Vokatis, B., & Zhang, J. (2016). The Professional Identity of Three Innovative Teachers Engaging in Sustained Knowledge Building Using Technology. *Frontline Learning Research*, *4*(1), 58-77.

[52] Williams, R. T., Pringle, R. M., & Kilgore, K. L. (2019). A Practitioner's Inquiry into Vocabulary Building Strategies for Native Spanish Speaking ELLs in Inquiry-Based Science. *Research in Science Education*, *49*(4), 989-1000.

[53] Worthington, T. A. (2018). Letting Students Control Their Own Learning: Using Games, Role-Plays, and Simulations in Middle School U.S. History Classrooms. *Social Studies*, *109*(2), 136-150.

[54] Xhomara, N. (2018). *Curriculum and Academic Performance*. Monograph. Lambert Academic Publishing. ISBN: 978-613-9-85640-4. Omniscriptum Publishing Group. Germany.

[55] Xhomara, N. (2019). The collegial school management as a predicting variable on prevention of disruptive behaviors and students' life skills. *Pedagogika/Pedagogy*. *136*(4). DOI: https://doi.org/10.15823/p.2019.136.10.

[56] Xhomara, N. (2020). How prior knowledge, learning, teaching, and assessment affect students' achievements in Mathematics. *Research in Education and Learning Innovation Archives*, *25*, 68-91. DOI: 10.7203/realia.25.15780.

[57] Xhomara, N. (2020). Individual study work and lecturer support as predictors of students' academic success. *International Journal of Knowledge and Learning*, *13*(3). DOI: 10.1504/IJKL.2020.109881.

[58] Xhomara, N. (2022). Critical thinking: Student-centered teaching approach and personalized learning, as well as previous education achievements, contribute to the critical thinking skills of students. *International Journal of Learning and Change*, *14*(1), 101-120. DOI: 10.1504/IJLC.2022.119513.

[59] Yu, H. B. (2015). Promoting Chemistry Learning through Undergraduate Work Experience in the Chemistry Lab: A Practical Approach. *Journal of Chemical Education*, *92*(3), 433-438.

[60] Yuliati, L., Riantoni, C., & Mufti, N. (2018). Problem Solving Skills on Direct Current Electricity through Inquiry-Based Learning with PhET Simulations. *International Journal of Instruction*, *11*(4),123-138.

[61] Zhang, L., & Li, Z. (2019). How Does Inquiry-Based Scientific Investigation Relate to the Development of Students' Science Knowledge, Knowing, Applying, and Reasoning? An Examination of TIMSS Data. *Canadian Journal of Science, Mathematics and Technology Education*, *19*(3), 334-345.