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Effectiveness of Authentic, Inquiry-Based Learning in the Performance of Grade 8 Students in Science: Basis for Instructional Supervision

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ABSTRACT

Based on the observation during the teaching-learning process in science, students lack problem-solving, reasoning, and communication skills. Hence, the researcher crafted this study on the integration of authentic inquiry-based learning in teaching science because we need to prepare students to be productive citizens who can used critical thinking and communication skills to make informed decisions and these concepts must be mastered by them. The main objective of this study is to evaluate the effectiveness of authentic inquiry-based learning in the performance of Grade 8 students in science. A proposed instructional supervision plan was formulated based on the result of the study to assist and guide instructional leaders and administrators in providing technical assistance to the teachers to make this intervention effective in the implementation. A quasi-experimental research design employing researcher-made science test questions as pre-test and post-test to determine the performance of the students before and after the intervention. Simple percentage and t-test of mean difference were the statistical tools used to interpret the result of the study. The study revealed a significant difference in the performances of Grade 8 students in science before and after the integration of authentic, inquiry-based learning in teaching. The exposure of the students in learning through hands-on activities and experimentation as a way of finding solutions to science problems has motivated them to engage in scientific processes whereby allowing them to do the activities independently while the teacher serves as facilitators. Through these activities, the interests of the students to achieve higher learning outcomes in science are boasted and they learn to work cooperatively. The crux of this intervention to create a culture of learning, respectfully challenging, testing, redefining, and present concepts as something that can be improved on to enhance the learning experience of which authentic, inquiry-based learning has achieved. Thus, the integration of authentic, inquiry-based learning is an effective strategy to improve the performance of the students in science.

Keywords — Effectiveness, Authentic Inquiry-Based Learning, Performance, Grade 8 Students, Science, Instructional Supervision

I. INTRODUCTION

Science is a systematic enterprise that builds and organizes knowledge in the form of testable explanations and predictions about the universe and certain phenomena. The scientific method is a fundamental approach in science, involving observations, hypothesis formation, experimentation, and analysis to understand and explain natural phenomena. It plays an integral role in all aspects of our lives: medicine, weather, food, and even communication. It

allows us to understand our world to create a better future. Therefore, it is critical that we prepare students to pursue science related fields and compete in an increasingly scientific and technological world.

Many businesses owners state that today's children lack problem-solving, reasoning, and communication skills to make them employable (White, 2013). Not all students will grow up to be scientists, however, we need to prepare them to be productive citizens who can use critical thinking and communication skills to make informed decisions. Hence, integrating authentic, inquiry-based learning is essential to achieve mastery of the concepts conveyed.

Inquiry-based learning offers a shift in pedagogy by allowing educators to give students control over their learning (Maxwell, Lambeth, & Cox, 2015). This strategy places teachers in the role of facilitator while students take responsibility for their learning. Students are given the opportunity to create their own meaning of content through exploration. Learning takes place by encouraging students to ask questions, investigate solutions, create new knowledge as information is gathered, discuss discoveries and experiences with peers, and reflect on their newly gained knowledge (Turkmen, 2009). This is a fundamental shift from traditional instructional strategies in which content is predetermined, students listen or read along while the teacher lectures on a topic, and students are assessed on their memorization of facts presented during lecture.

Looking into the real-world or the real scenario of educational institution, the lack of science laboratory equipment and apparatuses hinders the achievement of supposed to be acquired by students for the subject, science. There are schools who have not supplied with the required science equipment which is useful in conducting experiments. The reason that students perform low when they already reach higher education. To make science learning meaningful to all students, teachers and school heads created school interventions and innovation projects to continuously provide the best science education that the students are supposed to acquire. Hence, some of them integrate authentic, inquiry-based learning in teaching science.

In the school where the researcher is currently teaching, it is observed since authentic, inquiry-based learning is implemented, scientific knowledge, critical thinking, and problem-solving skills of the students were enhanced. As inquiry-based learning is implemented, teachers have noticed the benefits of the strategy to the attainment of achieving science education goals, to equip the students with the knowledge needed to face challenges and adversities. Students who take part in inquiry-based learning show an increased understanding of content knowledge as well as increased thinking skills (Ergul et al., 2011). This increase in content knowledge and thinking skills is desirable for schools due to the increased emphasis on high stakes standardized testing. The use of inquiry-based learning in classrooms has been linked to increases in positive student learning behaviors, such as motivation and positive attitudes toward school subjects (Borovay, Shore, Caccese, Yang, & Hua, 2019). An increase in these types of behaviors is important because they can be helpful for students during the duration of schooling.

As frequently implemented the intervention, the researcher is still doubtful whether the integration of authentic, inquiry-based learning is useful in teaching science and would create a student who can do the real scientist work and be able to provide more genuine and immersive understanding of science. Thus, it is in this premise that the researcher decided to conduct this study to evaluate the effectiveness of authentic, inquiry-based learning in the performance of grade 8 students in science. A proposed instructional supervision plan was formulated based on the findings of the study. It is in the rationale that the researcher who is currently a grade 8 Science teacher in the above mentioned local, would like to delve worthy research undertaking that would benefit herself, the school she is currently teaching and that of her Graduate Program she is enrolled at.

This study evaluates the effectiveness of authentic, inquiry-based learning in the performance of grade 8 students in science in Matlang National High School, Isabel II District, Leyte Division for School Year 2023-2024. The findings of the study were the basis for the proposed instructional supervision plan.

Specifically, this study sought to answer the following questions:

1. What is the performance of the Grade 8 students before the integration of authentic, inquiry-based learning in teaching in science?

2. What is the performance of the Grade 8 students after the integration of authentic, inquiry-based learning in teaching in science?

3. Is there a significant difference in the performance of the Grade 8 students before and after the integration of authentic, inquiry-based learning in teaching in science?

4. What instructional supervision plan can be proposed based on the findings of this study?

II. METHODOLOGY

Design. This study employed the quasi-experimental research design utilizing the pre-test and post-test to evaluate the effectiveness of authentic, inquiry-based learning in the performance of grade 8 students in science for School Year 2023-2024. Matlang National High School, Isabel II District, Leyte Division is the main locale of the study. The 33 Grade 8 students enrolled in the said locale are the main respondents of the study. This study utilized the validated, researcher-made Science test in Grade 8. The competencies in the 2nd quarter Most Essential Learning Competencies (MELCs) were the basis in the formulation of the test. The researcher formulated a 30-item test questions which best describe activities on authentic, inquiry-based learning. The test was conducted before and after the integration of the intervention in teaching science lessons. Moreover, the researcher prepared lesson plans for teaching Science based on the competencies for the second quarter integrating authentic, inquiry-based learning through involvement of students on hands-on investigations, experiments, and real-world problem solving. The researcher guided the students in the conduct of investigations and experiments through the posing of problems which encouraged critical thinking, hones scientific inquiry skills, and promotes a deeper understanding of scientific principles by connecting theory to practical applications. The materials crafted and other activities formulated were submitted to the District Coordinator and Quality Assurance Team for evaluation, validation, and adjustments before it was utilized by the students in the classroom. A matrix of activities was crafted to guide the teacher-researcher the flow of her study. This research focused on evaluating the effectiveness of authentic, inquiry-based learning in the performance of grade 8 students in science through the pre-test and post-test and its significant difference. A Proposed Instructional Supervision Plan based on the findings of the study is the output.

Sampling. There are 33 Grade 8 students involved in this study. They are the pupils enrolled in the grade for School Year 2023-2024 in the said locale. Complete enumerations were used to identify the respondents of the study. A researcher-made test was used as a tool and the implementation of the intervention was administered personally to each of the pupils during the assessment period following the prescribed health protocol.

Research Procedure. The researcher prepared the research design and tools utilized in the study. Approval and recommendation from the Panel of Examiner of the Graduate Studies was sought. A letter request to conduct this study was forwarded to the Office of the Schools Division Superintendent. Upon approval, permission from the District

Supervisor and School Head was secured before the actual gathering of data. Orientation of the participants and administration of the pre-test was done face-to-face after the approval of the permit from the parents of the respondents. Data privacy was emphasized also in the meeting. After accomplishing the pre-test, intervention was given within four weeks. Grade 8 students conducted hands-on investigations into certain phenomenon, conduct experimental activities, perform scientific study, accomplish problem-solving activities in science. The teacher facilitated the students in formulating answers to the activities and learning materials and other resources provided by the teacher which form part of the intervention for the study. After the intervention, a post-test was administered. Answers were checked, collected, tabulated, and submitted for statistical treatment. Analysis and Interpretation of Data. Making of Proposed Improvement Plan followed. A Matrix of Activities was prepared by the researcher to track the progress of gathering the data.

Ethical Issues. The researcher properly secured the permission to conduct the study from the authorities through written communication. In the formulation of the intervention materials that was used in the study, the use of offensive, discriminatory, or other unacceptable language was avoided. The respondents' names and other personal data were not included in this study to protect their privacy. Participation of the respondents was also voluntary. Orientation was conducted for the respondents with their parents. In the orientation, issues and concerns were addressed and consent to be included in the study were signed. The researcher-maintained objectivity in analyzing and discussing the results. All authors whose works were mentioned in this study were properly quoted and were acknowledged in the reference.

Treatment of Data. Simple Percentage was employed to evaluate the performances of the Grade 8 students before and after the integration of authentic inquiry-based learning in teaching Science. **t-Test of Mean Difference** was used to determine the significant difference in the performances of the Grade 8 students before and after the integration of authentic inquiry-based learning in teaching Science.

III. RESULTS AND DISCUSSION

TABLE 1

PERFORMANCE OF GRADE 8 STUDENTS BEFORE THE INTERVENTION

Score Range	Description	PRETEST	
		Frequency	%
25-30	Excellent	0	0
19-24	Very Good	0	0
13-18	Good	1	3
7-12	Fair	28	85
1-6	Poor	4	12
Total		33	100
Weighted Mean		**8.58**	**Fair**

Table 1 presents the performance of Grade 8 students before the integration of authentic, inquiry-based learning in teaching in science. It was shown on the table that among the 33 Grade 8 students, 4 or 12% got a score of 1-6 which is interpreted as poor. This means that these students achieve a lower level of understanding of scientific concepts. They used traditional methods such as rote memorization or didactic instruction that is why students' lower order thinking skills were developed. This implies that these students need a hands-on, experiential approach where they will actively explore scientific phenomena. They need to learn to conduct experiments of their own with the guidance of the teacher.

In this group of students, teachers must create a classroom environment where students must engage in activities and be able to find solutions to the problems posted in the activities. Authentic, inquiry-based learning must be integrated in teaching science concepts. Inquiry-based learning is a pedagogical mind-set. It can be used in the classroom to engage students in a self-driven learning process, and is gaining popularity in science related curriculum, at every educational level (Pedaste et al., 2015). It can also be used in a wide variety of other contexts. It however need not be used in isolation, and it does not stand in the way of other forms of learning and teaching. It is a creative approach of combining creative and best approaches to instruction, as an attempt to build on learner curiosity.

Moreover, 18 or 85% got a score of 7-12 which is interpreted as fair. This means that students achieve an average or moderate levels of understanding or proficiency in scientific concepts. This implies that the students' learning approach is in traditional way where the teacher gives them the concepts of the lesson without doing significant activities or showing to the students the solutions to every problem in science. This implies further that teachers must create interactive activities where findings solutions need to conduct experimentation. The integration of authentic, inquiry-based learning is aimed at improving upon this by providing more engaging and interactive experiences that can help students to better understand and apply scientific principles. One of the key challenges in education is to move students beyond just receiving knowledge and skills passively and instilling a sense of being able to create innovative solutions to situations, problems, and challenges that they face continuously at work and otherwise, or to become self-regulated and self-motivated learners (English &Kitsantas, 2013) and this can be addressed if students were taught authentic, inquiry-based learning.

Further, only 1 or 3% got a score of 13-18 which is interpreted as good. This means that these students achieve a high level of understanding and proficiency in scientific concepts. This implies that the students had acquired knowledge of authentic, inquiry-based learning even before the integration of the intervention. The student also possesses the knowledge of solving science-related problems through hands-on activities or experiences. But, achieving good performance is not enough, especially when talking about excellence. Hence, this student also needs further learning especially in applying scientific concepts in his/her day-to-day activities which involves science. One of the key challenges educators face today globally, is finding ways to prepare students to be competitive in the current job market, and tertiary educational setting. To do this, the educator must find ways of actively engaging the students in the classroom environment to develop not only content knowledge, but also critical thinking and problem-solving skills (English &Kitsantas, 2013).

Finally, the performance of the Grade 8 students before the integration of authentic, inquiry-based learning in teaching in science got an average mean of 8.58 which is interpreted as fair. This means that the Grade 8 students had achieved a lower level of understanding scientific concepts, thus, a need for intervention activities which will involve the students in solving science-related problems. This implies additional learning support materials and activities which will develop their understanding and applying such knowledge in making connections with previous learning to arrive at a concrete solution to problems. Integrating authentic, inquiry-based learning in teaching science is needed by the students to achieve educational goals and attain the desired learning outcomes for the period. Today's emphasis on authentic, inquiry-based methods aims to give students authentic learning opportunities, which allow for students to learn both concepts and content knowledge through experience (Levy, Thomas, Drago, & Rex, 2013). In science classes, this learning would occur through scientific processes, such as experiments, observational data collection, and other guided learning activities. Inquiry-based learning would ideally equip students with the skills to enter their fields prepared to think critically, problem solve, work collaboratively, and learn through experience. In the field of science, these skills translate well to the jobs available, such as research, medicine, engineering, and resource management.

TABLE 2

PERFORMANCE OF GRADE 8 STUDENTS AFTER THE INTERVENTION

Score Range	Description	POST TEST	
		Frequency	%
25-30	Excellent	7	21
19-24	Very Good	22	67
13-18	Good	4	12
7-12	Fair	0	0
1-6	Poor	0	0
Total		33	100
Weighted Mean		**21.97**	**Very Good**

Table 2 presents the performance of the Grade 8 students in science after the integration of authentic, inquiry-based learning. It was revealed on the table that among the 33 Grade 8 students, 4 or 12% got a score of good. This means that after the integration of authentic, inquiry-based learning, the students achieved a high level of understanding scientific concepts whereby utilizing their experiences in the activities done. This implies students critical thinking skills were developed through the involvement of the students in all the hands-on activities prepared by the teacher. Students who demonstrate good performance not only excel in traditional assessments but also show a deeper understanding of how scientific concepts apply to real-world scenarios.

Moreover, 22 or 67% got a score of 19-24 which is interpreted as very good. This means that these students have acquired higher order thinking skills in solving problems. The levels of understanding, critical thinking, and practical applications of scientific concepts are exceptional. This implies mastery of the scientific concepts for they were able to think creatively, solve complex problems, and effectively communicate their findings and results. The integration of authentic, inquiry-based learning had provided them with the knowledge and skills in relating scientific understanding to the hands-on activities they are doing. Students here are more dedicated and motivated to do the tasks given them for they are the once doing the experiments with the guidance and assistance of the teachers.

Further, 7 or 21% got a score of 25-30 which is interpreted as excellent. This means that students had achieved an exemplary performance in science through the integration of authentic, inquiry-based learning. The experiences of the students in doing the hands-on activity, and being responsible in finding solutions to the problems, exploring, and discovering content materials and reflecting upon learning processes to have a deeper understanding of scientific concepts had helped them in achieving excellent performance. This implies effectiveness of the intervention provided to them and motivation to achieve the desired learning outcomes.

Finally, the performance of the Grade 8 students after the integration of authentic, inquiry-based learning has an average mean of 21.97 which is interpreted as very good. This means that after introducing problems or phenomena for the students to solve and interpret using scientific practices through experimentation, the students were able to communicate the results of their activities, critical thinking was developed and working collaboratively was emphasized. This implies greater understanding of scientific concepts and the scientific process in solving problems. Authentic, inquiry-based learning would ideally equip students with the skills to enter their fields prepared to think critically, problem solve, work collaboratively, and learn through experience. In the field of science, these skills translate well to the jobs available, such as research, medicine, engineering, and resource management. In addition to increases in student motivation for science, authentic, inquiry-based instruction has been shown to significantly increase students'

understanding of science content and increase student science scores (Granger, Bevis, Saka, & Southerland, 2009: Banilower, Fulp, & Warren, 2010). Studies also show inquiry can lead to higher reading and math test scores (Governor's STEM Advisory Council, 2015-2016). Inquiry-based instruction allows children to make sense of the world around them instead of learning science in isolated pieces.

TABLE 3

TEST OF DIFFERENCE IN THE PERFORMANCE OF GRADE 8 STUDENTS BEFORE AND AFTER THE INTERVENTION

Aspects	Test Scores		Computed T	Critical T	Decision	Interpretation
Grade 8 Students in Science	Pre Post	8.58 21.97	2.742	0.891	Reject H_o	Significant

Table 3 presents the test of difference in the performances of Grade 8 students is science before and after the integration of authentic, inquiry-based learning. It was revealed on the table that the pre-test of 8.58 had increased to 21.97 after the integration of authentic, inquiry-based learning which resulted to 2.742 computed value of t. This result shows that the computed t of 2.742 is greater than the critical value of t of 0.891 at 0.05 level of significance, so null hypothesis is rejected. This means that there is a significant difference in the performances of Grade 8 students in science before and after the integration of authentic, inquiry-based learning. This implies effectiveness of the intervention provided to the students. The exposure of the students in learning through hands-on activities and experimentation as a way of finding solutions to science problems has motivated them to engage in scientific processes whereby allowing the do the activities independently while the teacher serves as facilitators. Through these activities, the interests of the students to achieve higher learning outcomes in science are boasted and they learn to work cooperatively. The crux of this intervention is to create a culture of learning, respectfully challenging, testing, redefining, and present concepts as something that can be improved on to enhance the learning experience of which authentic, inquiry-based learning has achieved. The result of the study is supported by Qamariyah et al. (2021) where on they researched the impact of inquiry-based learning on this type of sociocentric issue to see the effect on development of students' higher-order thinking skills. The results of the post-test showed large differences between the control and experimental groups. Qamariyah et al. (2021) stated that this difference was likely because the experimental group was consistently practicing higher order thinking skills, while the control group focused on memorization. Qamariyah et al. (2021) concluded that authentic inquiry-based learning can strengthen students' higher-order thinking skills and prepare students to think critically about sociocentric issues.

IV. CONCLUSIONS

The study revealed a significant difference in the performances of Grade 8 students in science before and after the integration of authentic, inquiry-based learning in teaching. The exposure of the students in learning through hands-on activities and experimentation as a way of finding solutions to science problems has motivated them to engage in scientific processes whereby allowing them to do the activities independently while the teacher serves as facilitators. Through these activities, the interests of the students to achieve higher learning outcomes in science are boasted and they

learn to work cooperatively. The crux of this intervention to create a culture of learning, respectfully challenging, testing, redefining, and present concepts as something that can be improved on to enhance the learning experience of which authentic, inquiry-based learning has achieved. Thus, the integration of authentic, inquiry-based learning is an effective strategy to improve the performance of the students in science.

V. RECOMMENDATIONS

1. Utilize the proposed instructional supervision plan formulated.

2. Teachers should implement, employ, and incorporate authentic, inquiry-based learning into the classroom for the students to construct and develop their own understandings of knowledge and actively learn and interact with curriculum content.

3. Teachers and school heads should be equipped and prepared for the classroom environment to promote effective authentic, inquiry-based learning for meaningful and deeper instruction and learning.

4. School heads must establish an inclusive classroom and help promote further authentic, inquiry-based learning with sense of ownership of learning upon the students.

5. Teachers must conduct research and understand the necessary components, materials and planning time needed to implement authentic, inquiry-based learning to present effective learning among lessons in science.

6. Administrators and science advocates should be morally encouraged to introduce authentic, inquiry-based learning strategies and methods into science classroom to promote deeper and active learning, and

7. Future researchers should replicate this study to include different locales and include different variables aside from the mentioned in this study.

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REFERENCES

[1] Abdi, A. (2014). The effect of inquiry-based learning method on students' academic achievement in science course. Universal Journal of Educational Research, 2(1), 37-41. https://doi.org/10.13189/ujer.2014.020104

[2] Archer-Kuhn, B., Lee, Y., Finnessey, S., & Liu, J. (2020). Inquiry-based learning as a facilitator to student engagement in undergraduate and graduate social work programs. Teaching & Learning Inquiry, 8(1), 187-207. http://dx.doi.org/10.20343/teachlearninqu.8.1.13

[3] Attard, C., Berger, N., & Mackenzie, E. (2021). The positive influence of inquiry-based learning teacher professional learning and industry partnerships on student engagement with STEM. Front. Educ. 6:693221. https://doi.org/10.3389/feduc.2021.693221

[4] Baldock, K., & Murphrey, T. (2020). Secondary students' perceptions of inquiry-based learning in the agriculture classroom. Journal of Agricultural Education, 61(1), 235-246. https://doi.org/10.5032/jae.2020.01235

[5] Bayram, Z., Özyalçın Oskay, Ö., Erdem, E., Dinçol Özgür, S., & Şen, Ş. (2013). Effect of inquiry-based learning method on students' motivation. Procedia - Social and Behavioral Sciences, 106, 988-996. https://doi.org/10.1016/j.sbspro.2013.12.112.

[6] Bernard, P., Dudek-Rózycki, K., & Orwat, K. (2019). Integration of inquiry-based instruction with formative assessment: The case of experienced chemistry teachers. Journal of Baltic Science Education, 18(2), 184-196. https://doi.org/10.33225/jbse/19.18.184

[7] Bezen, S., & Bayrak, C. (2020). Teaching mechanical waves by inquiry-based learning. Journal of Baltic Science Education, 19(6), 875-892. https://doi.org/10.33225/jbse/20.19.875

[8] Buck Institute for Education. (2013). Project-based Learning for the 21st Century.BIE, http://www.bie.org/.

[9] Corlu, M., & Corlu, S. (2012). Scientific Inquiry Based Professional Development Models in Teacher Education. Educational Sciences: Theory and Practice, 514-521.

[10] Dolenc, N., Beaulieu, P., & Sheppard, P. (2020). Maintaining scientific inquiry in online education. Research Issues in Contemporary Education, 5(3), 13-25. https://files.eric.ed.gov/fulltext/EJ1293469.pdf

[11] Dunn, J., & Ramnarain, U. (2020). The effect of simulation-supported inquiry on South African natural sciences learners' understanding of atomic and molecular structures. Education Sciences, 10, 1-12. http://dx.doi.org/10.3390/educsci10100280

[12] Entwistle, N., & Ramsden, P. (2015). Understanding Student Learning. Routledge Revivals, Routledge.

[13] Feyzioglu, E., & Demirci, N. (2021). The effects of inquiry-based learning on students' learner autonomy and conceptions of learning. Journal of Turkish Science Education, 18(3), 401-420. https://files.eric.ed.gov/fulltext/EJ1325556.pdf

[14] Fielding, M. (2012). Beyond student voice: Patterns of partnership and the demands of deep democracy. Revista de Educacion.

[15] Freeman, S., Eddy, S., McDonough, M., Smith, M., Okoroafor, N., Jordt, H., & Wenderoth, M. (2014). Active Learning Increases Student Performance in Science, Engineering, and Mathematics. Proceedings of the National Academy of Sciences, 8410-8415.

[16] Friedlaender, D., Burns, D., Charp, H., Harvey, C., & Hammond, L. (2014). Student-centered Schools: Closing the opportunity Gap. Palo Alto: Stanford Center for Opportunity Policy in Education.

[17] Gormally, C., Brickman, P., Hallar, B., & Armstrong, N. (2009). Effects of inquiry-based learning on students' science literacy skills and confidence. International Journal for the Scholarship of Teaching and Learning, 3(2), 1-16. https://doi.org/10.20429/ijsotl.2009.030216

[18] Gutwill, J., & Allen, S. (2012). Deepening students' scientific inquiry skills during a science museum field trip. Journal of the Learning Sciences, 130-181.

[19] Hannafin, M., Hill, J., Land, S., & Lee, E. (2014). Student-centered, open learning environments: Research, theory, and practice. Springer, New York, 641-651.

[20] Ho, L., & Chan, L. (2015). Problem based learning as the instructional approach to field learning in the secondary school setting.

[21] Hodges, K. (2015). A study of problem-based learning content acquisition and academic achievement in career and technical education courses at the middle-school level. Essential readings in problem-based learning: Exploring and extending the legacy of Howard S. Barrows, 131-146.

[22] Jackman, E. (2011). Natural Curiosity: Building children's understanding of the world through environmental inquiry/A resource for teachers.

[23] Kacar, S., & Balim, A. (2021). Investigating the effects of argument-driven inquiry method in science course on secondary school students' levels of conceptual understanding. Journal of Turkish Science Education, 18(4), 816-845. http://files.eric.ed.gov/fulltext/EJ1339469.pdf

[24] Kaya, G., & Avan, Ç. (2020). An inquiry-based science activity: Floating-sinking-staying between the surface and bottom. Journal of Inquiry Based Activities, 10(2), 112-126. https://www.ated.info.tr/ojs-3.2.1-3/index.php/ated/article/view/5

[25] Kitsantas, A., & English, M. (2013). Supporting Student Self-Regulated Learning in Problem- and Project-Based Learning.Interdisciplinary Journal of Problem-based Learning.

[26] Korkman, N., & Metin, M. (2021). The effect of inquiry-based collaborative learning and inquiry-based online collaborative learning on success and permanent learning of students. Journal of Science Learning, 4(2), 151-159. https://files.eric.ed.gov/fulltext/EJ1292922.pdf

[27] Kuhlthau, C., Maniotes, L., & Caspari, A. (2015). Guided Inquiry: Learning in the 21st Century. ABC CLIO.

[28] Lee, J., Blackwell, S., Drake, J., & Moran, K. (2014). Taking a Leap of Faith: Redefining Teaching and Learning in Higher Education Through Project-Based Learning. Interdisciplinary Journal of Problem-based Learning.

[29] Luft, J. (2001). Changing inquiry practices and beliefs: The impact of an inquiry-based professional development programme on beginning and experienced secondary science teachers, International Journal of Science Education, 23(5), 517-534. http://dx.doi.org/10.1080/09500690121307

[30] Maknun, J. (2020). Implementation of guided inquiry learning model to improve understanding physics concepts and critical thinking skill of vocational high school students. International Education Studies, 13(6), 117-130. https://doi.org/10.5539/ies.v13n6p117

[31] Marra, R., Jonassen, D., Palmer, B., & Luft, S. (2014). Why problem-based learning works: Theoretical Foundations.Journal on Excellence in College teaching, 221-238.

[32] Maxwell, D., Lambeth, D., & Cox, J. (2015). Effects of using inquiry-based learning on science achievement for fifth-grade students. Asia-Pacific Forum on Science Learning and Teaching, 16(1), 1-31. https://www.eduhk.hk/apfslt/download/v16_issue1_files/cox.pdf

[33] Nopiya, N., Hindriana, A., & Sulistyono, S. (2020). Students' science process skills and interpersonal intelligence in biology learning using guided inquiry. Journal of Biological Education Indonesia, 6(1), 123-134. https://doi.org/10.22219/jpbi.v6i1.10634

[34] Nunaki, J., Damopolii, I., Kandowangko, N., & Nusantari, E. (2019). The effectiveness of inquiry-based learning to train the students' metacognitive skills based on gender differences. International Journal of Instruction, 12(2), 505-516. https://doi.org/10.29333/iji.2019.12232a

[35] Panasan, M., & Nuangchalerm, P. (2010). Learning outcomes of project-based and inquiry-based learning activities. Journal of Social Sciences, 6(2), 252-255. https://eric.ed.gov/?id=ED509723

[36] Pedaste, M., Maeots, M., Leijen, A., & Sarapuu, T. (2012). Improving Students' Inquiry Skills through Reflection and Self-Regulation Scaffolds.Technology, Instruction, Cognition, and Learning.

[37] Pedaste, M., Maeots, M., Siiman, L., De Jong, T., Van Riesen, S., Kamp, E., & Tsourlidaki, E. (2015). Phases of inquiry-based learning: Definitions and the inquiry cycle.Educational Research Review, 47-61.

[38] Ponce, O. (2014). Investigación de Métodos Mixtos en Educación.San Juan: Publicaciones Puertorriquenas.

[39] Ponce, O., & Maldonado, P. (2015). Mixed methods research in education: Capturing the complexity of the profession.International Journal of Educational Excellence, 111-135.

[40] Putri, L., Permanasari, A., Winarno, N., & Ahmad, N. (2021). Enhancing students' scientific literacy using virtual lab activity with inquiry-based learning. Journal of Science Learning, 4(2), 173-184. https://eric.ed.gov/?id=EJ1292932

[41] Qamariyah, S., Rahayu, S., Fajaroh, F., & Alsulami, N. (2021). The effect of implementation of inquiry-based learning with socio-scientific issues on students' higher-order thinking skills. Journal of Science Learning, 4(3), 210-218. https://doi.org/10.17509/jsl.v4i3.30863

[42] Rahmat, I., & Chanunan, S. (2018) Open inquiry in facilitating metacognitive skills on high school biology earning: An inquiry on low and high academic ability. International Journal of Instruction, 11(4), 593-606. https://files.eric.ed.gov/fulltext/EJ1191720.pdf

[43] Robbins, M. (2001). MFT Researchers Gain Crucial Skills, Feedback, Support. Family Therapy News, 1-27.

[44] Sahintepe, S., Erkol, M., & Aydogdu, B. (2020). The impact of inquiry-based learning approach on secondary school students' science process skills. Open Journal for Educational Research, 4(2), 117-142. https://doi.org/10.32591/coas.ojer.0402.04117s

[45] Sarioglan, A. (2021). Development of inquiry-based learning environment scale: A validity and reliability study. Malaysian Online Journal of Educational Sciences, 9(4), 27-40. https://eric.ed.gov/?id=EJ1315800

[46] Sarioglan, A., & Gedik, I. (2020). Investigated effects of guided inquiry-based learning approach on students' conceptual change and durability. Cypriot Journal of Educational Sciences, 15(4), 674-685. http://dx.doi.org/10.18844/cjes.v15i4.5050

[47] Savery, J. (2015). Overview of Problem-based Learning: Definitions and Distinctions.Essential Readings in Problem-based Learning: Exploring and Extending the legacy of Howard S Barrows, 5-15.

[48] Scanlon, E., Anastopoulou, S., Kerawalla, L., & Mulholland, P. (2011). How technology resources can be used to represent personal inquiry and support students' understanding of it across contexts. Journal of Computer Assisted Learning, 516-529.

[49] Schmidt, H., Rotgans, J., & Yew, E. (2011). The process of problem-based learning: What works and Why. Medical Education, 792-806.

[50] Scott, C., & Sutton, R. (2009). Emotions and Change During Professional Development for Teachers: A Mixed Method Study. Journal of Mixed Methods Research, 151-171.

[51] Sever, D., & Guven, M. (2015). Effect of inquiry-based learning approach on student resistance in a science and technology course. Educational Sciences: Theory and Practice, 14(4) 1601-1605. https://files.eric.ed.gov/fulltext/EJ1045037.pdf

[52] Shi, W. Z., Ma, L., & Wang, J. (2020). Effects of inquiry-based teaching on Chinese university students' epistemologies about experimental physics and learning performance. Journal of Baltic Science Education, 19(2), 289–297. https://doi.org/10.33225/jbse/20.19.289

[53] Silver, C., & Barrows, H. (2006). Goals and Strategies of a Problem-Based Learning Facilitator.Interdisciplinary Journal of Problem-based Learning.

[54] Skelton, P., Blackburn, J., Stair, K., Levy, N., & Dormody, T. (2018). Agriscience education through inquiry-based learning: Investigating factors that influence the science competence of middle school students. Journal of Agricultural Education, 59(1), 223-237. https://doi.org/10.5032/jae.2018.01223

[55] Smallhorn, M., Young, J., Hunter, N., & Burke da Silva, K., (2015). Inquiry-based learning to improve student engagement in a large first year topic. Student Success, 6(2), 65-71. https://doi.org/10.5204/ssj.v6i2.292

[56] Smyrnaiou, Z., Foteini, M., & Kynigos, C. (2012). Students' Constructionist Game Modelling Activities as Part of Inquiry Learning Processes.Electronic Journal of E-Learning, 235-248.

[57] Streich, I., & Mayer, J. (2020). Effects and prerequisites of self-generation in inquiry-based learning. Education Sciences, 10(277), 1-16. http://dx.doi.org/10.3390/educsci10100277

[58] Torre, D., Vleuten, C., & Dolmans, D. (2016). Theoretical perspectives and applications of group learning in PBL. Medical Teacher, 189-195.

[59] Walker, C., & Shore, B. (2015). Understanding classroom roles in inquiry education: Linking role theory and social constructivism to the concept of role diversification. Sage Open.

[60] Weina, H., Liang, C., & Fang, Y. (2008). The Change and Role of Teacher in PBL Teaching. Journal of Mathematical Medicine, 495-497.

[61] Williams, M. (2003). WISE Enquiry in fifth grade Biology.Research in Science Education, 415-436.

[62] Zhao, L., He, W., Liu, X., Tai, K., & Hong, J. (2021). Exploring the effects on fifth graders' concept achievement and scientific epistemological beliefs: Applying the prediction-observation-explanation inquiry-based learning model in science education Journal of Baltic Science Education, 20(4), 664-676. https://doi.org/10.33225/jbse/21.20.664