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Uplifting Students' Interest and Ability in Chemistry by PJBL-STEM Model

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ABSTRACT

The PISA 2006-2018 report shows a less significant development of our country's literacy and scientific abilities. Hard work and more efficient methods are needed for the development of education in Indonesia, especially chemistry which is known as the central of science. The STEM learning approach is believed to be able to improve the quality of learning, and make it interesting. The approach used in this research is the class observation of the Project Based Learning (PjBL) method, the STEM (Science Technology Engineering Mathematic) approach, which is carried out by the students of SIS Kelapa Gading-NEJ. There were two student groups who were observed completing assignments per semester over a period of 3 semesters (2 academic years). PjBL learning is better in terms of completeness than Non-PjBL. The difference in the percentage of task completeness is between 20-32%, the difference in value is between 10-24%. Furthermore, PjBL learning with STEM is better than Non-STEM, with a difference in the percentage of task completeness 12%, the difference in value is 9%. This is because it makes students more engaged, happy, motivated, more understanding and in accordance with the learning needed in the 21st century.

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1. INTRODUCTION

The International Baccalaureate (IB) defines chemistry as an experimental science combining academic study with acquiring practical and investigative skills in the three branches of science: chemistry, biology, and physics. Chemistry is referred to as the center of science. This is because the principles of science support the physical environment in which we live and all biological systems. Chemistry is often a prerequisite for many tertiary courses, such as medicine, biology, and environmental science (Seymour et al., 2019; Petillion & McNeil, 2020).

The context of chemistry is not only laboratory testing, food additives, and dangerous substances, but the scope of chemistry involves everything around us. The American Chemical Society (ACS) writes that hearing, seeing, tasting, and touching all involve a complex series of chemical reactions and interactions in our bodies (Kelley, 2021). Without realizing it, we also do chemistry when cooking, taking medicine, washing, mopping with floor cleaner, spraying mosquito repellent, etc.

The discipline of chemistry is divided into five main sub-disciplines: organic chemistry, analytical chemistry, physical chemistry, inorganic chemistry, and biochemistry (Chamizo, 2017; Garg, 2019). In recent years, it has developed into nuclear chemistry, polymer chemistry, biophysical chemistry, bioinorganic chemistry, environmental chemistry, etc. The description above shows how important chemistry is. However, learning chemistry experiences many obstacles. Many students would prefer something else to this chemistry. Research that aims to discover what makes students believe that chemistry is complex groups four factors into the difficulty of learning chemistry: teachers, students, the learning environment, and the chemistry lesson itself. Scientific language literacy occupies the most significant percentage of challenges in learning chemistry (Nuhfer et al., 2016; Wondeamanuel et al., 2014).

Data about literacy and scientific abilities in our country can be shown from the 2018 Program for International Student Assessment (PISA) report released by the Organization for Economic Co-operation and Development (OECD). In reading ability, Indonesia achieved an average score of 371, whereas the average score of countries assessed by the OECD was 487. Meanwhile, science ability was 389, with the average score of countries taking part in the OECD assessment being 489 (Kemendikbud, 2019). This data shows that our country's reading and science abilities are still low compared to other countries.

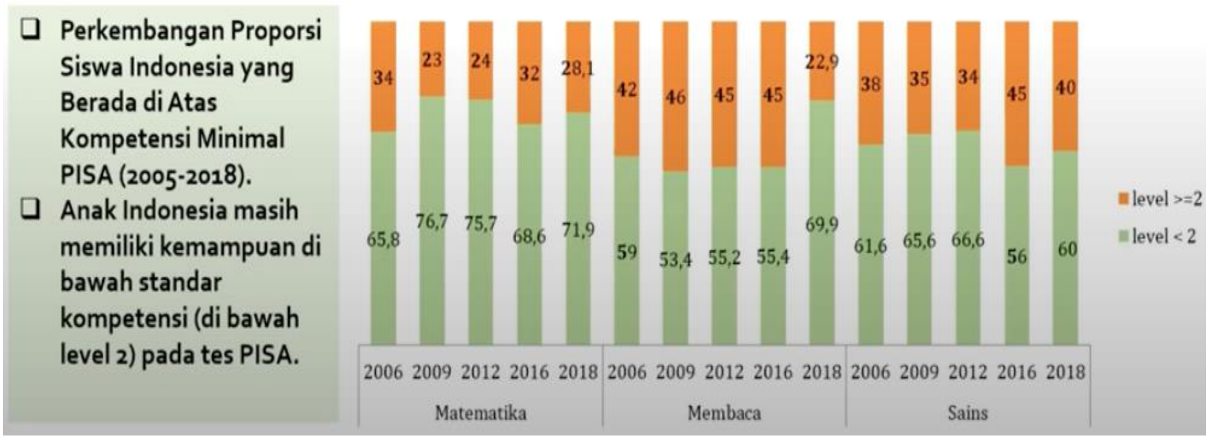

Figure 1. Development of the Proportion of Indonesian students who are above the PISA Minimum Competency (2005-2018)

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The data above shows less significant development in our country's literacy and science capabilities. The data above should be a whip for our policymakers and practitioners to work hard and look for more efficient ways to develop education in Indonesia. One approach Indonesia can take to improve science skills is project-based learning/PjBL STEM (Science, Technology, Engineering, and Mathematics). The United States has seriously paid attention to learning with this STEM approach. In 2007, the National Agency for Science in the United States put forward a series of recommendations to address the critical needs of the STEM Education system in the United States (Heuser et al., 2017; Krug & Shaw, 2016). The offers include the establishment of an independent non-federal and federal official body, the establishment of an Assistant Secretary for Education by the United States Department of Education to coordinate and facilitate STEM programs, and many other recommendations aimed at developing STEM education from early childhood education to diploma program.

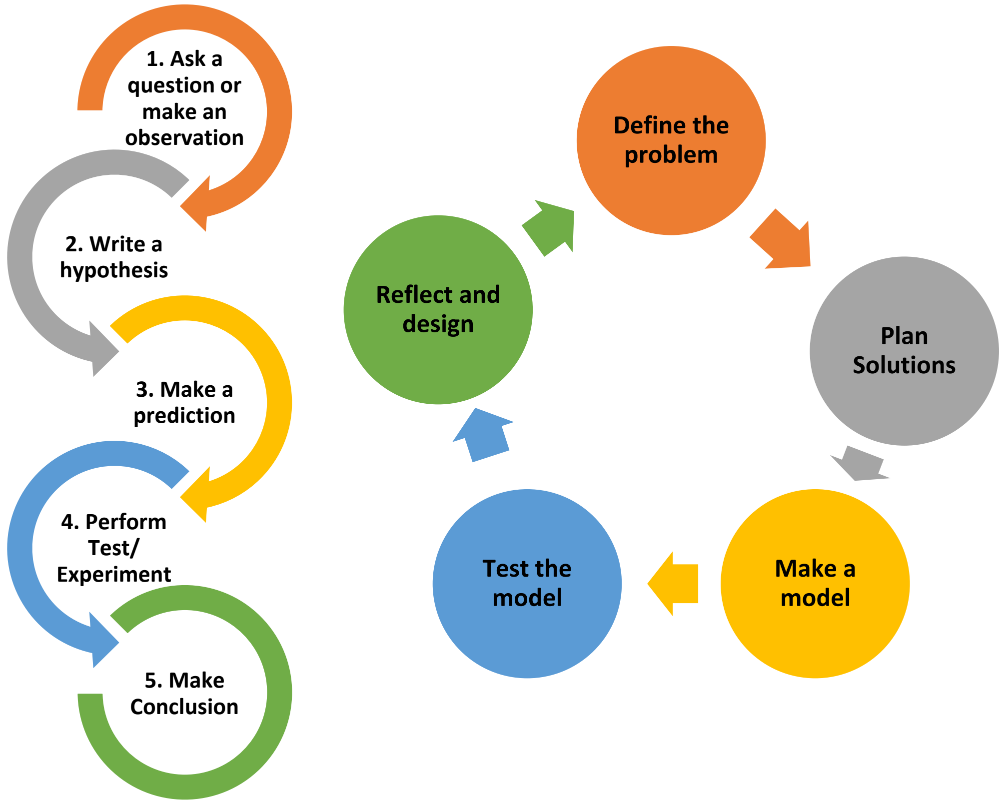

Figure 2. The Relationship Between Scientific and Process Engineering in STEM Education

PjBL STEM is believed to improve the quality of learning and make it enjoyable (Hadiyanti, 2021; Permanasari et al., 2021; Sahin, 2015) . Several countries have integrated STEM learning into their curriculum, for example, Taiwan (Lou et al., 2010 in STEM Indonesia 2020). Finland, the Philippines, Australia, and Vietnam are other countries that implement STEM. Indonesia collaborates with USAID to develop this learning (STEM Indonesia, 2020). Based on the explanation above, this research aims to obtain results from an analysis of the role of STEM in increasing students' interest and abilities in chemistry lessons.

2. METHODOLOGY

The method used in this study is quasi-experimental with a quantitative approach. Quasi-experimental method, namely a method that has an experimental group and a control group

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but does not use a random sample arranged by the researcher (Fraenkel et al., 2012) This means that in this study, the researcher did not organize samples with similar characteristics, such as the same learning conditions and student achievement, and then differentiated the treatment. But it uses class conditions that have been regulated by the school (Awaliyah, C.R. 2016). This method is often chosen in STEM research because it does not allow researchers to control all the necessary variables (Komarudin, 2016).

Class	Pre-test	Treatment	Post-test
Experimental Group	O	X	O
Control Group	O	C	O

X = Treatment by implementing PjBL-STEM.
C = Treatment by applying PjBL-Non STEM and non PjBL-non STEM

3. RESULT AND DISCUSSION

3.1. Observation Results of Study Group A From Grades 9 to 10

Study group a was observed from grade 9 to grade 10 Class 9 semester 2 in May 2020. Semester assignments are not PjBL, not STEM Class 10 semester 1 in November 2020. Non-STEM PjBL semester assignments Class 10 semester 2 in May 2021. PjBL STEM Semester Assignments During Group A in class 9 semester 2, May 2020. The assignment they received was to make questions and answer keys for each critical sub-topic in chemistry lessons. (not PjBL, not STEM) During Class A in class 10, semester 1, November 2020. The assignment they received was to make a video presentation with material drawn and made by themselves/handwritten (PjBL, not STEM). During Class A in Class 10, semester 2, May 2020. The assignment they received was to make a model of the International Space Station (PjBL STEM).

In this model, students model a shoe box and an air filter from gauze. The box has two rooms: the astronaut room and the CO_2 conversion room, which is converted into O_2. Next, they put coffee/chocolate powder as a model for air particles, which will be blown out with a hairdryer towards the filter. The role of the filter is to change the attached CO_2 to O2. Then, the absorption efficiency is calculated by weighing the weight of the gauze before and after blowing the coffee/chocolate grounds. Best design if powder adsorption efficiency is high and there is no coffee/chocolate "leakage" in other rooms (in shoe boxes). Coffee and chocolate particles that reflect carbon dioxide are weighed. The amount of mass absorbed is converted to the number of moles. This is then converted into the number of oxygen particles produced.

Figure 1. Documentation of the Implementation of PjBL STEM Class 10 SIS Kelapa Gading NEJ Students

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They used a shoe box as a model for the international space station, which made 2 rooms (a model of the astronaut room and the CO2 to O2 convention room) separated by a functioning filter absorbs CO2 and is converted to O2.

Figure 2. Documentation of Weighing Filters Placed Between 2 Rooms

This filter is a cartridge model that converts CO2 (represented by coffee/chocolate grounds) into O2. The difference in mass before and after weighing the filter after the coffee/chocolate powder is exhaled is the effective mass of CO2 which is converted into O2

Table 3. Observation Results of Study Group A in Carrying Out Semester Assignments Within 3 Semesters with Different Assignment Methods, Namely Not PjBL and Not STEAM, PjBL Not STEAM, and PjBL STEAM

	Not-PjBL Not STEAM	PjBL Not STEAM	PjBL STEAM
Percentage of task completion	60%	80%	92%
Average Score	65%	79%	88%

3.2. Observation Results of Study Group B from Grades 7 to 9

Study groups (groups) B were observed from grade 7 and grade 9. Grade 7 semester 1, November 2019. Semester assignments are not PjBL, not STEAM Grade 7 semester 2, May 2020. STEM PjBL Semester Assignment Class 9 semester 1, November 2022. Semester PjBL assignment with STEM.

During Class B in class 7, semester 1, November 2019. The assignment they received was to make a scientific report with secondary data (not PjBL, not STEM). During Class B in class 7, semester 2, May 2020. The assignment they received was to make a learning video in the shape of the moon in 1 cycle with a self-created model. (PjBL STEM). During Class B in class 9, semester 1, November 2021. The assignment they received was to make a learning video for atomic structure with an atomic structure model.

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Figure 3. Documentation of STEM PjBL results for 7th grade students at SIS Kelapa Gading

Task theme: phases of the moon in 1 cycle. Model from waste paper. The simulation is carried out in a dark place, resembling the atmosphere in space. The images shown resemble those taken by NASA.

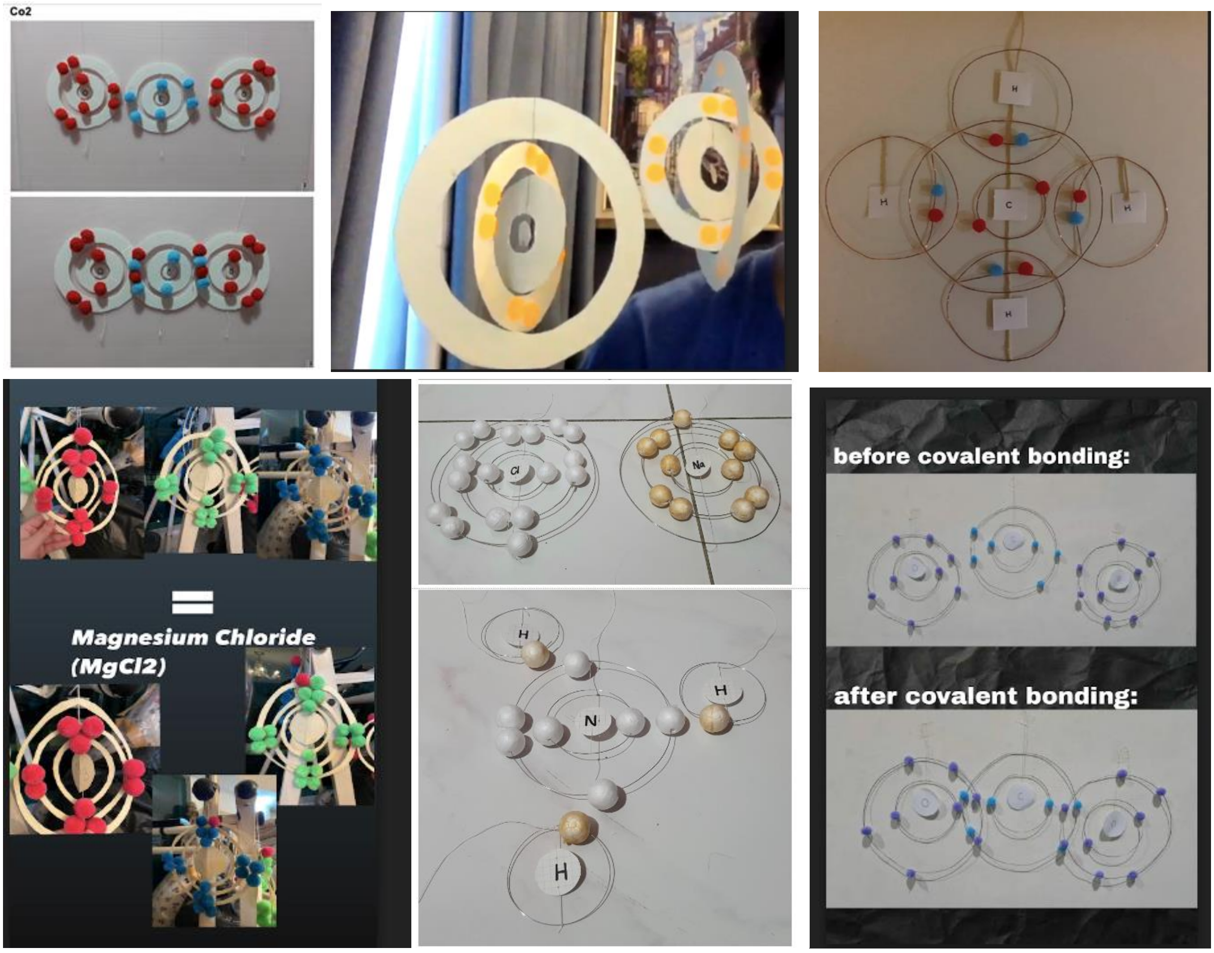

Figure 4. Documentation of STEM-Approach Project-Based Learning (PjBL) Conducted by Grade 9 SIS Kelapa Gading-NEJ students

PjBL's theme is "Chemical Bond 3D Learning". Students make learning videos with models of atomic structure made with a variety of their own creativity.

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Table 4. Observation Results of Study Group B Carrying Out Semester Assignments Over A Period of 3 Semesters Using Different Methods, Namely Not-PjBL & Not-STEM, and PjBL STEM

	Not-PjBL Not STAM	**PjBL Not STAM**	**PjBL STEM**
Percentage of task completion	70%	90 %	92%
Average Score	75%	85%	89%

Based on the results of observations of 2 study groups in 3 semesters of word, it can be observed that PjBL learning is better in terms of completeness compared to non-PjBL. The difference in task completion percentage is between 20-32%, and the difference in score is between 10-24%. Furthermore, PjBL STEM is better than non-STEM, with a difference in task completion percentage of 12% and a difference in value of 9%. The STEM PjBL is 21st-century education-oriented: Mathematics, science, social, and humanity. Developed scientific attitude: critical, logical, analytical, creative, and able to adapt, as well as independent. The PjBL model has the characteristics of students facing real problems, thinking about finding a solution and working together to create a project to solve the problem (Anazifa, & Djukri, 2017; Fajra & Novalinda, 2020; Uziak, 2016).

The values developed in PjBL are student-centered, where the teacher is only a facilitator; students can also develop skills in the 21st century (Keiler, 2018; Pedersen & Liu, 2003; Tiantong & Siksen, 2013). PjBL can also link scientific processes and engineering processes (Egenrieder, 2010; Syukri et al., 2021). Learning activities become increasingly high. Students are also becoming more interested in STEM and inspired. The 5E learning models, namely engagement (participation), exploration, explanation, elaboration, and evaluation, are also used/integrated with STEM (Wahono et al., 2021). Teachers can engage (participate) students so that children's interest and curiosity increase; exploration, such as testing hypotheses, recording observations, and collaborating to solve problems; explanation, explaining the results obtained in their language style; elaboration, applying and connecting learned concepts to solve problems; evaluation, students are given questions to diagnose the implementation of learning activities and find out students' understanding of the activities carried out. Through these 5E values, 4C/K can be achieved. Integrating STEM into learning is a wise step to increase children's knowledge of chemistry lessons and foster a sense of love and higher interest (Asghar et al., 2012; Burt & Johnson, 2018).

Integrating STEM will make children happy because they will grow in confidence that their knowledge can answer existing problems (Bustamante et al., 2018; McComas & Burgin, 2020; Tabiin, 2020). The creativity they do and the learning outcomes will encourage curiosity and inspire children to know more deeply and then choose STEM disciplines in their future careers/businesses. STEM-related jobs will absorb more workers because, with the world's population and complex problems, STEM disciplines are indispensable for economic growth and meeting human needs/desires. Some students at SIS Kelapa Gading-NEJ with moderate academic achievements are enthusiastic about pursuing STEM disciplines, especially those with high academic achievements. This is a positive signal that integrating STEM into learning is very appropriate.

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4. CONCLUSION

PjBL is better in completeness than non-PjBL, based on the difference in task completion percentage and grades. Furthermore, PjBL learning with STEM is better than non-STEM, with differences in the rate of task completion and grades. This is because PjBL makes students more involved, happy, motivated, and understanding better and is by the learning required in the 21st century.

REFERENCES

Anazifa, R. D., & Djukri, D. (2017). Project-based learning and problem-based learning: Are they effective to improve student's thinking skills?. *Jurnal Pendidikan IPA Indonesia*, *6*(2), 346-355.

Asghar, A., Ellington, R., Rice, E., Johnson, F., & Prime, G. M. (2012). Supporting STEM education in secondary science contexts. *Interdisciplinary Journal of Problem-Based Learning*, *6*(2), 4.

Awaliyah, C. R. (2016). *Implementation of the pjbl model with the stem approach to improve concept mastery and creativity of middle school students in ecosystem materials* (Doctoral dissertation, Indonesian University of Education).

Burt, B. A., & Johnson, J. T. (2018). Origins of early STEM interest for Black male graduate students in engineering: A community cultural wealth perspective. *School Science and Mathematics*, *118*(6), 257-270.

Bustamante, A. S., Greenfield, D. B., & Nayfeld, I. (2018). Early childhood science and engineering: Engaging platforms for fostering domain-general learning skills. *Education Sciences*, *8*(3), 1-13.

Chamizo, J. A. (2017). The fifth chemical revolution: 1973–1999. *Foundations of Chemistry*, *19*, 157-179.

Egenrieder, J. A. (2010). Facilitating student autonomy in project-based learning to foster interest and resilience in STEM education and STEM careers. *Journal of the Washington Academy of Sciences*, *96*(4), 35-45.

Fajra, M., & Novalinda, R. (2020). Project Based Learning: Innovation to improve the suitability of productive competencies in vocational high schools with the needs of the world of work. *International Journal Of Multi Science*, *1*(08), 1-11.

Fraenkel, J. R., Wallen, N. E., & Hyun, H. H. (2012). *How to design and evaluate research in education (8th ed.)*. McGraw-Hill.

Garg, K. C. (2019). PhD theses accepted by Aligarh Muslim University (AMU) in the discipline of chemistry: A Bibliometric Study (1935-2014). *Journal of Indian Library Association*, *54*(2), 73-78.

Hadiyanti, N. F. D., Prihandoko, A. C., Murtikusuma, R. P., Khasanah, N., & Maharani, P. (2021, March). Development of mathematics e-module with STEM-collaborative project based learning to improve mathematical literacy ability of vocational high school students. In *Journal of Physics: Conference Series* (Vol. 1839, No. 1, p. 012031). IOP Publishing.

DOI: https://doi.org/10.17509/pdgia.v20i3.47343
p- ISSN p. ISSN 1693-5276 e- ISSN 2579-7700

Heuser, B. L., Wang, K., & Shahid, S. (2017). Global dimensions of gifted and talented education: The influence of national perceptions on policies and practices. *Global Education Review*, *4*(1), 4-21.

Keiler, L. S. (2018). Teachers' roles and identities in student-centered classrooms. *International journal of STEM education*, *5*(1), 1-20.

Kelley, E. W. (2021). LAB theory, HLAB pedagogy, and review of laboratory learning in chemistry during the COVID-19 pandemic. *Journal of Chemical Education*, *98*(8), 2496-2517.

Kemendikbud. (2019). *Hasil PISA Indonesia 2018: Akses Makin Meluas, Saatnya Tingkatkan Kualitas***.**https://www.kemdikbud.go.id/main/blog/2019/12/hasil-pisa-indonesia-2018-akses-makin-meluas-saatnya-tingkatkan-kualitas

Komarudin, U. (2016). *Penggunaan E-Book Berbasis STEM Untuk Meningkatkan Penguasaan Konsep Siswa dan Technology Engineering Literacy Siswa* (Doctoral dissertation, Universitas Pendidikan Indonesia).

Krug, D., & Shaw, A. (2016). Reconceptualizing st® e (a) m (s) education for teacher education. *Canadian Journal of Science, Mathematics and Technology Education*, *16*(1), 183-200.

McComas, W. F., & Burgin, S. R. (2020). A critique of "STEM" education: Revolution-in-the-making, passing fad, or instructional imperative?. *Science & Education*, *29*(4), 805-829.

Nuhfer, E. B., Cogan, C. B., Kloock, C., Wood, G. G., Goodman, A., Delgado, N. Z., & Wheeler, C. W. (2016). Using a concept inventory to assess the reasoning component of citizen-level science literacy: Results from a 17,000-student study. *Journal of microbiology & biology education*, *17*(1), 143-155.

OECD. (2019). PISA 2018. http://www.OECD.org/PISA2018Database

Pedersen, S., & Liu, M. (2003). Teachers' beliefs about issues in the implementation of a student-centered learning environment. *Educational Technology Research and Development*, *51*(2), 57-76.

Permanasari, A., Rubini, B., & Nugroho, O. F. (2021). STEM education in Indonesia: Science teachers' and students' perspectives. *Journal of Innovation in Educational and Cultural Research*, *2*(1), 7-16.

Petillion, R. J., & McNeil, W. S. (2020). Student experiences of emergency remote teaching: Impacts of instructor practice on student learning, engagement, and well-being. *Journal of Chemical Education*, *97*(9), 2486-2493.

Sahin, A. (2015). STEM students on the stage (SOS): Promoting student voice and choice in STEM education through an interdisciplinary, standards-focused project based learning approach. *Journal of STEM Education*, *16*(3), 1-10.

Seymour, E., Hunter, A. B., & Harper, R. P. (2019). *Talking about leaving revisited*. Springer.

STEM Indonesia. (2020). *Menjadikan belajar lebih menarik.* https://stem.id/stem-menjadikan-belajar-lebih-menarik/

DOI: https://doi.org/10.17509/pdgia.v20i3.47343
p- ISSN p. ISSN 1693-5276 e- ISSN 2579-7700

Syukri, M., Yanti, D. A., Mahzum, E., & Hamid, A. (2021). Development of a PjBL model learning program plan based on a stem approach to improve students' science process skills. *Jurnal Penelitian Pendidikan IPA*, *7*(2), 269-274.

Tabiin, A. (2020). Implementation of steam method (science, technology, engineering, arts and mathematics) for early childhood developing in kindergarten mutiara paradise pekalongan. *Early Childhood Research Journal (ECRJ)*, *2*(2), 36-49.

Tiantong, M., & Siksen, S. (2013). The online project-based learning model based on student's multiple intelligence. *International Journal of Humanities and Social Science*, *3*(7), 204-211.

Uziak, J. (2016). A project-based learning approach in an engineering curriculum. *Global Journal of Engineering Education*, *18*(2), 119-123.

Wahono, B., Chang, C. Y., & Khuyen, N. T. T. (2021). Teaching socio-scientific issues through integrated STEM education: an effective practical averment from Indonesian science lessons. *International Journal of Science Education*, *43*(16), 2663-2683.

Woldeamanuel, M., Atagana, H., & Engida, T. (2014). What makes chemistry difficult? African *Journal of Chemical Education, 4*(2), 31-43.

DOI: https://doi.org/10.17509/pdgia.v20i3.47343
p- ISSN p. ISSN 1693-5276 e- ISSN 2579-7700