Advances in Social Science, Education and Humanities Research, volume 566
Proceedings of the 5th Asian Education Symposium 2020 (AES 2020)

Scientific Approach-Integrated Local Wisdom Content:

A Physics Learning Design To Enhance Students' Critical Thinking and Problem Solving Skills

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***Abstract*—Good critical thinking and problem solving skills become essential factors in helping students to achieve a better performance in learning physics. This research was aimed at analyzing the effect of scientific approach-integrated local wisdom content on senior high students' critical thinking ability, and problem solving skills. This research used a quasi-experiment with the post-test only control group design. The research population consisted of all eleventh grade students of SMA Negeri 4 Singaraja in the academic year 2018/2019 with the total of 220 students. The equality of the classes was firstly tested and the sample was then selected by random sampling technique. The research instruments were critical thinking ability test and problem solving skills test. Before they were used, their validity and reliability were tested. The obtained data were analyzed descriptively and to test the hypothesis of this research used MANOVA at $\alpha = 0.05$. The results of the study revealed that there was a difference simultaneously on students' critical thinking ability and problem solving skills between students who learned through the scientific approach-integrated local wisdom content learning model and those who learned with conventional learning model. Higher critical thinking and problem solving skills was achieved by the students who learned through the scientific based-learning approach with local wisdom content.**

Keywords—scientific process based-approach, local-genius based content, critical thinking ability and physics problem solving skills

I. INTRODUCTION

In the current era of globalization, the challenge of quality improvement in all aspects of life is no longer negotiable. The rapid development of science and technology requires every nation to utilize its potential resources in order to survive and be able to win the competition with other countries. This means that every nation needs to enhance a competitive attitude towards human resources (HR) systematically and continuously through education and training. In order to face the challenges of the future (towards generation 2045), five minds of the future are required which consist of disciplined mind, synthesizing mind, creating mind, respecting mind, and the ethical mind [1]. Furthermore, the globalization must be "resisted" by developing creativity and entrepreneurship through a transformative critical pedagogic in national education [2]. Thus, the important thing that must be prepared for human resources in the future is the ability to think. Education nowadays must be directed at increasing the competitiveness of the nation in this global competition. This can be achieved if education in schools is directed not solely on mastery and understanding of scientific concepts, but also on improving students' thinking ability, especially in high order thinking.

Science education has a great potential in developing students' high order thinking ability. In addition to studying science products in the form of facts, concepts, principles, laws, and theories, science education also develops scientific attitudes and thinking skills of students [3,4]. Through it, students will be encouraged to develop personal experiences and practical skills which will be very useful in the process of solving a problem [5]. Lewis and Kelly also emphasized that science education provided both in formal and non-formal education is very important in developing the quality of human life [6].

Despite the various efforts that have been done by the government relating to the development of human resources quality through science learning in schools, some researches and assessments of the human resources quality in Indonesia still reflects some low figures. The survey from *Trend International Mathematics Science* (TIMSS) in 2011 reported that Indonesia is ranked 36th out of 49 countries in the world on the average value of science in the cognitive domain. Indonesia obtained scores of 425, 426, and 438 for the knowing, applying, and reasoning abilities, respectively. All these scores were below the TIMSS average score, which is 500 [7]. In 2012, Indonesia ranked 121st among the countries in the world for the Human Development Index compiled by UNDP (United Nation Development Program) [8]. There was

also the results of a survey conducted by the OECD (Organization for Economic Co-operation and Development) in 2015, which showed Indonesia's position ranked 69th out of 76 countries for science skills based on the category of 15-year-old students [9]. The low cognitive and reasoning abilities shown in the study done by TIMSS and UNDP for either elementary or junior high school students give impact on their critical thinking and problem solving skills when they are in the senior high school. The study conducted by Azizah, et al in 2015 showed that 76% of senior high school students experience some difficulties in learning physics due to the lack of their problem solving skills [10]. The low critical thinking skills owned by the senior high school students is also reflected from the various social problems that occur, as seen in printed media, television, and other social media, related to provocation and slander through hoaxes that can damage and destroy the social order of the nation which are divisive among the Indonesian. This requires the criticality of the community in facing this false news so that the integrity of the unitary state of the Republic of Indonesia is maintained. The low quality of critical thinking skills possessed by senior high school students is also shown by another study conducted by Sadia (2008) which revealed that the critical thinking skills of students in SMP and SMAN in the province of Bali were still relatively low [11]. This is due to the dominance of teachers in the learning process which does not give access to students to develop the knowledge through their own discovery and their thinking processes. Based on these explanations, then in science learning especially in physics learning, it is expected that students gain meaningful experiences to develop their thinking abilities.

The implementation of the 2013 Curriculum (K-13), as the new curriculum in Indonesia, has consequences for the changes in the learning and assessment system. The 2013 curriculum emphasizes the use of scientific approach in the learning process and it requires the teacher to balance the assessment of the student's learning outcomes which includes competency attitudes, knowledge and skills through the authentic assessment. The implementation of scientific approach in learning provides a positive influence on teachers and students, because it refers to a scientific thinking process that trains systematic and holistic thinking [12]. This approach allows teachers to improve the process of learning by breaking the process down into steps or stages which contains detailed instructions for conducting students learning [13].

In order that the scientific approach gives more motivation and meaningful learning to students as well as improving both their problem solving and critical thinking ability, it is very important to integrate it with local wisdom/cultures, such as the Balinese culture. Baker, *et al* stated that if the science learning process does not pay more attention to the students' local wisdom then the students will tend to "reject" or only accept the science concepts they learned partially [14]. Local wisdom is defined as truth that has been steady lived in one particular area [15]. The local wisdom is also referred to as a human effort in using his mind (cognitive ability) to act and behave towards something, object, or event that occurs in a particular place. Wisdom etymologically means the ability of a person to use his mind to respond to an event, object or situation, while local indicates the interaction space where the event or situation occurred. Thus, local wisdom is substantially the norm that applies in a society that is believed to be true and becomes a reference in acting and behaving daily. Geertz explained that local wisdom is an entity that really determines the dignity of human beings in the community [16]. This local wisdom can be in the form of indigenous knowledge, attitudes and behaviors (values), and artifacts (tangible objects created by human works) [17]. In physics learning, these local wisdom/cultures can be used as media and learning model to stimulate, motivate and help students construct new knowledge. In its implementation, these local wisdom will help students to connect and assimilate the new physics concept they learn into their prior knowledge. By using local wisdom in learning, teacher can also explain physics concept with a familiar and more describable example to students. Rosengrant stated that by helping students to link between the abstract representations of physics concepts to more concrete representations enhances student learning and problem-solving ability [18].

Based on those explanations, the objective of this research is to test the effectiveness of physics learning through scientific approach-integrated local wisdom content in enhancing senior high students' critical thinking and problem solving skills.

II. METHODS

This research was a quasi-experiment with post-test only control group design. There are two variables used in this study, i.e., independent and dependent variables. The independent variable was the learning model and the independent variable were problem solving and critical thinking. The use of learning model as a treatment was differentiated into two, i.e., scientific based-learning approach combined with local wisdom content for the experimental group (EG) and conventional learning for the control group (CG).

The population of this research was 220 eleventh-grade students of SMA N 4 Singaraja in the even semester on academic year 2018/2019. Based on the population characteristics, in which all classes in the population are qual, two samples were then chosen by random sampling techniques from existing classes as the experimental group (EG) and the control group (CG). In this study, each group consisted of 30 students.

The data of this research were collected using the critical thinking and problem solving skill test. The tests of critical thinking skills was developed into 10 items of an objective test and meets the indicators of interpretation, analysis, evaluation, inference, and explanation. Meanwhile, the problem solving test consist of 2 items of essay test which assess the students' cognitive level of ability from C3 (Apply) to C5 (Synthesize). All instruments used in this study meet valid and high

requirements. The data were analysed through descriptive statistics and factorial analysis with a 5% significance level.

III. Results and Discussions

A. Results

Based on the data analysis, it was found that the average scores of critical thinking and problem solving skills of the students in experimental group who learned through the learning model with scientific approach-integrated local wisdom content were higher than those obtained in control group who learned through the conventional learning model. The average score of critical thinking skills of the students were 66.00 (fair category) in experimental group and 52 (poor category) in control group. In terms of problem solving skills, the average score for the experimental group was 55.00 (fair category) while the control group was 34 (poor category) (Figure 1). It was also found that around 43% of the students in the experimental group achieved critical thinking scores in the good category and 50% are in the good and fair categories for problem solving skills. Whereas in the control group most students got scores in the poor and bad categories respectively for critical thinking skills and problem solving (See figure 2).

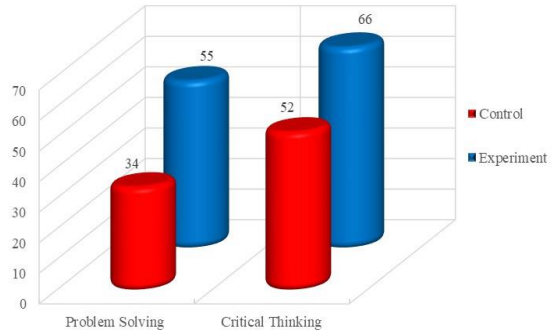

Fig. 1. The average score of critical thinking and problem solving skills.

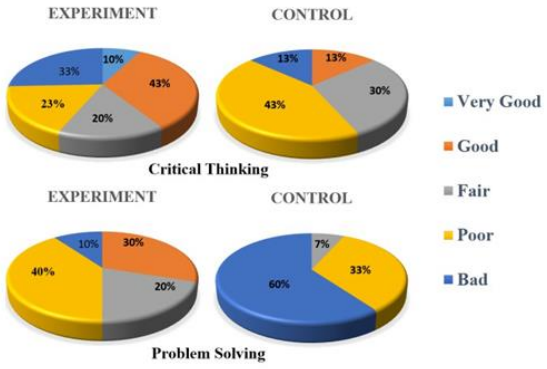

Fig. 2. Percentage of frequency distribution of critical thinking and problem solving skills scores.

The normality of the data distribution of the critical thinking and problem solving skills of the students in the experimental and control group were tested using the Kolmogorov-Smirnov Test. The homogeneity of variance data was tested using the Levene's Test of Equality of Error Variances. The summary of the result of normality and homogeneity test are shown in Table 1 dan 2.

TABLE I. Results of Normality Test

Variable	Class	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	*df*	*Sig.*	*Statistic*	*df*	*Sig.*
Critical Thinking Skills	Control	.154	30	.068	.952	30	.186
	Experiment	.151	30	.079	.943	30	.110
Problem Solving Skills	Control	.138	30	.152	.959	30	.295
	Experiment	.134	30	.181	.945	30	.123

[a]. Lilliefors Significance Correction

TABLE II. Results of Homogeneity Test

		Levene Statistic	df1	df2	Sig.
Critical Thinking Skills	Based on Mean	.615	1	58	.436
	Based on Median	.478	1	58	.492
	Based on Median and with adjusted df	.478	1	57.969	.492
	Based on trimmed mean	.588	1	58	.446
Problem Solving Skills	Based on Mean	2.397	1	58	.127
	Based on Median	2.325	1	58	.133
	Based on Median and with adjusted df	2.325	1	57.223	.133
	Based on trimmed mean	2.393	1	58	.127

Based on Table 1, the data distribution of the score of the students' critical thinking and problem solving skills of the experimental and control groups are normally distributed (sig normality > 0.05). We can also see in Table 2 that the homogeneity of variance data in both group are homogenous (sig homogeneity > 0.05). The inter-correlation test between dependent variables is shown in Table 3.

TABLE III. The Summary of The Result of Inter-Correlations Test

		Critical Thinking Skills	Problem Solving Skills
Critical Thinking Skills	Pearson Correlation	1	.319*
	Sig. (2-tailed)		.013
	Sum of Squares and Cross-products	16018.333	5376.667
	Covariance	271.497	91.130
	N	60	60
Problem Solving Skills	Pearson Correlation	.319*	1
	Sig. (2-tailed)	.013	
	Sum of Squares and Cross-products	5376.667	17743.333
	Covariance	91.130	300.734
	N	60	60

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

Based on the results of the analysis in Table 3, it appears that the inter-correlations between the dependent variables are

entirely below 0.8 (0.39). This means that there is no very strong correlation between critical thinking and problem solving skills. Thus, the requirements for analysis using Manova has been met. Simultaneous and inter-subject analysis of multivariate (Manova) test results are presented in Table 4 and Table 5, respectively.

TABLE IV. THE SUMMARY OF SIMULTANEOUS MANOVA TEST

Effect		Value	F	Hypothesis df	Error df	Sig.
Intercept	Pillai's Trace	.961	705.464[b]	2.000	57.000	.000
	Wilks' Lambda	.039	705.464[b]	2.000	57.000	.000
	Hotelling's Trace	24.753	705.464[b]	2.000	57.000	.000
	Roy's Largest Root	24.753	705.464[b]	2.000	57.000	.000
Class	Pillai's Trace	.429	21.411[b]	2.000	57.000	.000
	Wilks' Lambda	.571	21.411[b]	2.000	57.000	.000
	Hotelling's Trace	.751	21.411[b]	2.000	57.000	.000
	Roy's Largest Root	.751	21.411[b]	2.000	57.000	.000

TABLE V. THE SUMMARY OF THE RESULT OF INTER-SUBJECT ANALYSIS MANOVA TEST

Source	Dependent Variables	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Critical Thinking Skills	3081.667[a]	1	3081.667	13.816	.000
	Problem Solving Skills	6406.667[b]	1	6406.667	32.777	.000
Intercept	Critical Thinking Skills	207681.667	1	207681.667	931.116	.000
	Problem Solving Skills	119706.667	1	119706.667	612.436	.000
Class	Critical Thinking Skills	3081.667	1	3081.667	13.816	.000
	Problem Solving Skills	6406.667	1	6406.667	32.777	.000
Error	Critical Thinking Skills	12936.667	58	223.046		
	Problem Solving Skills	11336.667	58	195.460		
Total	Critical Thinking Skills	223700.000	60			
	Problem Solving Skills	137450.000	60			
	Critical Thinking Skills	16018.33	59			
	Problem Solving Skills	17743.333	59			

Based on the results of analysis using MANOVA test as given in Tables 4 and 5 the following findings are established. From table 4, the value of F = 21,41 with sig. value of 0.00 < 0.05, meaning that there is a simultaneous difference in critical thinking and problem solving skills between the students who learned through the learning model with scientific approach-integrated local wisdom content and those who learned through conventional learning model. Based on table 5, the value of F = 13,816 with sig. value which is less than 0,05 indicates that there is a significant difference of critical thinking skills between the group of students who learned through the learning model with scientific approach-integrated local wisdom content and those who learned through conventional learning model. The value of F = 32,77 with sig. value < 0.05, meaning that the problem solving skills between students who learned through through the learning model with scientific approach-integrated local wisdom content and those who learned through conventional learning model are significantly different.

B. Discussions

The research showed that the critical thinking and problem solving skills of the students who learned through scientific approach based-learning model combined with local wisdom content were better than those who learned through conventional learning model. The implementation of the scientific approach based-learning model give more opportunities to the students to explore themselves and improve their understanding of concepts and critical thinking skills. Students become more active in building their own understanding through extracting information independently, carrying out the process of accepting information to the stage of communicating the information or concepts they learned. Through the investigation activities which were given in this scientific approach based-learning model, the students are encouraged to practice their ability in compiling information to decisively examine and solve the problems. This is in accordance with what was stated by Snyder that a learning environment which actively involves student in the process of problem investigation or information-seeking will effectively develop students' critical thinking and problem solving skills [19]. Haryono and Wardani also stated that learning process through scientific approach (science process skills) would be able to increase student learning activities that would have an impact on improving students' learning outcomes and their problem solving abilities [20,21].

The process of integrating scientific based-learning approach with local wisdom based-content helps students to understand the concepts more easily. This is due to the delivery of content via local wisdom give them more real visualization. Due to their familiarity of the local wisdom, the content or material delivered through this local culture will give a more vivid prior knowledge and facilitate them in understanding the contents more deeply. This is supported by the results of research conducted by Suyatna which states that in physics learning, the use of visualization models in the form of a moving or static model is able to help students improve their learning outcomes through the provision of different assistance based on the concept taught [22]. Through

the presentation of physics content via this local culture, students become more enthusiastic in participating the learning process. Some abstract physics concepts that are difficult to present through practicum outside the classroom cause some difficulties for students to understand the essence of the concepts being taught [23]. Therefore, the use of local culture-based content media facilitates students to get an image of how the concept of physics is applied directly in the real life phenomena that they are familiar with so it makes the process of learning physics in the classroom more enjoyable.

Using media or video assistance that displays the real application of physics concepts in a particular local culture, also enables students to think more critically when they find some interesting things from the media. These learning media can be more concentrated on giving cases and problems to be solved by students so that this can effectively motivate and help them developing their critical thinking skills [24]. On the other hand, the integration of local cultures/wisdom into the learning media facilitate the teacher in presenting and transferring physics concepts consisting of some mathematical equations more manageably. The teacher is also facilitated in terms of giving questions or real problems that can explore students' abilities in developing their problem-solving abilities. Combining the physics learning with local wisdom content also help the teacher in taking steps to improve students' problem solving abilities. Presentation of material through local wisdom content can be used during the initial stage of scientific approach-based learning process to illustrate how the concept of physics is applied in a phenomenon or event that is observed by students directly in their own culture. Starting from here, the teacher can present questions that arouse students' curiosity about the concepts being studied, then proceed with the giving of further questions which serve as discussion material for students to solidify their understanding of the concepts.

Although the critical thinking and problem solving skills of students who learned through the learning model with **s**cientific approach-integrated local wisdom content were better than those obtained by the students who learned through conventional learning model, the results were still not optimal. This can be seen from the problem solving score achieved by the students which were only in the fair category. The non-optimal results found in this research were caused by the following factors: (1) the lacking of positive habit of the students to be active during the learning process. Some of the students get already used to with the previous conventional learning model which tend to make them become passive. This give rise to some difficulties for the teacher especially when the students were asked to conduct some investigation and information-seeking to solve given problems, (2) the limit of classroom time which tend to make it difficult to conduct the whole learning process optimally, and (3) The difficulty in relating local wisdom which were relevant to the material or learning topics especially the ones which consist of some abstract concepts. In order that students' critical thinking and problem solving skills can be improved optimally, all these obstacles should be eliminated as much as possible by preparing a good lesson plan which enables the learning process with scientific approach-integrated with local wisdom content be conducted optimally. It also important to habituate the students to be active during the class by giving them more opportunities to take roles in the learning process so that they all can participate actively.

IV. Conclusion and Outlook

Based on the results and data analysis of this study, it can be concluded that there is a simultaneous difference in critical thinking and problem-solving skills between the students who learned through the learning model with scientific approach-integrated local wisdom content and those who learned through conventional learning model. The average score of critical thinking and problem solving skills of the students who learned through the learning model with scientific approach-integrated local wisdom content are 66 and 55 respectively, which were better than those obtained by the students who learned through conventional learning model. Some obstacles found in the implementation of the learning model with scientific approach-integrated local wisdom content are as follows : (1) the lacking of positive habit of the students to be active during the learning process, (2) the limit of classroom time which tend to make it difficult to conduct the whole learning process optimally, and (3) The difficulty in relating local wisdom which were relevant to the learning material. Based on the conclusion, it can be suggested that in order to have an optimal results through the implementation of the learning model with scientific approach-integrated local wisdom content, the teachers should prepare a good lesson plan and explore more local cultures which can be integrated to the learning material. It is also suggested to the principal of the school to provide complete science laboratory facilities to support the effectiveness learning process. A further study needs to be done with a broader scope and involving more schools as the subject research to see the result at a larger scale.

References

[1] H. Gardner. Five Minds for The Future (Alih Bahasa Tome Beka). Gramedia Pustaka Utama; 2007.

[2] H.A.R. Tilaar, Pengembangan Kreativitas dan Enterpreneurship dalam Pendidikan Nasional. Jakarta: Kompas, 2012.

[3] A.T. Collette and E.L. Chiappetta, Science Instruction in the Midle & Secondary School. New York: Maxwell Macmillan International, 1994.

[4] I.W. Suastra, Pembelajaran Sains Terkini: Mendekatkan Siswa dengan Lingkungan Alamiah dan Sosial Budayanya. Singaraja: Undiksha Press, 2013.

[5] Y. Gödek, Journal of Kirsehir Education Faculty 5, 2004.

[6] J.L. Lewis and P.J. Kelly, Science and Technology Education and Future Human Needs, Pergamon Press, Oxford, 1987.

[7] Tim PISA Indonesia, Hasil TIMSS 2015 (2015)

[8] United Nation Development Program, Human Development Reports 2013. New York: UNDP 2013.

[9] Oganization for Economic Co-operation and Development Team, Education at a Glance 2015: OECD Indicators, OECD 2015.

[10] R. Azizah, Lia Yuliati, Eny Latifah, "Deskripsi Kesulitan Belajar Peserta Didik dan Faktor Penyebabnya dalam Memahami Materi Listrik Dinamis Kelas X SMA N 2 Bengkayang," Jurnal Penelitian Fisika dan Aplikasinya (JPFA), Vol. 5, No.2, pp. 44-53

[11] I.W. Sadia, Model Pembelajaran yang Efektif untuk Meningkatkan Berpikir Kritis. Jurnal Pendidikan dan Pembelajaran Undiksha, No. vol. 41, no. 2, pp. 219-237, 2015

[12] Wahyono, Ishak A, Rusman, "Implementation of scientific approach based learning to think high levels in state senior high school in ketapang" International Journal of Education and Research, Vol. 5, No. 8, 2017.

[13] X. Tang, J.E. Coffey, A. Elby and D.M. Levin, "The scientific method and scientific inquiry: Tension in teaching and learning, 2009.

[14] D. Baker and P.C. Taylor, "The Effect of Culture on the Learning of Science in non-WesternCountries: The Results of a Integrated Research Review," International Journal Science Education, Vol. 17, 1995.

[15] I.K. Gobyah, Berpijak pada Kearifan Lokal. Bali: Bali post. 2003. www.balipos.co.id.

[16] C. Geertz, Kebudayaan dan Agama. Yogyakarta: Kanisius Press, 1992.

[17] I.W. Suastra, Balinese Lokal Wisdoms and their Implications in Science Education at School. International Research Journal of Management, IT & Social Sciences (IRJMIS) Vol. 4 Issue 2, March 2017, pages: 42-50, 2017.

[18] D. Rosengrant, A. Van Heuvelen and E. Etkina, "Do students use and understand free-body diagrams?," Physical Review Special Topics-Physics Education Research, vol. 5, no. 1, pp. 010108, 2009.

[19] L.G. Snyder and J.S. Mark, "Teaching Critical Thinking and Problem Solving Skills" The Delta Pi Epsilon Journal Volume L, No. 2, Spring/Summer, 2008.

[20] Haryono, "Model Pembelajaran Berbasis Peningkatan Keterampilan Proses Sains," Jurnal Pendidikan Dasar, vol. 7, no. 1, pp. 1-13, 2006.

[21] Wardani, Sri, Antonius, Tri and N.P. Niken, "Peningkatan Hasil Belajar Siswa Melalui Pendekatan Keterampilan Proses Sains Berorientasi Problem-Based Instruction," Jurnal Inovasi Pendidikan Kimia, vol. 3, no. 1, pp. 391-399, 2009.

[22] A. Suyatna, D. Anggraini, D. Agustina and D. Widyastuti, "The role of visual representation in physics learning: dynamic versus static visualization," Journal of Physics: Conf. Series 909, 2018.

[23] M. Nasir, "How to teach physics using information and communication technology media? a review to propose new idea of learning models," IOSR Journal of Research & Method in Volume 8, Issue 6 Ver. IV, 2018.

[24] S. Wahyuni, "Pengembangan perangkat pembelajaran IPA berbasis kearifan lokal untuk meningkatkan kemampuan berpikir kritis siswa," Jurnal Pendidikan Fisika Indonesia, vol. 11, no. 2, pp. 156-161, 2015.