COMPARISON OF LEARNING IN INDUCTIVE AND DEDUCTIVE APPROACH TO INCREASE STUDENT'S CONCEPTUAL UNDERSTANDING BASED ON INTERNATIONAL STANDARD CURRICULUM

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ABSTRACT

This study aimed to determine the pattern of a more effective learning approach between the inductive and deductive approach in improving students' conceptual understanding referring to the international standard curriculum on the X graders for the material property particulate subject matter. Through the deductive approach, students already have a picture/concept in their minds. But by using an inductive approach, students use their logic to understand concepts and summarize it. The research method applied in this study is a descriptive-comparative method with a triangulation analysis technique. Instruments used in the study were a questionnaire for the students, observation sheets, and three-tier diagnostic test items for pretest and posttest. The average pretest scores for deductive and inductive classes were 54.70 and 48.25, respectively. The result of the observation sheet analysis showed the deductive approach surpassed 12 points more than the inductive approach in improving the student's learning activity. The result of the questionnaire analysis showed that 38 of 68 students prefer the learning process using deductive to inductive approach, and thought that it was suitable with the students' characteristics. While the average posttest scores for deductive and inductive classes were 68.16 and 55.47, respectively. The analysis result of the N-Gain test towards the pretest and posttest results regarding the three-tier diagnostic test items indicated achievement of student's conceptual understanding using a deductive approach which was 14.2225% higher than the use of the inductive approach. The Triangulation Analysis stated that the deductive approach was more effective in improving students' conceptual understanding of Chemistry and material topics as well as material classification. While the inductive approach was more effectively applied to the topic of Particle Kinetic theory.

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Keywords: deductive; inductive; conceptual understanding

INTRODUCTION

The rapid flow of globalization and technological advancement requires a person to keep innovating and become a professional in his field. This makes the competition tighter, not only among the domestic community but globally, especially since the enactment of the ASEAN Economic Community (AEC) in 2015 (Abdurofiq, 2014) for Asian countries. To afford people who have high competitiveness, it requires education with international quality and standard. Based on the data of Programme of International Student Assessment (PISA) which was initiated by the Organization for Economic Co-operation and Development (OECD) By 2015, out of a total of 540,000 15-year-old students from 72 countries who took the test in science, it was found that the difference in the average score of countries with the lowest rank was 224 points (Gurria, 2016).

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This shows a huge gap in the achievement of the mastery of science materials. With the belief that all children have the same competence, this data shows that the material taught in some countries has not been able to match an internationally standardized curriculum.

Implementation of an education system that refers to the international curriculum needs to be supported by the participation of various parties, especially educators. Teachers play an important role in guiding and developing student competence so that the objectives of the curriculum can be achieved. One of the goals of the international curriculum is to provide a fun and useful learning for the student learning experience (IGCSE, 2016). One of the teacher's efforts in realizing the goal is through the selection of the model or the appropriate learning approach to be applied in the learning activities.

In the field of science, especially chemistry, learning without proper understanding makes chemistry seem difficult for the students. Chemistry material is difficult to be understood and learned, especially when students are in a position to believe in something without seeing (Stojanovska et al., 2014). In the initial material in the International standard chemistry curriculum, the material property particulate, subjects such as atoms, molecules, particle kinetic motions, or diffusion events are matter that cannot be observed directly. Given that this material is important and as a basis for being able to understand the material at the next level, then the role of teachers is very important in helping students have a correct, strong, and full understanding of the concept.

Broadly speaking, the educational approach model is divided into two, namely inductive and deductive (Nisbet, 2009). The inductive approach leads to student-centered while the deductive approach leads to teacher-centered (Rahmah, 2017). The learning process is often delivered in the classroom using a deductive approach. The deductive approach is explaining the principle of the lesson content, then described in terms of its application or examples in certain situations (Doppelt et al., 2008). The deductive approach helps students to directly apply the theories or formulas that have been obtained in solving a problem, but this approach limits the students in developing their understanding. Failure to link material content to things in everyday life contributes to a decrease of student interest in science (Silverstein & Osei, 2010; Heit & Rotello, 2010). The deductive approach is done by giving the material at the beginning followed by explanations and examples, while the inductive approach requires students to be able to use logic, understand concept maps, and infer (Liu, 2016). Therefore, the characteristics of a deductive approach to learn can also begin with the provision of cases, facts, or examples that reflect a concept or principle, then students are guided to develop themes and produce theories through the interconnection of existing themes (Creswell & Clark, 2011). In other words, inductive learning patterns are also likely to increase students' concept of understanding. Inductive teaching methods include discovery learning, inquiry-based learning, problem-based learning, project-based learning, case-based teaching, and just-in-time teaching (Smart et al., 2012; Fisher, 2018).

The problem in this study is which approach between inductive and deductive that is more effective in increasing the conceptual understanding of X graders in Chia-Chi Senior High School based on the international standard curriculum. This study aimed to find out which learning approach between inductive and deductive that is more effective in improving students' conceptual understanding of material property particulate subject matter.

METHODS

This study was conducted at the National Tainan Chia-Chi Senior High School in the first semester of the 2016/2017 academic year in October until November 2016. The population in this study was the students of National Tainan Chia-Chi Senior High School in class 101, 102, 103, 104, and 105 with a total of 192 students. Based on the field condition, the population studied using Chinese as the everyday language while this learning material was delivered by the researchers using the English language, therefore, the sample was taken by using purposive sampling technique with the consideration that the sample students should have a good average English proficiency. The samples of this study were class 101 (K1) and class 102 (K2). The dependent variable in this study was the students' conceptual of understanding. The independent variable is the type of learning approach used in the class. Control variables included lesson plans, media, time allotment, and teachers. The subject matter of this study was material property particulate. This material was the first material in the syllabus of the Cambridge International General Certificate of Secondary Education (IGCSE) in 2016, of which the Cambridge IGCSE is an international curriculum developed by the international education program institution, the Cambridge International Examination (CIE) for students aged 14-16.

This study used a descriptive-comparative research method. The comparative study was conducted to find out the comparison of conceptual understanding improvement of the students who got lessons using the deductive and inductive approaches. The design pattern of the study is shown in Table 1. This comparative study is divided into 5 stages, namely: determination of research problem; determination of groups that have characteristics to be studied; selection of comparison groups; data collection using instruments after conducting the research; data analysis.

This study hypothesized that there was a difference in the students' improvement of conceptual understanding between the use of inductive and deductive approache based on the international standard curriculum on the X graders of National Tainan Chia-Chi Senior High School. To test the hypothesis, the data collection method used in the form of a test method, supported by documentation method, questionnaire method, and observation method. The research instruments used were in the form of a checklist of student data, a three-tier diagnostic test, student questionnaire and observation sheet of learning. All instruments validated by lecturers and diagnostic tests had met the validity and reliability requirements since all questions were taken from published books.

The data obtained based on the questionnaire instrument was used to find out which type of approach was preferred by the students as well as following the characteristics and abilities of the students. Each of the statements led the student to one of the approaches to the student's chosen scale. The observation sheet instrument was used to find out which approach pattern was more effective in improving student learning activity. There were three observers, namely Chia-Chi school chemistry teacher, an assistant of Education and Psychology postgraduate program, and a student of Physical Education undergraduate program. The data obtained using test instruments given as pretest and posttest were analyzed quantitatively to determine whether there was a difference in the concept understanding improvement of the class treated with the inductive approach to the class treated with the deductive approach, as well as the magnitude of the increase achieved by each approach. The statistical tests included normality test, homogeneity, paired-samples T-test, N-gain test, and hypothesis test. Furthermore, all

research data obtained through the use of student questionnaires, observation sheets, and diagnostic tests were analyzed using triangulation techniques to draw research conclusions.

Table 1. Research Design Patterns

Sample	Initial	Treatment	Final
K1	Pretest	Deductive approach	Posttest
K2	Pretest	Inductive approach	Posttest

RESULTS AND DISCUSSION

Learning Process with Inductive and Deductive Approach

In both sample classes, class 101 got lessons using a deductive approach, while in class 102 used an inductive approach. The delivery of materials was aided by the use of PowerPoint media and accompanied by two Chia-Chi teachers, they were the chemistry teacher, an English teacher, and two assistants. The material presented was the material property particulate which is the initial material in the international curriculum. In this study, the main material was divided into 3 sub-materials, namely Chemistry and Material, Kinetic Theory, and Material Classification. Delivery of the material using a deductive and inductive approach adapted to the Cambridge IGCSE syllabus which detail is shown in Table 2.

Before material was delivered by the researcher, research activities were started with a pretest to determine the students' level of conceptual understanding before being treated. The delivery of the material was done three times face to face, each meeting for 50 minutes. After the three sub-materials delivered, posttest activities were done for both classes to find out the improvement of students' conceptual understanding after being given different treatment for each class.

Descriptive Analysis of Using Inductive and Deductive Approach

To test the effectiveness of inductive and deductive used in learning approaches to students' conceptual understanding and student learning activities, descriptive analysis was conducted based on students' questionnaires and observation sheets by observers.

Table 2. Learning Activities in Deductive and Inductive Classes

Sub-Material	Competence	Deductive (K1)	Inductive (K2)
Chemistry and Materials	Describing changes in form in melting, boiling, evaporating, freezing, condensation, and sublimation events.	Explanation on definition of chemistry, materials, the four aspects of the material (composition, structure, properties, and changes), examples for each aspect, as well as the game of the nature of the chemical / physical and chemical / physical changes.	Giving three pictures, namely the picture of water, salt, and oxygen gas cylinders. Students are given the opportunity to define the material as well as mention the material aspect based on the existing characteristics.
Particle Kinetic Theory	Describing the structure of solids, liquids, and gases in terms of particle, arrangement, and type of motion. Explaining the diffusion event. Describing the pressure and temperature of the gas associated with the particle motion.	Explanation on definition of kinetic theory, influencing factor, its relation with phase of substance (solid, liquid, and gas), and naphthalene heating graph.	Giving picture of diffusion event of solid, liquid, gas. Students connect with kinetic theory and its factors. Students interpret the graph of water heating.
Material Classification	Showing an understanding of the material types.	Description of the material classification chart, as well as examples for each classification (Pure substance: element, compound, mixture).	Giving a question about the difference between $CaCO_3$ and Ca as well as a mixture of Fe and S image with and without heating. Students classify these substances into the right class.

Student Questionnaire

Student's questionnaires were used to determine which type of approach was preferred by students as well as which one was more appropriate to the characteristics and ability of students to absorb and understand a subject matter. Giving students a questionnaire was done after the whole series of learning activities completed or after the posttest implemented. The results of the students' questionnaires are shown in Table 3. A total of 58 out of 68 students prefer to know the subject theory at the beginning of the lesson before being given further explanations and examples or in other words the students choose a deductive approach as a more desirable approach. Another result shows that 12 out of 68 students had difficulty in linking one example to another. The characteristics of such students indicated that students were less suitable if they were given an inductive approach model that required them to be able to link each given concept and example, to understand the concept pattern, and to draw a conclusion.

Table 3. Student Questionnaire

Treatment	The Number of Students
Students are better in understanding chemistry if they are given concrete examples at the beginning of the lesson.	44/68
Students prefer to know the theory of a material at the beginning of the lesson before being given explanations and further examples.	56/68
Students have difficulty in drawing conclusions from a subject matter.	20/68
Students prefer subjects that use logic rather than memorization.	34/68
Students prefer to know the summary of the material at the beginning of the lesson than at the end of the lesson.	47/68
Students have difficulties in linking one example to another.	12/68

Observation Sheet by Observer

The observation sheets of student activity during classroom learning were filled by observers based on what was seen and felt during the learning process. Commonly observed aspects included student activeness in the classroom, student's attention to the material presented by the teacher, and activities done by the students in the classroom. The result of the scale calculation on the two approach models given by the observer on the observation sheet is presented in Figure 1.

The results showed that students who were given learning with a deductive approach were more active than students who were given an inductive approach. Student activity in deductive class which was more prominent than inductive class was that students were more active in confirming questions given by teacher and students pay more attention to explanation given by the teacher, which meant that students focus ed and trued to understand what was delivered by the teacher (Stephens et al., 2020). The students activity in both classes in terms of asking questions was still less because students seemed embarrassed in conveying questions in English.
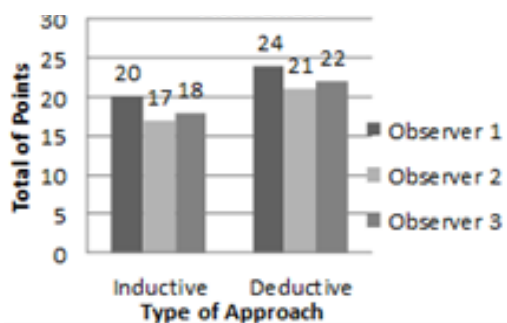

Figure 1. Results of Observation towards Inductive and Deductive Classes

Result of Quantitative Analysis on Inductive and Deductive Approach

Quantitative analysis was used to determine the use of a more effective learning approach in improving students' conceptual understanding of the material property particulate based on the international curriculum, in which the data obtained from the results of the three-tier diagnostic test. The test items of the three-tier diagnostic test consisted of a closed-ended answer, multiple-choice, open-ended reason, and a confidence level of students in answering questions, as shown in Figure 2.

Figure 2. Test Item Example of Three-Tier Diagnostic Test

The effectiveness of the approach is based on the results of the pretest and posttest. Thirteen questions were tested and analyzed to determine the effectiveness of this approach. The questions were divided into three sub-concepts: chemistry and materials; kinetic energy; classification of materials. In the first sub-material there were four concepts of the nature and type of change in the form of matter, both chemically and physically. The second sub-material contained the concept of energy involved in the process of changing the form of matter. The last sub-material contained the concept of material classification based on its constituent components. Analysis of the test results of these concepts can be seen in Table 4.

Table 4. Achievement Results of Posttest - Pretest Scores for Each Sub-Material

Sub-Material	Concept	Achievement-pretest posttest Value (%)	
		Inductive	Deductive
Chemistry and Materials	Physical properties	**32.35**	19.45
	Phase of substance	2.94	**8.33**
	Chemical changes	11.78	**22.22**
	Physical changes	0.00	**2.78**

Kinetic energy	Diffusion	2.95	**5.55**
	Temperature factor and particle size	**26.48**	25.00
	The solid molecular kinetic becomes liquid	**14.70**	5.56
	Naphthalene cooling curve	2.94	**19.44**
	Particle distribution	**26.47**	-5.55
	Expansion event	**8.83**	8.33
	Microscopic dissolution events	14.70	**44.44**
Material Classification	Compound and elemental molecules	0.00	**13.88**
	Particle	-5.88	**22.22**

Statistical analysis in this study was divided into three stages, namely the sampling phase of the data test, the initial phase of the data test (pretest), and the final phase of the data test (posttest). At these three stages, a normality test was performed using the Shapiro-Wilk test. In the pre-sampling stage normality test of students' scores on the mid-semester of 2016/2017 academic year, it was found that both classes of samples belong to normal, i.e. for class K1 and K2 respectively at 0.527 and 0.180, so the sample class could be used to represent the population since the significance value was more than 0.05. The normality rates for the initial stages in the K1 and K2 classes were 0.150 and 0.066. While in the final stages, the normality rates of the K1 and K2 classes were 0.057 and 0.081. Since the significance value of all classes at each stage was greater than 0.05, then the class was normally distributed. Based on these circumstances, the research was analyzed using a parametric test.

In the initial and final stages, a homogeneity test was done to find out the variance of the two sample classes at each stage. The analysis showed that the two classes had different population variance. For the initial stage of the paired-samples t-test, the mean showed the two classes had the same initial concept understanding ability. In the final stage of hypothesis testing using t-Test: Two-Sample Assuming Unequal Variances showed that there was a difference between the students' conceptual understanding improvement by using the inductive and deductive approach in X grader of National Tainan Chia-Chi Senior High School.

In the initial and final stages, the researchers conducted the mean comparison analysis as well as the average score of the n-Gain test to determine changes in the score increase between the pretest and posttest results. In the deductive class, the average score increase was greater than the inductive class, which was 13.4615 for the deductive class and 7.2263 for the inductive class. Data analysis using the n-Gain test showed deductive class was 14.2225% higher than inductive class. Both n-gain results were included in the high category.

N-Gain test results showed that both approaches could improve students' cognitive domains (based on the results of the pretest and posttest), but the deductive approach gave a better effect than the inductive approach. The descriptive analysis included the results of the student questionnaire and observation sheet done by the observer, while quantitative analysis was obtained from the test results about the three-tier diagnostic test. The results of descriptive and quantitative analyses were then analyzed by using the triangulation analysis technique.

Based on the questionnaire results, it was found that most students preferred to use the deductive approach model, and based on their character, the students were more suitable to use the deductive approach. Students preferred to use a learning scheme where principles or theories were given earlier in the lesson then clarified by giving examples or problems. The underlying reason for this statement was that students already have a picture or concept in their minds about the material presented by the teacher. Therefore students will accept, conceive, and understand the given examples and problems since they have principles that are built by the teacher at the beginning of the lesson (Lee & Park, 2013). Meanwhile, in terms of character, most students had difficulty in interconnecting things. They had difficulty in concluding the concepts they studied. Therefore, the inductive approach was less suitable for students who were still experiencing difficulties in developing their frame of mind. Students tend to reject all of the instruction forms that make them have their responsibility for their learning (Sudria et al., 2018). Naturally, Students tend to love the learning process which is guided by their teacher that tends to use the deductive approach model. The application of inductive process in the class-

room which is not supported by the guidance of teacher can lead students to become resistant in improving their interest of learning, making the learning outcomes low, making incomprehension to the concept of material, and making mastery of the material low (Lee & Lin, 2019).

Based on the observation sheet, observers found that students who were given a deductive approach tended to be more active than students who were given an inductive approach. One of the factors was that it triggerred the students to have the ability to capture the given material. The general-specific (deductive) approach pattern have indirectly provided students the main topic that will be discussed in the main process of teaching-learning. Students who have been equipped with theories and basic principles will have a better understanding of the material goals so students will be easier to follow the lessons well and actively involved in conveying the material that has been acquired during the process Learning. Active learning will lead to a longer-lasting understanding of concepts (Odabaşi & Kolburan, 2013).

The next analysis was a quantitative analysis that was based on a three-tier diagnostic test. According to IGCSE (2016), there are three aspects of assessment. First, knowledge with understanding; second, processing information and problem-solving; third, experimental and investigative skills. From thirteen questions of the three-tier diagnostic test, those questions already coverred these three aspects. Therefore, both the material and the diagnostic tests already fulfilled the standard of the international curriculum. The subject matter of this research was material property particulate.

The first sub-material were Chemistry and Material. Based on Table 4, the appropriate approach which is suitable to improve students' understanding of the concept in this sub-material is a deductive approach model. Mostly, students do not have the right understanding of the concept of physical and chemical changes. Therefore, to make students have the right understanding, the effective learning should begin with the explanation of chemistry and its definition, and the material should be viewed from Chemistry point of view (Order, structure, nature, and change). Then the teacher should reinforce students' understanding by providing examples and its application in everyday life. The use of an inductive approach to this material has not been able to incorporate students' minds which is still abstract to the material they learn (Suprapto et al., 2018).

In the second sub-material, the inductive approach was more effective in helping students to understand the concepts of Kinetic Theory. In this material, students did not understand what happens to the compound molecules when there was a change in temperature or when the compound changes form. Therefore, the explanation of theory and principle is not enough to help students understand to relate the theories into real problems, especially in the sub-microscopic aspect. Students can achieve a level of analytical understanding through problem-based learning which cannot be achieved by the conventional learning process (Schmidr et al., 2011; Ajai et al., 2013). Thus, the application of the inductive approach method by giving examples and concrete problems at the beginning will help students to understand an action-reaction pattern on factors that affect the kinetic motion of particles. As a result, students can construct their theories based on the observations and analysis they have done. Therefore, the understanding concept can be achieved effectively by students.

In the third material classification, deductive approach was effective to improve students' understanding. The student found difficulties to distinguish between compounds and mixtures, substances or material on sub-microscopic aspects. By introducing students to a group or classification of material, students found easier to understand examples of elements, compounds, or mixtures. Besides, students were more active follow the teaching and learning process in the classroom, because students have already understood in classifying material.

Learning activities were made in such a way so every approach had its special character. For a class that used a deductive approach, the learning process began with providing definitions and followed by examples related to theories. Meanwhile, for the inductive approach, the learning process began with presenting data or observation, specific problems, or complex cases that found in everyday life, then they would do interpretation, observation, and analysis. Students needed facts, rules, ways, and principles to find the answer to their problems. Based on the analysis of the results of these three instruments, it was found that there was a difference between the use of deductive and inductive approaches to improve students' understanding.

Generally, the learning processes in the classroom use a deductive approach, wherein the learning process, teachers play an important role in the learning activities. Based on average

scores of before and after treatment, it was found that the deductive approach was more effective to improve students' understanding compared with the inductive approach (Ndemo et al., 2017). On the one hand, based on triangulation analysis, not all sub-materials delivered deductively. The deductive approach was appropriate to be applied in the first and third sub-materials, Chemistry and Material and Material Classification. While the inductive approach was appropriate to be applied in the second material, the Kinetic Theory. The results of previous research found that the learning process using both inductive and deductive approach did not show any significantly different results in the short answers and multiple-choice questions (Ihedioha & Osu, 2012; Lee & Park, 2013). However, in this study, it does not happen. Each approach has advantages and disadvantages that can affect the understanding of students depend on the material.

To minimize the weaknesses of each approach, the main factor that should be considered in the deductive and inductive approach is material (Atta et al., 2015). Therefore, the material property particulate should be given in the first graders of Senior High School because there are only a few students who understand the material. The learning instruction begins with content and experience that is familiar by students so students can make a connection with their existing knowledge (Biggs, 1996; Glaser, 2016). In other words, an inductive approach is appropriate to be applied for students who already have basic knowledge of the material to be delivered (Jebreen, 2012). Seeing the reality on the field, an inductive approach is difficult to be applied for new students of Senior High School. However, the sub-material also affects the effectiveness of the application of inductive or deductive approaches. If the problem is based on experience and observation then the inductive approach will be used, meanwhile, if the material is based on certain laws, rules, and principles, the deductive approach is more effective to be applied apply (Trochim, 2006; Ihedioha & Osu, 2012). Based on the material study of international curriculum-standard, the appropriate topic in implementing deductive approach is subjects that contains the points or charts that known by students w first, such as Chemistry and Material and Material Classification. While the inductive approach is more suitable for the subject relates to the concrete problem or material, especially microscopic aspects, such as Kinetic Theory. By paying attention to these factors, the model can be precisely targeted approach, so that the content of the material as the goal of teaching can be absorbed and understood maximally by students.

In the international standard curriculum, the understanding of the material is important to be owned by the students to make students understand other subjects at advanced levels, active and able to think deeply, and train students to not memorize the material. The result of the learning process which is done by memorizing without understanding will make less understanding of the material. Therefore, it can lead to misunderstandings in developing basic concepts to solve various t problems (Stojanovska, 2012; Marsita et al., 2010). Therefore, the teacher's role in determining the appropriate learning models can help students not only acquire knowledge as a whole, but the students have a conceptual understanding of knowledge, capable to implement scientific thinking to overcome everyday life problems and improve the quality to become a potential student and capable to compete with other.

CONCLUSION

Based on the triangulation analysis, it was found that both approaches can improve students' conceptual understanding of the subject of material property particulate based on an international curriculum that relies on sub-topic material presented. The inductive approach is effectively used in observational and experimental issues, such as the sub-material Kinetic Theory, while the deductive approach is effectively applied to the material by applicable law or principle, such as the sub-materials Chemistry and Materials and Material Classification.

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