The use of information technology to improve student’s deep understanding of matter and energy

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Abstract. Advances in information technology make it easy to get a lot of information from the internet. Therefore, teachers must facilitate learning that encourages students to increase their deep understanding with the use of information technology. Through the implementation of the PDCA model, which consists of Plan, Do, Check, and Act, students gradually search for information on the topic of material change. The topic which consists of three sub-topics, namely: (1) the composition; (2) the electricity; and (3) the magnetism. The subjects in this study were 20 students from the superior class of S1 Science Education. The implementation of the PDCA model is designed as follows, (1) the planning stage, students are given the task of finding information by internet about the topics that become their assignments. Students read and understand it; (2) the doing stage, students are asked to describe what is read, and formulate questions from the information read; (3) the checking stage, students re-examine the questions formulated; and (4) the action stage, students look for information to answer the questions in the previous stage. The study was conducted in two cycles. The results were obtained that there was an increase in students’ deep understanding of all sub-topics.

1. Introduction

To be able to enter a superior class, students must go through a selection process. Aspects selected include: achievement index, Test of English Proficiency (TEP) scores, superior class selection test scores, and interview scores. With this selection process, excellent students have greater potential compared to regular classes. For this potential to increase, learning must be designed by increasing in-depth understanding, by getting used to asking 5W1H questions and answering them. The higher the level of questions that are formulated, the greater the student’s effort to answer the question, so the deeper the student’s understanding, or a deeper understanding will be formed. In this study the habit of asking questions is designed by implementing the PDCA model (plan, do, check, and act). The formulation of the problem in this study is: "how to improve students' deep understanding with the implementation of the PDCA model?"

In the PDCA model, there are four stages, namely: plan-do-check-act cycle (Figure 1). The cycle has no end, so the PDCA should be repeated and repeated for continuous improvement. These stages are illustrated in Figure 1, below:
In this learning that is improved is a deep understanding of students. To increase deep understanding, we must pay attention to the potential students have. The potential is the ability and strength possessed by someone, both physical and mental, which allows it to be developed if it is supported by adequate training and facilities [2]. The potential can be called the hidden power or ability possessed by someone who can be optimized [3]. Through deep learning, students are intrinsically interested and try to understand what they are learning. An in-depth approach to learning has been described as a way for students to understand content in full by linking and compiling ideas, and searching for the underlying principles [4], [5]. Definition of deep learning is examining new facts and ideas critically, and tying them into existing cognitive structures and making numerous links between ideas [6], [7], [8], [9].

To optimize students' in-depth understanding in superior classes, a PDCA (plan-do-check-act) learning model is applied. Through PDCA, students are trained: read and understand readings; formulating questions, checking questions; and describe the answers to the questions formulated earlier. Characteristics of the teaching method, how students perceive the teaching context, and student factors play a role. Many of these factors are intertwined and how they relate to each other and differ across different student centered learning environments. [10], [5].

To have a deep understanding means being able to put together pieces of information and use them to understand something (for example solving problems, writing new ideas, and so on). Table 1 below shows you a few things you can do if you have a deep understanding. Compare with understanding the "surface" of a topic.

### Table 1 Description of some actions associated with deep understanding

[https://www.polyu.edu.hk/obe/students/files/deep.pdf](https://www.polyu.edu.hk/obe/students/files/deep.pdf)

| Action        | Description                                                                 |
|---------------|-----------------------------------------------------------------------------|
| Factual recall| Listing a pieces of information in unrelated manner. This is not deep understanding! |
| Contrast      | Show the important difference between things.                               |
| Compare       | Show how things are alike or not alike                                       |
| Explain       | Give the meaning of a topic clearly.                                         |
| Relate        | Show that the ideas are connected to each other.                            |
| Analyze       | Examine in detail the elements of a topic and how they relate to each other. |
| Apply         | Make use of specific knowledge or concepts to solve a problem.              |
| Reflect       | Show new understanding of something by studying past experience.            |
| Generalize    | Draw a general conclusion from a number of facts.                           |
| Recommend     | Suggest what is a appropriate to do base on a critical evaluation of available information. |
| Hypothesize   | Propose an idea which can be used as a starting point for further study.     |
2. Method
This study uses a class action research design (action research classroom), by implementing the PDCA model (plan, do, check, and act), in the Matter and Energy course. As the subject in this study were students of Science Education, class of 2017 U a number of 20 students. Indicators of competency achievement in this course include: students can (1) explain about the composition of substances, electrical substances, and magnetism of substances; (2) identify changes in physics and chemical changes around them; (3) explain chemical changes or physical changes that can affect the composition of a substance, electricity, or magnetism of a substance; (4) describe the advantages and disadvantages of changing the composition of a substance, electrical substances, or magnetism of substances; (5) describe the relationship between matter and energy. To achieve this indicator, PDCA learning is carried out as follows,

1. Plan Phase
At this stage, students are divided into study groups consisting of 3-4 students/groups. The whole group was given the task of reading in accordance with the topics specified, including: composition, magnetism, and electricity.

2. Stage Do
From reading assignments, students are asked to describe what is read by formulating the question. The questions formulated are categorized as HOT (analyze, evaluate, or create).

3. Check Stage
At this stage, students re-check the questions that have been formulated. Each group of students can measure whether the questions they have produced are able to provide the widest possible information to other groups when entering the action stage. If not, the group is allowed to rearrange questions related to the topic of their assignment.

4. Act Stage
At this stage, students look for information to answer the questions they have formulated at the "do" and "check" stages, by developing presentation material related to the topic for which they are assigned. Here is one example of the presentation material made by the "composition" group in the first cycle.

Data collection techniques by observing worksheets and evaluating during presentations. Measurement of student understanding is seen from the ability to make questions and describe answers.

Data were analyzed by categorizing the ability to form questions and describe, as surface, superficial, or deep understanding.

3. Results and Discussion
In this study, the first activity observed was the ability to formulate questions. The level of understanding is determined from the description made for each question that is formulated. The results of implementing the PDCA model to increase understanding, in two cycles can be shown in Table 1 below:

| Sub Topic               | Formulate the questions                                                                 | Level of understanding                                                                 |
|-------------------------|----------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------|
| The composition         | What is the composition of substances?                                                  | In the first question, the level of understanding is only on the surface, because students only define. but for the next three questions, students must understand the factors that can make the composition of a substance change, and explain the indicators of a change. |
|                         | What makes the composition of substances change?                                         |                                                                                       |
|                         | Why substances can change into a composition?                                            |                                                                                       |
|                         | What are the indicators of a substance undergoing a change in composition?               |                                                                                       |
In cycle 1, some questions are more defined, so students only remember. Remembering is categorized into surface understanding. Surface understanding largely answers questions about what, when, where and who, especially explicit, and requires little understanding or action [11].

Surface knowledge in the form of information can be stored in books and computers, and the mind/brain. Most of our daily lives such as conversation, description, and even self-reflection can be considered as surface thinking and learning that create surface knowledge. Much of what is taught in schools is focused on awareness and memorization (surface knowledge) with an inadequate focus on understanding or meaning [11].

In order for students to develop presentation material that can provide broader information to their peers, the next question must have a higher category, for example: "why, or how". On the composition sub topic, students can describe things that can make the composition of substances change. Substances can change into a composition because there are chemical changes. Chemical change is a substance change can produce new substance by chemical characteristics with different original substances. it can change in the form of combining a number of substances or decomposition of a substance. Chemical changes can be identified with the following characteristics: the formation of gas; formation of sediment; color changes; and temperature changes. For this explanation is categorized as shallow understanding

On the magnetism sub topic, the student explain how to eliminate the magnetic properties by dropped or slammed, heating on the magnet, and alternating electric current (AC). On the electricity sub topic, the student explain how the current flows from the battery in a circuit gives energy to the electrons and pushes them around a circuit, from the negative terminal of the cell, round the circuit and back to the positive terminal of the cell. The last two explanations are categorized as shallow understanding.

Shallow knowledge is when you have information plus some understanding, meaning and sense-making. To understand is to make some level of meaning, with meaning typically relating to an
individual or organization and implying some level of action. To make meaning requires context [11]. Characteristic of deep learning is relating new and previous knowledge [6], [7], [8], [9].

Table 2 Level of understanding in cycle 2.

| Sub Topic | Formulate the questions | Level of understanding |
|-----------|-------------------------|-----------------------|
| The composition | How can substances change in composition? Give three examples in your life for changes in the composition of substances! What is advantage and disadvantage from changes in substances composition? | Shallow understanding, because students can explain how substances can change in composition and give examples of changes in the composition of substances in everyday life. In the last question, students' understanding is deep because it can illustrate the advantages and disadvantages of changing the composition of substances. |
| The magnetism | Magnetic behavior is classified as paramagnetism, diamagnetism, and ferromagnetism. What distinguishes one from another? We know that magnets can conduct electricity, for example on bicycle dynamo. How can this be explained? | Deep understanding, because students explain differences in paramagnetism, diamagnetism, and ferromagnetism by being connected to the presence of free electrons in a metal. The description of the second question is also deep understanding. Students can explain the process of formation of electricity by magnets on a bicycle dynamo, a phenomenon called electro-magnetic induction. |
| The electricity | We know the terms conductor, semiconductor, and insulator. What is the difference between one and another? Can we convert conductors or semiconductors into insulators? How do you change it? | Deep understanding, because students explain differences from conductor, semiconductor, and insulator using the term conduction band, valence band, forbidden energy gap. |

In cycle 2, the question already requires students to give a deeper explanation. For example, students can explain how substances can change in composition because there are chemical changes. Chemical composition refers to the arrangement, type, and ratio of atoms in molecules of chemical substances. The chemical composition of a substance determines the properties of the substance. The students can give examples of changes in the composition of substances in everyday life, such as: the process of photosynthesis, fermentation, urea fertilizer, corrosion of iron, and combustion wood processing.

In magnetism, students explain the differences from paramagnetism, diamagnetism, and ferromagnetism by connecting to the presence of paired/unpaired electrons in metals. Paramagnetism refers to the magnetic state of an atom with one or more unpaired electron, for example: Aluminium (Al). The electron configuration for Al 1s²2s²2p⁶3s²3p¹. Diamagnetic is matter that is unaffected by the magnet. Diamagnetic has no unpaired electrons, for example Zinc (Zn). The electron configuration for Zn 4s²3d¹⁰. Changes in electron configurations will cause changes in the magnetism of the substances.

In electricity, students explain differences from conductor, semiconductor, and insulator using the term conduction band, valence band, forbidden energy gap. Conduction band is defined as the
outermost shells of the atom carry the electron free to move and thereby can carry electric current. Valance band is defined as the inner shells of the atoms in which the electrons are tightly bound to each other and cannot move freely. They need additional energy to move freely. The energy gap present between conduction band and valence band, is called forbidden energy gap.

In cycle 2, questions and answer descriptions show students' deep understanding. In-depth knowledge of students must develop understanding and meaning, integrate it, and be able to change the frame of reference as context. Developing in-depth knowledge is not an easy task. Gather relevant information and combine into several parts to build various patterns that must be taken when facing a new situation. In-depth knowledge usually provides the best solution for a problem. When someone has deep knowledge, the more learning they will build in the subconscious. In other words, in the area of focus, knowledge breeds knowledge. The more that is understood, the more that can be made and understood [11]

Personal development process that involves changes in perception and learning habits are complex [12], [13]. Learning is seen as a construction of knowledge and insight, taking knowledge, and gaining knowledge. For example, new knowledge must be accepted to solve specific questions, therefore, the practice of connecting between new knowledge and learners (building knowledge and insights) is necessary to increase this new sense of knowledge in the mind (taking knowledge through memorization and reproduction) [14], [15].

4. Conclusion

From the results of the study it can be concluded that to improve students' deep understanding, learning must facilitate students learning how to learn (learning to learn something), so students can develop ideas or creative ideas related to things that are learned. Through the habit of asking questions, students will try to find answers to these questions. The higher the level of difficulty of the questions that can be formulated, the greater the student's effort to answer the question, and the broader and in the student's understanding.

In accordance with the results of the implementation, suggestions that can be written here are the stages in the PDCA model implemented for individual assignments, so that each student can know their initial understanding and improvement. With students recognizing/knowing how much their understanding is, students will be motivated to develop it when learning facilitates them.

5. References

[1] Moen R 2010 *Foundation and History of the PDSA Cycle* Ronald Moen Associates in Process Improvement Accessed on: March. 1, 2020. [Online]. Available: deming.org>paper>PDSA.

[2] Habsari S 2005 *Bimbingan Konseling SMA Kelas XI* (Jakarta: Grasindo)

[3] Prihadhi E K 2004 *My Potensi* (Jakarta: Elek Media Komputindo)

[4] Trigwell K, Prosser M, & Ginns P 2005 Phenomenographic pedagogy and a revised approaches to teaching inventory *High. Educ. Res. and Dev.* 24 349–360

[5] Dolmans D H J M, Loyens S M M, Marcq H, & Gijbels D 2016 Deep and surface learning in problem-based learning: a review of the literature *Adv. in Health Sci. Educ.* 21 1087–1112

[6] Houghton W 2004 *Engineering Subject Centre Guide: Learning and Teaching Theory for Engineering Academics* (Loughborough: HEA Engineering Subject Centre)

[7] Biggs J 1999 *Teaching for Quality Learning at University* (SHRE and Open University Press)

[8] Entwistle N 1988 *Styles of Learning and Teaching* (David Fulton)

[9] Ramsden P 1992 *Learning to Teach in Higher Education* (Routledge)

[10] Baeten M, Kyndt E, Struyven K, & Dochy F 2010 Using student-centered learning environments to stimulate deep approaches to learning: Factors encouraging and discouraging their effectiveness *Educ. Res. Rev.* 5 243–260.
[11] Bennet D H 2008 *The depth of knowledge: Surface, shallow or deep?*. Accessed on: March. 18, 2020. [Online]. Available: https://www.researchgate.net/publication/235250697.

[12] Wingate U 2007 A framework for transition: Supporting “learning to learn” in higher education. *High. Educ. Q.* 61(3) 391-405

[13] Donnison S & Edwards S P 2012 Focusing on first year assessment: Surface or deep approaches to learning? *The Inter. J. First Year High. Educ.* 3(2) 9-20

[14] Vermunt J D & Vermetten Y J 2004 Patterns is student learning: Relationships between learning strategies, conception of learning, and learning orientations *Educ. Psychol. Rev.* 16 359-384.

[15] Lin M H, Huang M H, & Hsiung W C 2014 *The Learning Feature of Deep Knowledge and Its Relationship With Exercise*. Accessed on: May. 1, 2020. [Online]. Available: journals.sagepub.com.