Student’s Representations Preference In Learning Physics

By Abdurrahman

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STUDENTS' REPRESENTATIONS PREFERENCE IN LEARNING PHYSICS AND "THEMATIC PRE-CONCEPTIONS" IN QUANTUM PHYSICS CONCEPT

Abdurrahman[1], Liliasari[2], A. Rusli[3], Bruce Waldrip[4]

[1)]Lampung University, [2)] Indonesia University of Education, [3)]Bandung Institute of Technology, [4)] Monash University

Abstract

Quantum physics concepts require an adequate use of multi-modal representations and a deep conceptual understanding of the underlying abstract concept. However, requiring students to construct and use representations can assist developing understanding of quantum physics. Requiring students to argue and present evidence about the robustness of their representations can lead to a deeper understanding quantum physics concept. Investigation into students' ideas about some concepts in quantum physics can assist teachers or lecturers to design instructio16 more precisely. This study is an initial qualitative step into a mix-method research of the role of multiple representations in learning about quantum physics concepts. By using *Focus Group Discussion* (FGD) before learning and teaching quantum physics concept, we have investigated pre-service physics students' representations preference in learning physics and "thematic pre-conception" in quantum physics. The result showed that (1) students' representation (SR) is strongly dependent on teachers/lecturers' representation (TR) (2) Students were more likely to use existing represe15tion from a domain resource than to generate their own representation (3) Most of students were more likely to use mathematical representation in learning and physics problem solving (4) students' preconception in quantum physics was strongly influenced of classical physics conceptions (5) students' misconceptions in quantum physics concept have been identified.

Keywords : Representations preference, thematic preconception, quantum physics concept

Introduction

Many physics educators state that physics is not considered very attractive and interesting as an alternative to study for many students, even though the technology using in everyday life are consequences from many research in physics, especially quantum physics concepts (Zollman, Robello, and Hogg, 2002). Actually, quantum physics could be a very attractive field but students perceive quantum physics as very abstract and conceptually difficult. Therefore they generally have a weak level of the understanding of quantum physics.

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Quantum physics concepts can be built on a classical base theory, using many classical concepts and so 6an be rich in representations. If students' understanding is weak in these areas, the learning of quantum physics may still be difficult (Bao and Redish, 2002). Almost traditional teaching ignores the richness of representational of quantum physics. Student ability to build different kinds of physics representations for quantum physics can help them to understand and use physics concepts key.

Therefore, quantum physics lectures based on multimodality or multiple representations is an alternative way to enhance students understanding of quantum physics concepts.

Multimodality refers to the integration in science discourse of different modes to represent scientific reasoning and findings (Waldrip, Prain, & Carolan, 2006). The same concept is re-represented through different forms or "multiple representations" in verbal, numerical, visual, or action modes. A focus on multimodal thinking and representation encourages students to coordinate their different representations of scientific knowledge. Ainsworth (1999) posited that learner engagement with representations could support learning in three ways. These are (a) when the new representation complements past understanding by confirming past knowledge, (b) the new representation constrains interpretation by limiting the learner focus on key conceptual features, (c) the different representations enable learners to identify an underlying concept or abstraction across modes or within the same mode of representation.

Much previous research has shown that the use of multiple forms of representation in teaching concepts in science has great potential benefits, and yet poses significant challenges to students and instructors. Facility in the use of more than one representation deepens a students' understanding, but specific learning difficulties arise in the use of diverse representational modes (Meltzer, 2005)

As noted by Ford (Carolan, Prain, Waldrip, 2008) and many others a key aspect of the teachers' role in the science classroom is to guide and respond to students' attempts, through various representations, to make and justify causal claims about natural phenomena. They propose the following framework, its called *IF-SO* framework, to focus on key issues in topic planning (see I and F below), and teacher and student roles in learning through a sequence of refining representations during the development of a topic (S and O).

> I: identify key concepts. Teachers need to identify key concepts or big ideas of a topic at the planning stage to anticipate which mix of teacher- and student-constructed representations will engage learners, develop their understanding, and count as evidence of learning different dimensions of the topic. Teachers need to consider both the sequence of representational challenges posed by the topic, as well as the type of summary representational task that will enable students to consolidate their conceptual understandings at the completion of the topic.
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> F: focus on form and function. Teachers need to focus explicitly on the function and form (or parts) of different representations. If a particular representation is crucial to the topic, such as the utilization of ray diagrams to describe or understand reflection or refraction of light, then the nature and reasons for this convention may

need to be introduced and clarified at the outset of the topic. The conventions in less crucial representations could be covered incidentally or when needed. In working with any new representation students need to learn its function or purpose, and how this function is served by its form or parts. For example in working with graphs, students should be asked to consider why they are used in science, as well as to identify their key parts and their function, such as the purpose of each axis for establishing patterns of data interpretation. In this way teachers can guide students to learn a science toolkit of types of representations and their possible purposes as tools for engaging with, reasoning about, explaining and predicting causes for phenomena. Students also need to understand the limitations of any particular representation in addressing only some aspects of its target phenomena.

S: sequence. Students need to face a sequence of representational challenges which elicit their causal accounts of phenomena, enable them to explore and explain their ideas, extend these ideas to a range of new situations, and allow opportunities to integrate their representations into a meaningful summative account of the topic. Students also need to learn that different representations focus on different aspects of the topic, and therefore serve different purposes.

1. S: student representation. Students need to have opportunities to re-represent their claims to extend and demonstrate learning. They should be challenged and supported to coordinate representations as a means to express coherent, defensible and flexible understandings. Students need to be active and exploratory in generating, manipulating and refining representations. In seeking to show the complexity of a claim, students need opportunities to express and extend their representational resources and choices, and to integrate different representational modes to show conceptual understandings.
2. S: student interest. Activity sequences need to focus on meaningful learning through taking into account students' interests, values and aesthetic preferences, and personal histories. For example, learning about effective use of different energy sources could be developed through designing, trailing and modifying an energy-efficient vehicle.
3. S: student perceptions. Where appropriate, activity sequences need to have a strong perceptual context to allow students to use perceptual clues to make connections between aspects of the objects and their explanatory representations and claims. This is not to argue that all

theory-building or conceptual knowledge in the science classroom is perceptually-based, but rather that some conceptual learning in science can be enhanced by focusing on relevant student perceptions.

O: Ongoing assessment. Teachers should view representational work by students, including verbal accounts of the topic, as a valuable ongoing window into students' developing thinking and as part of the evidence of student learning. This assessment can be diagnostic, formative or summative, with a variety of forms of evidence contributing to judgments about students' conceptual knowledge and capacity to transfer understandings to new contexts and problems.

1. O: opportunities for negotiation. There needs to be opportunities for negotiation between teachers' and students' understandings of the intended and expressed meanings of representations. Students need to be encouraged to make self-assessments of the adequacy of their representations. Are they adequate to their ideas on the topic as well as the features of the object, and to what extent do they achieve the students' representational purposes and express intended meanings?

2. O: on-time. Students should participate in timely clarification of parts and purposes of different representations. Students need opportunities to compare the conventions and improvisations they have used to make claims about a topic with the claims made through "authorized" representational conventions. Understanding the reasoning and organizational affordances of the representational tools of science, such as graphs and diagrams, enables students to understand and communicate claims more clearly, and to understand why particular representations, often embedded within a complementary text, are used for different purposes, and for making claims about different aspects of the topic.

We consider that this idea will propose broad framework for guiding teacher interactions with students, especially for teaching and learning quantum physics concepts. The frameworks that we will propose based on the crucial role of students' prior conceptions about classical physics concept and developing ways of representing, students' representation preferences and reconcile these accounts with new understandings entailed in engaging with "authorized" representations.

Method

This paper will draw on data from an initial qualitative step into a mix-method research of the role of multi representation in learning about quantum physics concepts. The initial step in a sequential embedded mixed method design with embedded experimental model will be used in overall study could be seem in figure 1 (Creswell & Clark, 2007).

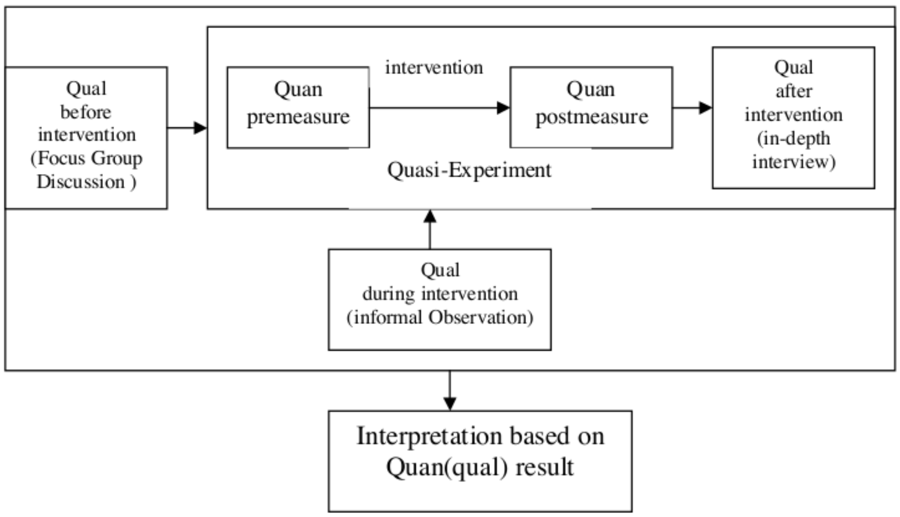

Figure. 1 Embedded Research Design (Adapted from Creswell & Clark, 2007)

By using *Focus Group Discussion* (FGD) before learning and teaching quantum physics concept, we have investigated pre-service physics student's representations preference in learning physics and "thematic pre-conception" in quantum physics. We call those conceptions "thematic conceptions" to distinguish them from individual conceptions held by single students (Bethge & Niedderer, 1996).

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Focus group discussions are *a qualitative research technique used to gain an in- depth*, but not representative, understanding of the attitudes, beliefs and perceptions of a specific group of people in their own language. A focus group is a facilitated, open conversation, recorded and observed by a note taker. A facilitator asks questions that stimulate interaction among participants on subjects relevant to the evaluation. Each participant should have the opportunity to speak, ask questions of other participants and respond to the comments of others, including the facilitator. Generally, it is best to hold several focus groups on the same topic. The first few focus group sessions are often longer because the facilitator is getting all new information. Thereafter, the facilitator is able to move quickly over points that have already been covered with previous groups if similar answers are emerging.

The number of focus group discussions that should conduct depends on the project needs and resources and whether different views from separate groups are still emerging. In general, at least two focus group discussions should be conducted among each specific target group (Gruden, et.al, 2002). In this study we involved 37 pre-service physics students that distributed to five group, each group consist of 7-8 persons.

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The research questions are:

- What are the students' preferences of representations before the unit of quantum physics concepts instruction based on multiple representations?
- What are the "thematic pre-conception" in quantum physics before the unit of quantum physics concepts instruction based on multiple representation?

Result and Discussion

It is suggested that multiple representations provide an environment for students to understand many physics concepts when moving among different representations of a physics idea. The first goal of this study is to explore pre-service physics students' preferences towards external multiple representations in learning physics and the problem solving physics.

The results from the focus group discussion were supported by the responses of students on the six interview task protocol about student's representation preference during learning physics at the University. Surprisingly, initially result of discussion showed that most of groups' students did not know about "representation" terminology in teaching and learning physics previously. However, further discussion result indicated that actually they ever face with various representations in physical concepts such as verbal explanation, symbolic representation, graphical, pictorial, mathematical, free body diagram (FBD), etc. Unfortunately, the students almost never use more than two representations to understanding a certain physics concept.

Another result noted that most of lecturers are more likely to use mathematical representation only in teaching physics, therefore mathematical representational mode was the most preferable type of representation for most of groups of students in learning and physics problem solving. Commonly the students got a good mark in quiz or physics examination if the physics problem item in mathematics representation format . This result indicated that pre-service physics student's representation (SR) is strongly dependent on teachers/lecturers' representation (TR). This condition is not support to enhance pre-service physics teacher performance in pedagogical content knowledge.

Furthermore, we notified that students are more likely to use existing representation from a domain resource than to generate own representation. The students felt be satisfactory to use representation format from lecturer, physics' books, physics web, and another sources in learning physics. Most of students said that activities to generate own representations in physics concepts very difficult and unfamiliar learning processes.

The second research question in this study is about students' preconception in quantum physics concept. Beside students' representation preferences, investigation into students' ideas about some concepts in quantum physics can assist teachers or lecturers to design instructional more precisely and help teachers to better understand students' ideas during instruction, especially in *IF-SO* framework context (Carolan, Prain, Waldrip, 2008). In this study we have investigated students' preconception about quantum physics concept through deep students' group discussion.

In this case classrooms communication and discussion does not take place in a situation where students face each other as totally unique individuals, and thus also understanding is not related to individual students, but rather relates to a situation determined by the existence of a whole group of students. That means that there is some "commonsense" binding this group of students together. So our aim is to describe early conceptions of students in quantum physics concept as "representations for groups of learners". We call those conceptions "thematic conceptions" to distinguish them from individual conceptions (Bethge & Niedderer, 1996).

One of the results showed that students' preconception about several quantum physics concepts is strongly influenced of classical physics conceptions. According to discussion result, most of group students believed that many classical concepts still be valid to use in quantum physics concepts. However most of students believe that quantum physics concept is more difficult and abstract than classical physics concept. Furthermore, the finding of this study complement the prior research that understanding many classical physics concept is prerequisite to a meaningful understanding of quantum physics concepts (Steinberg, *et al*, 1999).

Another significance results from this study indicated to identify some students' misconception about quantum physics concept. Most of group students still believed that the concept of "trajectory" is exist in quantum physics phenomena as like as in classical concepts. Furthermore, they have an idea that quantum physics concept only consist of just advanced mathematics and does not contains essential physical comments, nevertheless they believe that today's living technology is fundamentally quantum physics concepts dependent.

Another alternative conceptions have identified in this research are the concept of electron. Some of students believed that electron always behaves as a particle both in classical physics concept and modern physics concept. Other important point of the discussion result showed students' underlined that the position of an electron is clear and can be determined exactly. The information of being able to know position of an electron did not comply with the Quantum theory that contains information of probability of finding a localized electron only in a certain area. Quantum theory only defines the probability of finding an electron at a certain point in space not its definitive position; this is known as Heisenberg Uncertainty Principle (Çalışkan, Selçuk and Erol, 2009).

Conclusion

In this study the researchers began with students' representation preferences and "thematic preconception" in quantum physics concepts that have developed during the period of one year before. Our investigations show that pre-service physics students have an idea about representation preferences that is strongly depended on teachers/lecturers and source of another domain representations. Commonly agree with most of physics students features, mathematical representational mode was the most preferable type of representation for most of groups of students in learning and physics problem solving.

It is not surprising that before the teaching and learning unit "quantum physics concept" students' preconceptions of quantum physics show some alternative conceptions features. The result of this first step into overall mix method research will determine for choosing and propose broad *IF-SO* framework in order to design instructional quantum physics concept based on multiple representations more precisely.

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