An Analysis of the Students' Perceptions of Physics in Science Foundation Studies at the National University of Laos

Phimpho Luangrath (National University of Laos and Umea University)
Thongloon Vilaythong (National University of Laos and Umea University)

Abstract

This paper presents the situation of physics teaching and learning at the Science Foundation Studies program at National University of Laos. The study has focused on the students' understanding of concepts in mechanics, and the situation of the laboratory work activities. The research tools used in this study were the Force Concept Inventory test, interviews and questionnaires. The results show that in an international comparison the Lao students reveal a low level of conceptual understanding in mechanics. They also show no improvement in their conceptual understanding after teaching. The students have little experience of laboratory work. They had expectations that laboratory work would be an interesting part of Physics Foundation Studies Course. However, few of the students do get involved in the actual measurements and handling of equipment during the practical activities. So, many of them do not feel that they learn much physics through laboratory work. This corresponds to their teachers' understandings as well. Some strategies for improving the above mentioned aspects of physics teaching based on physics education research will be suggested.

Résumé

Cet article présentera la situation des processus d'enseignement et d'apprentissage de la physique au sein des classes préparatoires scientifiques de l'Université Nationale du Laos. Le but de ces classes est que les étudiants comprennent les concepts de mécanique et la situation des activités de laboratoire. Afin de mener cette étude, nous avons utilisé le test Force Concept Inventory (Inventaire des Concepts de Force), mené des interviews et appliqué des questionnaires. Au niveau international, les résultats montrent que les étudiants laotiens ont un niveau bas de compréhension des concepts de mécanique. Ils montrent également que ces mêmes étudiants n'améliorent pas leur compréhension après avoir participé au cours. Les étudiants possèdent peu d'expérience en laboratoire. Ils s'attendaient à ce que le travail de laboratoire soit une partie intéressante des classes préparatoires. Cependant, peu d'étudiants s'impliquent vraiment dans les mesures et dans la manipulation de l'équipement pendant les sessions de pratique. La plupart d'entre eux pensent donc ne pas apprendre grand-chose en physique pendant les pratiques de laboratoire. Cette sensation est également partagée par les professeurs. Notre objectif est donc de proposer quelques stratégies d'enseignement, soutenues par les recherches effectuées dans le domaine de l'enseignement de la physique.

INTRODUCTION

Lao People's Democratic Republic (Lao PDR) is a landlocked and mountainous country in South-East Asia. The population is about 5.62 million. Higher education, the education after the upper secondary education, is provided by universities, Teacher Training Colleges and private higher institutions. Universities in the Lao PDR consist of National University of Laos (NUOL)

located in Vientiane (Capital city), Champasak University located in the south of the country, and Souphanouvong University located in the north of Laos. NUOL is the first university which was established in 1995 by merging several higher education institutes. The number of students entering universities has been steadily increasing. In the academic year 2006-2007 there were about 32,000 students in total, of which 11,500 were females. However, many students come to study higher education with rather weak background knowledge (Xaysomphou, 2006; Boupha, 2008). In order to mitigate this problem, the School of Foundation Studies (SFS) was created at universities. The one year long SFS program has the task to improve students' knowledge of Natural and Social sciences in order to prepare them for future studies at the different faculties. The SFS Natural science stream has one compulsory Physics Foundation Studies Course. The present study is placed in the context of this course.

Our previous research (Vilaythong & Popov, 2007; Luangrath & Pettersson, 2007) shows that physics teaching-learning in Laos is very formal and theoretical, both in high schools and universities. Teachers mainly discuss mathematical formulas and train students to do theoretical exercises. They utilize the lecture format in their teaching. The students spend a lot of time solving problems individually (or copying the solutions from their more clever peers) during the tutorial sessions. Teachers seldom utilize demonstrations during lectures and they rarely organize practical work activities in school and university physics courses. Currently, among the three universities of Laos, only NUOL has laboratory work activities in the SFS physics course; therefore, this study was placed at NUOL. Internationally, the laboratory work is considered as one of the most important vehicles for teaching and understanding the processes of scientific thinking (Hofstein & Lunetta, 1982). However, Hofstein and Lunetta claim that laboratory work is of little help for improving the understanding of science. White (1996) also offers a pessimistic view that laboratory work helps teach the methods of science but he also has many suggestions on how to improve practice. There are, however, studies in which students perceive that they learn a lot from laboratory work (Hirvonen & Viiri, 2002). Santiboon (2007) used several questionnaires to study physics laboratory classroom environments. They found that Thai upper secondary school students show relatively favorable perceptions of these environments.

For many years there has been an international trend to focus more on basic concepts when teaching science (Van Heuvelen, 1991), but Laos has not yet followed this trend. This change in focus has been inspired by numerous studies of students' understanding of basic physics concepts (McDermott & Redish, 1999). Studies of students' conceptual knowledge in physics is developed by making use of different instruments. One well-known tool for studying students' understanding of mechanical concepts is the Force Concept Inventory (FCI) (Hestenes, Wells, & Swackhamer, 1992; Halloun, Hake, Mosca,

& Hestenes, 1995). The FCI is a multiple-choice test, consisting of 30 questions that cover central concepts of Newtonian mechanics. The students do not need to make any calculations to answer the questions in this test. Hake (1998) collected many results from the FCI used as pre-test and post-test in American high schools, colleges and universities. He showed that after the teaching of mechanics, the average score of correct answers increased by 20-40% for different groups of students (from 20-50% in the pre-test to 40-90% in the post-test).

The objective of this study was to obtain a better picture of the situation of physics education in Laos. We focused on students' conceptual knowledge in mechanics and laboratory work activities. We used the FCI to measure the conceptual knowledge of students. The following research questions were formulated:

- 1) How do the students' understandings of kinematics and force concepts change after they study mechanics?
- 2) What are the students' perceptions of the conceptual questions used in the FCI?
- 3) How are physics laboratory activities valued by the students and teachers?

METHOD

In the first part of this study, we examined the conceptual understanding of basic mechanics concepts of 75 students (4 classes) that were enrolled in the physics course in the SFS. We chose to use the FCI test, which is one of the most widely-used tests in physics education. Many researchers use the FCI to test students' understanding of the concepts of mechanics. Thus, it has become a standard for assessing conceptual knowledge in mechanics. We selected this test because it is easy to compare with many other studies. Before the FCI was sent to students it was translated into the Lao language. The FCI test was given two times (before and after the students studied kinematics and the three Newton's laws of motion). The students had one lecture and one tutorial each week, and a lab session every second week. Lecture, tutorial, and lab session lasted 90 minutes each. After three weeks of mechanics studies, the students were given the same FCI test. The students had about 50 minutes to complete the test and then were asked to answer a 10-minute questionnaire about the FCI test.

The data was analyzed and the average scores of the pre-test and post-test were calculated. If more than 10% of the questions were not answered (or had more than one answer) by a student, that student's answers were not included in the analysis. Also, the students who took part in only one of the tests were omitted when the average was calculated. The *z* test was used to check if observed differences in scores were statistically significant.

The students with the highest score were chosen for interviews. Eight students were interviewed. The interviews lasted about 10-20 minutes and were

recorded. It was a semi-structured interview based on the questionnaire that the students had already answered. This included their feelings about the FCI test, questions that were both easy and difficult to understand, and about the time available for working with the FCI test. The students were also encouraged to express their opinion about the form of the test.

In order to study the situation with the laboratory work activities, as the second part of this study, a questionnaire was also used. The work of Reid and Skryabina (2002) provided a source of inspiration in the formulation of the questions. The questionnaires were given to 428 Natural science students at the School of Foundation Studies and 12 physics teachers at NUOL. The questionnaire to the students focused on their attitude toward the laboratory work in physics and the organization of laboratory activities. The questionnaire for the teachers focused on their perceptions of the situation with laboratory work.

The students used about fifteen minutes to fill in the questionnaire. The distribution and collection of questionnaires were done with the help of local assistants and the class teacher. The physics teachers returned their answered questionnaires after three days. All informants were aware of the anonymous treatment of their answers.

RESULTS

One of the objectives of this study was to investigate how the students' understandings of physics concepts changed after their studies of mechanics. A small difference in average score was found between the pre- and post-test. The students had, on average, 20% of the correct answers in the FCI pre-test, while in the post-test it increased to 22%. This small difference in scores is not statistically significant ($p > 0.05$).

The questionnaire and the interview revealed students' mixed feelings about the FCI test:

“The FCI test is a good test because it gives us some new knowledge”.

“We can think and use our knowledge to explain before we choose the answer”.

“We have never seen these kinds of questions before.”

Interviewed students stated that some questions were easy to understand (for example, question number 7, about a steel ball attached to a string that swung in a circular path in a horizontal plane. It asks about the path of the ball after the string breaks.). Students said that question number 7 was easy to understand because they could imagine the phenomenon when they read this question. The students had on average 44% correct answers of this question in the pre-test, while in the post-test it increased to 49%. There is a small improvement in the students' score of this question between the pre-test and post-test. The difference in scores is also found to be statistically significant ($p = 0.05$).

When asked about what questions were difficult to understand they mentioned number 8 and 13. Students said that question number 8 was difficult to understand because they could not imagine the phenomenon of this question. The question talks about a hockey puck sliding with constant speed in a straight line, and asks about the path of the puck after receiving a kick. The students had on average 27% correct answers of this question in the pre-test, while in the post-test it increased to 29%. There is a very small difference in the students' average score between the pre-test and post-test and the difference is not significant ($p>0.05$). The students had difficulty understanding the context of this question, but the picture could help them to choose an answer.

Students thought that question number 13 was difficult too. The question talks about a boy throwing a steel ball straight up and asks about the force(s) acting on the ball. Although they could imagine this phenomenon, it was difficult for the students to translate from the phenomenon to physics concepts. On average, 5% of the students chose a correct answer to this question in the pre-test, while in the post-test it increased to 17%. There is a clear improvement in the students' score of this question between the pre-test and post-test. The difference in scores is found to be statistically significant ($p=0.05$). From the answers in the pre-test, we see that 88% of the students chose an answer that included a force in the direction of motion. In the post-test, this number decreased to 76%.

The questionnaire also asked what the students thought was a proper time for answering the FCI test. About 40% of the students that answered the FCI thought that 50 minutes was a suitable time for the test, while 60% thought that the time was too short. The students explained that they had to use a lot of time to think and read because some questions didn't show any pictures, and some questions were difficult to understand. The last question was an open question in which students could describe any opinions of this test. Some students suggested some changes to the test:

"In our opinion, some questions should have pictures to explain."

"Some questions should change the context from what is familiar in other parts of the world to contexts that are familiar in Asia because the context of the question is important for us when we read and try to understand before we choose the answer."

The study also aimed to gain insight into the students' and teachers' views on laboratory work activities in physics. The natural science students at SFS have laboratory work activities as a part of the physics course and they had already completed two laboratory tasks activities by the time of the study. The results show that the majority of students (69%) expected that physics laboratory work would be interesting and enlightening. However, this opinion became more skeptical when they consider physics laboratory activities in the SFS course. Thus, half of the students (49%) felt their understanding of doing the physics experiments in this course just as fair or even poor. The students complained

that the theory and practice did not go hand-in-hand in the SFS physics course. In some cases, an experiment was done before they had even studied the corresponding theory. The students could not see how this laboratory work could lead them to better understanding of the theoretical concepts.

They also complained that there were too many students in each laboratory group (usually 5-7 students) which they thought negatively influenced their possibilities for learning and handling of equipment. About half of the students (47%) who answered the questionnaire considered problems with equipment as major obstacles in their labwork followed by unclear presentations of experimental procedures (30% of students thought that this should be improved).

These results are in tune with the physics teachers' responses. The teachers believed, in general, that teaching physics with laboratory activities would help students achieve greater understanding of physical concepts and processes. However, they also accepted that there were problems with laboratory work organization. More than half of the physics teachers (58%) felt that, in reality, the laboratory activities were not as effective as they could have been (fair or bad). Some teachers commented that having the laboratory work in the study schedule does not automatically guarantee improvement of students' understanding of physics concepts. The teachers felt that the situation could be improved if all students had opportunities to handle physics equipment on a regular basis. This would require students to work in smaller groups of 2-3 students under supervision of the teachers assisted by laboratory instructors; however, at the moment, NUOL does not have laboratory technicians nor sufficient numbers of instructors among the staff.). On the other hand, almost all physics teachers who answered the questionnaire accepted that they still had limited experience, knowledge and skills in organizing laboratory work activities. They felt a need for further training in this area.

DISCUSSION

The results show that in an international comparison, the Lao students have a low level of conceptual understanding in mechanics. The students' score were quite low in the pre-test and the post-test of the FCI test, 20% and 22%. In the summary of FCI results by Hake (1998) the pre-test scores are in most cases found between 20% and 70%. The result of the average score of students from the National University of Laos is found to be in the low side of this range. Furthermore, the small improvement in the post-test results is not statistically significant, so it is not possible to claim that there has been any change at all in the students' understanding of concepts as revealed by the FCI test. The teaching does not improve the understanding of mechanical concepts as measured by the FCI test.

When analysing this result it must be remembered that the FCI test is not perfect to use in a Lao students context. There are some questions that have

an unfamiliar context for Lao students. The clearest example of this is question number 8 that talks about ice hockey. Lao students have no experience of a hockey puck that slides without friction on ice. Many students probably had to guess on this question. If the students chose the answer at random, this would result in a 20% correct answer only by chance. This is rather close to the observed 27% correct answers in the pre-test.

There were a few questions that the students could answer based on their own experiences. One example was question number 7 which asks about a path of a steel ball after the string brakes. This could be answered correctly by students that have swung objects around themselves and have made careful observation of the path after losing the grip. This question had the highest percentage of correct answers, 49% in the post-test.

Another problem when using the FCI test is that students are not used to reading these kinds of conceptual questions. Many students complained that it took a lot of time to read and understand the questions. However, students could probably understand the described situation in most of the questions. The low score could be explained by a failure to understand basic concepts of physics. In question number 13 there were only 5% of the students that chose the correct answer in the pre-test. Almost all students chose an answer that included a force in the direction of the movement of the ball. This is a well-known misconception that is often found (Hestenes et al. 1992; McDermott, 1984; Bayraktar, 2009). The increase from the pre-test to the post-test in the number of correct answers corresponds exactly to the decrease in the number of answers that included a force in the direction of motion. This could be interpreted that the teaching does help some students to abandon this type of misconception. However, it is still a very low number of correct answers (17%).

The most striking result in this study is the fact that the students still show a low score on the FCI-test after studying mechanics. The teachers made use of only lecture format and the black board to explain to students in the lecture room. In tutorial sessions, students solved the problems individually. This method does not improve students' understanding about physics concepts. Students can apply the equations to solve some problems, but some students could not solve some complex questions. Moreover, students could not apply the theory to explain the phenomena in the real situation.

To improve the teaching-learning process, we suggest that study groups should be organized in the tutorial session. This has been found in other studies (Gautreau & Novemsky, 1997; Benckert & Pettersson, 2008) to be an effective way of teaching. The students have the opportunity to discuss problems and exchange ideas with their friends and teachers. In this way the students can talk about physics concepts and have a better chance to grasp the meaning of them.

After two experimental tasks in the physics course, half of the SFS students felt that laboratory work enhanced their understanding of theory and physics phenomena. Laboratory work actually could foster students

understanding of physics (Hirvonen & Viiri, 2002). The other half of the students stated that this laboratory work did not improve their physics understanding. There were also honest comments that physics is not a major subject of their future studies; therefore, they only needed to pass this course rather than learn to understand. The laboratory activities at NUOL seem not to be as effective as they should be. We follow here Miller and Abraham's (2009) definition of "effective", that is, there is not a good match between what the students are intended to do and learn, and what the students actually do and learn in the lab classes at NUOL. This study uncovered some factors which could negatively affect the quality of laboratory work activities at SFS physics course. First, there are too many students in each experiment group. Second, the equipment used was not working as it should. Many students also claimed that the lab instruction did not clearly describe what they were required to do. However, developing a more detailed instruction could easily make it become more of cookbook type of instruction. As we know, instructions of the cookbook types do not improve students' deep understanding of physics concepts. This has been discussed for almost a century as Bless (1933) stated that cookbook instruction certainly does not stimulate the student's capacity for reasoning. However, the cookbook instruction style could be appropriate for those students that take part in laboratory work for the first time.

In order to improve this laboratory course, this study has suggested: first, the need to improve the teachers' abilities and skills in using laboratory equipment; second, reducing the experiment group's size to about 2-3 students and third, rewriting the laboratory instructions so that they are clear and precise about the purpose of each experimental task (Millar & Abrahams, 2009).

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Phimpho Luangrath is a teacher in the Department of Physics at the National University of Laos in Vientianne, Lao PDR. At present, she is also a PhD student of Physics Education in the Department of Physics, Umea University, Sweden. Her research interest is about Lao students' knowledge of the basic concepts of mechanics. She can be reached at phimpho@yahoo.com.

Thongloon Vilaythong is a teacher in the Department of Physics at the National University of Laos in Vientianne, Lao PDR. At present, he is also a PhD student of Physics Education in the Department of Physics, Umea University, Sweden. His research focuses on the use of laboratory work in physics studies. He can be reached at thongloon_thong60@yahoo.com.