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The Impact of Dynamic Assessment on Achievement of Students in Physics

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Abstract
Dynamic assessment (DA) originated from Vygotsky's ZPD theory has been widely accepted and employed as an effective tool to improve students' learning in recent years. This study investigates the impact of DA on the development of students in physics taught in higher education, that is, at the university level. For the purpose of the present study, sixty undergraduate students in the Faculty of Computing, Engineering and the Built Environment at Ulster University were randomly divided into two groups as experimental group and control group. Over an 8-week period, the students in the experimental group were asked to perform 16 physics tasks through DA procedure, whereas the students in the control group received traditional teaching instruction. Results indicated that the students in experimental group improved their physics knowledge significantly compared to their peers in the control group. The findings of this study suggest that DA is an effective method to improve students' physics knowledge.
Keywords: assessment, dynamic assessment, physics education

1. Introduction

Different methods have been proposed by researchers to help students improve their learning of physics. Traditional methods for teaching physics courses (in general science courses) employ a lecturing type of instruction in which most students are passively listening to their lecturer and writing down or taking notes. However, educational researchers have challenged this method of instruction because they stress the need for students to actively participate in constructing knowledge using classroom communication systems (Class-talk). This method can help lecturers establish a more interactive and student-centred classroom. In particular, it has the potential to be more effective and useful when teaching large courses. As an approach, this method has been found to help lecturers engage students in active learning in the classroom. In addition, it enhances the overall communication within the classroom (Dufresne, Gerace, Leonard, Mestre, & Wenk, 1996).

Interactive Engagement (IE) has also proved to be an effective method in teaching physics. During practicing IE students are questioned and challenged to think about a subject, or they are given a task which requires thinking. Utilizing this method students interact with each other, with their teacher as a coach or guide. Students might also interact with teaching materials provided by their teacher (on paper or computer). The key point in this method is the active and thoughtful interaction. The results from this practice indicate that using IE strategies improve students' problem solving skill. In particular, the research has also shown that IE methods can enhance mechanics-course effectiveness much better than that achieved using a traditional practice (Hake, 1998).

Assessment is one of the most critical parts of teaching and learning activities. A number of new assessment methods have been proposed and investigated. In all of those new methods, both students and instructors take some responsibilities. Being active rather than passive for students in any activity results in flourishing results. For example, there is considerable evidence collected by researchers in physics education that traditional instructional methods are not effective in promoting conceptual learning in physics. There is also widespread evidence that active learning methods work well in many different environments. Activity-based interactive learning environments well serve the diversity of students studying physics (Laws, Sokoloff, & Thornton, 1999).

Assessment can also be integrated into an interactive environment. There are mainly two types of assessments: DA and static assessment. In the static assessment, the evaluator administers an assessment, and the individual's performance on that assessment is determined by comparison to norms or set criteria. A static assessment assesses the skills and knowledge the individual has gained from his or her prior experiences. It does not assess the individual's ability to acquire skills and knowledge since that happens before the assessment is undertaken. DA, in contrast to static assessment, looks at an individual's ability to acquire skills or knowledge during the evaluation. In the dynamic assessment, a skill is tested, then taught and then retested (Dollaghan & Campbell, 1998).

The main focus of this paper is to study the effectiveness of DA in teaching and learning science and engineering with a focus on Physics. DA is a relatively new approach to educational evaluation. It has been defined as an interactive approach to conducting assessments in educational context that focuses on the ability of

the learner to respond to intervention (Alderson, Haapakangas, Huhta, Nieminen, & Ullakonoja, 2014).

DA approach was developed because of the insufficiency of conventional testing methods in providing information about student's learning ability, specific poor functions, and providing appropriate mediation strategies which are responsible for learning difficulties and cognitive modifiability (Tzuriel, 2000). DA is an assessment procedure which provides the opportunity for examinees to receive instruction during the assessment. In other words, during DA approach, assessment and instruction are not considered as separate activities, but these two are together as a single activity (Poehner, 2007). Dynamic assessment has been originated from Vygotsky's sociocultural theory, specifically the concept of the Zone of Proximal Development (ZPD) (Fahmy, 2013). DA is described by characteristics such as interactive, process-oriented and ZPD-sensitive. These features make DA a new form of assessment which distinguishes it from traditional type of assessment (Tajeddin & Tayebipour, 2015).

In Vygotsky's (1978) sociocultural theory, higher order cognitive development is constructed by the contextualized interaction between a knowledgeable peer and a novice. Zone of Proximal Development (ZPD), which is a Vygotskian notion, constitutes the ground for the formation of DA. Vygotsky suggested the concept of ZPD which is defined as the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in collaboration with more capable peers (Vygotsky, 1978). According to Vygotsky (1978), an accurate assessment of ability entails considering both actual developmental level and potential developmental level. DA is an example of a procedure which takes into account the ZPD of a learner and offers an appropriate mediation within the learner's ZPD. Mediation is important feature of DA which distinguishes it from other traditional assessment methods. It refers to the assistance that is offered usually by the instructor to the student based on his/her ZPD.

Two main methods in DA have been proposed by Lantolf and Poehner (2008): interventionist and interactionist. In interventionist DA, learners receive mediation during a test item by item in the form of standardized and fixed set of clues and hints. As Lantolf (2009) stated, the interventionist DA has two main advantages: firstly, since the mediation is not dependent on the responses of individual students, it can be conducted with a large number of students through using computers simultaneously and secondly, as the number of hints is fixed, it becomes possible to compare learners with each other. In contrast, in interactionist approaches, mediation is not prepared before a test but it is developed during the test based on discussions with the individual, in other words, it is continually changed based on the learner's responses.

Although, most of the current research studies have reported the positive effects of DA approach on students' learning development (e.g., Ajideh & Nourdad, 2012; Shrestha & Coffin, 2012; Tabatabaee, Alidoust, & Sarkeshikian, 2018), however, only few studies to date have investigated the effects of DA on students' learning in the context of science studies (e.g., Popa & Păuc, 2016; Wang, 2011). Moreover, no study, to the knowledge of the authors, has documented on the effectiveness of DA approach on achievement of students in physics. Accordingly, this study attempts to bridge this gap by examining the impact of DA approach on improving the learning of physics of students in a university. It was hypothesized that there would be significant differences between the physics achievement of students who received DA based instruction and those who received traditional teaching instruction.

2. Methodology

2.1 Participants

This project involved 60 undergraduate students of physics in the Faculty of Computing, Engineering and the Built Environment at Ulster University in the UK. The participants were selected randomly from the first year students of the department. They had the option not to participate. The male participants were 33 forming 55% of the sample and the female participants 27 forming 45%. These students were randomly divided into two groups: experimental group and control group. The two groups were of equal size, 30 students in each group. The average age of participants was 18.9 years, with a range from 18 to 21 years.

2.2 Procedure

This study followed the pre-test-post-test experimental design. Before performing the experiment, the participants in both experimental group and control group were given a pre-test on physics in order to examine the homogeneity of the participants in the study. For the pre-test, which was the researcher-made test, the students were asked to accomplish 8 physics tasks. To make sure about the quality of the test, validity and reliability of the test were measured. For the content validity of the test, two physics teachers were asked to evaluate the test items in the pre-test. Any necessary changes were then implemented. In order to examine test reliability, different methods were employed: test–retest (Cronbach's alpha = .991) and alternative form analysis (Cronbach's alpha = .897) were calculated. According to Pallant (2013), test reliability above 0.7 is generally accepted as adequate. As the calculated values, .991 and .897 are more than 0.7, the test is proved to be reliable.

After ensuring about the homogeneity of the students, they were asked to participate in eight class sessions over a period of 8 weeks. During the experiment, the students in control group provided with the normal way of teaching of physics but in the experimental group the participants were assessed and given the required assistance through DA procedures. The DA model which is designed for this study follows the 'graduated prompt approach' designed by Campione and Brown (1987). Its development is based on the interventionist approach of the assessment. In this model, the examinees are provided assistance item by item and if they cannot answer an item correctly, they are offered pre-fabricated and fixed set of mediation gradually range from general to specific. However, this approach varies somewhat from that typically used by other DA approaches as the ability of the students to transfer the learned information to different contexts is also considered as important principle.

Following the 'graduated prompt approach', a framework of DA of physics was developed which consists of seven stages as follows:

(1) Teacher refers to the main parts of the task questionably
(2) Teacher provides a general explanation regarding the main points of the task
(3) Teacher refers to formula that is required for finding the solution
(4) Teacher provides the correct answer
(5) Teacher provides the learner with full explanations.
(6) Teacher provides a similar task for the student to solve
(7) Teacher asks the students to give an example of the real life situation that he/she can apply the solving strategy used in the given task

If the student's answer was correct, no mediation was provided but if the student's answer was not correct, the instructor follows seven forms of mediation in order. Each participant in the experimental group received the treatment individually. At the end of this study, to investigate the impact of DA on the learners' physics knowledge, all of the participants were given a post-test on the subject. The post-test contained 8 physics tasks similar to the ones used in the pre-test. To ensure the reliability of the post-test, two measures of test-retest reliability (Cronbach's alpha = .91) and alternative form analysis (Cronbach's alpha = .87) were conducted. Also, the validity of the test was established by consulting with two experts. The students in DA group were provided with DA but the students in the control group were received traditional teaching instruction.

3. Results

To investigate homogeneity of students' knowledge in Physics, a pre-test was administered before starting the study. All students were given eight problems from different subjects in Mechanics including Equilibrium, Friction and Motion. Using SPSS software, the data was analysed and the results, as presented in table 1, showed that there was no significant difference between physics scores of two groups meaning that all 60 participants were homogeneous in terms of physics knowledge.

Table 1

Physics Scores Means and Standard Deviations obtained in Pre-Test

Groups	N	Mean	Standard Deviation	Standard Error Mean
Non-DA group	30	14.56	1.69550	0.30955
DA-group	30	15.5	2.25526	0.41175

After completing the treatment sessions, to evaluate the impact of using DA on the students' physics knowledge and their problem solving skill, the students in both groups were given a post-test in which they were asked to solve eight problems from the same subjects as used during the pre-test i.e. Equilibrium, Friction and Motion. The results obtained by participants in the experimental group and control group were compered. Table 2 presents the means and standard deviations of the two groups on the post-test. As the results show, the experimental group (DA) obtained higher mean scores ($\bar{X}$= 17.90) in comparison with the control group's means ($\bar{X}$=15.03) implying that experimental group performed better than the control group.

Table 2

Physics Scores Means and Standard Deviation Obtained in Post-Test

Groups	N	Mean	Standard Deviation	Standard Error Mean
Non-DA group	30	15.03	1.32	0.24204
DA-group	30	17.90	1.34	0.24612

After completing the test to find out whether the difference between the two groups was significant an independent-samples t-test was employed. Iindependent samples t-test is a standard method to compare the means of two independent groups in order to determine whether there is statistical evidence that the associated population means are significantly different (Kent State University, 2018). When the *p*-value is less than the conventional 0.05, the conclusion is that the two means do indeed differ significantly. The results for F-value, *p*-value and other parameters are presented in table 3.

Table 3
Independent Samples t-Test in Post-Test

Levene's Test for Equality of Variances			t-Test for Equality of Means		
	F	Sig.	Sig (2-tailed)	Mean Difference	Std. Error Difference
Equal variances not assumed	.007	0.933	0.00	2.86667	0.34519

As shown in table 3, there is a meaningful difference between two groups on their performance in the post-test. Technically speaking F= .007 and p = 0.00 proved that the difference is significant at the 0.05 level in terms of dependent variable. The findings support the hypothesis of the study which states that DA would improve students' physic knowledge.

4. Discussion

Different teaching and learning methods in science and engineering, especially physics education, have been proposed and examined by different researchers. Interaction is the common component of those methods, that is, students are actively engaged in teaching and learning activities. In this study DA was practiced in teaching physics to undergraduate students requiring dynamic interaction between students and their teacher. In other words, DA is a process in which the teacher mediates the students with some form of support such as suggestions and feedback. In this paper, DA procedure was designed for physics education and successfully implemented in teaching and learning activity. The findings of this study indicated that the students who had received DA treatment improved their physics knowledge in comparison with the students who did not receive such treatment and assistance.

The results of the current study confirmed previous research conducted by several researchers that students who received DA improved their learning (e.g., Popa & Păuc, 2016; Wang, 2011). In his study, Wang (2011) found that DA resulted in development of junior high school mathematical ability. Similarly, the findings of the study conducted by Popa and Păuc (2016) indicated the effectiveness of DA on mathematical achievement of the students. Based on the results of the study, the researchers concluded that be DA can be employed not only in classroom assessment, but also in instructional contexts with the purpose of improving students' performance and achievement.

A possible reason for the beneficial effects of DA is that this method provides an innovative context for students to learn. During DA method, the examiner has the opportunity to interact with the students and supports in a way that is not permitted in traditional methods of the assessments. This closely parallel to Vygotsky's sociocultural theory (1978) which states that learning is a social process. According to sociocultural theory, higher forms of thinking to perform certain complex skills originate in and are shaped by social interaction.

This study indicated that the expert/novice interaction could help students reach beyond the current level of ability, which was the development of students' physics knowledge. The results showed that the students' physics knowledge improved in the post-test significantly, indicating that the mediation of the teacher could help the students reach from other-regulation (i.e., performing a task by the support of the others) to self-regulation (i.e., performing a task independently). This finding supports Lantolf' (2006) argument that during DA what is being done by the support of others is what can be done independently in the future. Furthermore, the findings of the study indicated that the learned information by the students in the DA group was effectively transferred to the new contexts. One possible explanation might be due to offering mediation in the form of hints and leading questions through which the students had enough opportunities to reflect on their performance during the assessment process.

The results indicated that the interaction between the teacher and the students in the form of a graded set of hints and leading questions was effective in the improvement of students' physics knowledge. This finding was in line with that of Wang (2011); he found that providing instructional hints in a graduated way to the learners' performance was effective in their learning. Some higher order thinking skills such as analysing, reasoning, and problem solving required deep processing on the part of the students, and the students needed to reflect more in order to appropriately apply them in performing physics tasks. That is, the students needed more support and guidance from the teacher to improve these skills.

5. Conclusion

The purpose of this study was to investigate the effectiveness of DA on the achievement of the students in Physics. The findings of the current study showed that DA had a significant and meaningful impact on improving the students' achievement in physics knowledge. The results also revealed that students in the experimental group who had benefited from DA mediation had a higher gain score of physics in comparison with those who did not receive the mediation procedures in the control group.

These findings lend more empirical support for the key concepts behind DA. In other words, this study indicated that interaction during the assessment improves students' learning. The results of this study also

showed that providing mediation in the form of a graded set of hints and leading questions is effective in developing students' physics knowledge.

In sum, the results of this study indicated that DA is a powerful teaching and learning tool. However, it requires teachers to dedicate quality time to design the treatment and implement in class. In an area where time is scarce, this could be seen as a problem. Recent advances in technology and the use of freely available online tools and resources offers solutions which need to be explored and exploited to benefit both the tutors and the students.

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