Developing Science Teaching and Learning in the Lower Secondary School Level through the Digital-based Exercise Integrated in Science Textbooks

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Keywords: Digital-based exercise, Online Testing, Online Assessment

Abstract

The Institute for the Promotion of Teaching Science and Technology (IPST) is a government agency who has responsibility to develop science textbook and to provide professional development to science teachers across Thailand. The transforming paper-based exercise that provide at the end of each unit in the textbook to digital-based format will provide many advantages for IPST. First of all, the digital-based exercise will serve as a formative assessment tool to promote student learning. Students can access the exercise through either QR code or web-link printed on the last page of the unit and then start doing exercise. After they finish the exercise, students immediately receive the score and short explanation of each item, which they can reflect their own learning and review the concept at the same time. Second, the digital-based exercise can provide real time data of student learning who using IPST textbook across the country. This data could be useful for IPST staffs who are textbook authors and professional developers to either rethinking or designing the new projects. For instance, to revise the future edition textbook, to develop supplementary materials that support learning and addressing and difficulties and misconception, and to design effective professional development that meet the needs of each group of teachers. Even through the online testing is a good tool to access students' learning achievement, the system still has some issue that needs to be modified. For instance, according to the result after one year launching of the lower secondary school level exercise, we found that some students visited the test in a very short time and left the system or some data show that students did not answer the entire test. Therefore, the result taken from this group of student cannot reflect much about their understanding of the concepts. According to this issue, IPST may need to modify the system so that being able to collect the result about students' learning achievement more effectively.

Introduction and Background

Technology recently becomes a part of people's lives, including the area of education because technology makes things easy, accessible, and feasible, it is reasonably served a tool to support teaching and learning. Aligned with the usefulness of technology, the Institute for the Promotion of Teaching Science and Technology (IPST), the government organization who directly takes responsible for developing science textbook and providing professional development for teachers across Thailand, has developed the digital-based exercise which is another format to assess students' understanding in science concepts. Comparing to the traditional way of exercise, the digital format is quiet new experience for Thai student when they can only scan the QR code appeared on the last page of each unit in the printed science textbook in order to access to the digital exercise. In case there is not any device to scan QR code, there is an URL of the web-link printed under it (Fig.1), so students can use this URL for doing the exercise on a computer.

Fig.1 Example of the QR code and the web-link to log in to the test

By mean of using this news format of exercise, we aim to challenge students with the new approach of assessment, encourage students to do their own self-assessment as well as study by themselves from the explanation provided in the system after they have submitted the answers. On the other hand, IPST textbook authors can gather data from students across the country about their understanding of each concept provided in the textbook.

In regards of using the online exercise, this technique promotes flexible learning. Also, it helps to foster student-centered learning environment as it is accessible for students to perform their own self-assessment (Bartlett, Reynolds, & Alexander, 2000; Farmer, 2005; Robles & Braathen, 2002). Therefore, online assessment can be viewed as a system for evaluating student academic achievement. Another advantage of online exercise is that the users can do the test anytime and anywhere and be able to gain immediate feedback as many users like the speed of result and feedback (Ricketts & Wilks, 2002; Gaytan & McEwne, 2007). The researchers as well commented that it is important that the online testing system provides the users with clear explained feedback (Tallent-Runnels et al., 2006). Roble and Braathen (2002) also mentioned in their study that teachers may also use the result from the test to identify the weakness of the contents students may still have in order to support them with supplementary materials to help them to learn well.

Purpose and Objective

On account of the background, the purpose of this study is to understand the benefits of online assessment technique which is in form of digital-based exercise integrated with IPST's science textbook. To address this purpose, the objective of this study is to figure out "What are the benefits of the digital-based exercise?"

Methods

The descriptive statistic was used for this study in order to understand meaning of the results as well summarize students answers to measure their own understanding on each science concept which can reflect the effectiveness of online assessment. Data were solicited from students who took the digital-based exercise using IPST e-testing system across the country.

Data Collection and Data Analysis

The data of this study has complied from the results students took the exercise in each unit of IPST's grade 7th science textbook throughout 1 year. The science concepts that used to assess students learning were classified into 6 units as shown in Table 1.

Table 1 Science concepts presented by units in IPST' science textbook

Unit	Science Concepts	Numbers of items	Concepts that are measured
1	Nature of science	-	• The importance and the meaning of science • Scientific methods
2	Pure substance	15	• Boiling and melting points • Density • Classification of pure substance • Atom structure • Classification of elements and their usefulness
3	Cell as a unit of life	10	• Light microscope • Cell structure and function • Cell transportation: Diffusion and Osmosis
4	Plants	15	• Plant reproductive: Sexual and asexual reproduction • Plant propagation • Factors and products of photosynthesis • Plant mineral • Transportation in plant
5	Thermal energy	17	• Models of particulate nature of matter • Heat and the change temperature of matter • Heat and the expansion and contraction of matter • Heat and the change of state • Heat transfer in daily lives • Thermal equilibrium
6	Atmosphere and weather	14	• Atmosphere • Air temperature • Pressure and wind • Humidity • Cloud and rain • Forecasting

There were about 2,330 students participating in the digital-based exercise in IPST system. Most of them were students in schools and a few numbers were parents and university members. The students joining the exercise were from many provinces across of the country as shown in Table 2.

Table 2 The number of students took the exercise from each region of Thailand

Unit	Number of students classified by region							
	Bangkok	Central	North	East	West	South	Northeast	NA
2	82	55	46	70	31	29	90	22
3	70	236	27	5	70	66	93	30
4	36	178	80	17	75	25	16	25
5	61	53	62	29	4	22	43	17
6	33	318	110	16	7	15	45	19

***Unit 1 is about Nature of Science, so we did not bring to count as score for Science content.

As the system was relatively flexible, it allowed the students to leave the site anytime they want. Accordingly, there was no time frame or no limit of time for students to submit their answer. As revealed in Table 3, we found that some students spent amount of time to complete the test. The maximum time of each unit was approximately 2 hours even if there were just 10-15 items per each unit. While considering the minimum time students used, it was very short. We noticed that some students employed just 2-3 mins to complete the exercise. Hence, we assumed that students might not complete all the items or they just skipped some items without carefully read them.

Table 3 Time that students have spent during taking the test

Unit	Numbers of items	Time (hours)			
		Maximum	Minimum	Average	Time per item
2	15	2:48:53	0:02:44	0:15:01	0:01:00
3	10	2:05:54	0:01:41	0:09:30	0:00:57
4	15	2:58:53	0:03:20	0:15:28	0:01:02
5	17	2:19:53	0:03:04	0:16:42	0:00:59
6	14	2:00:29	0:02:51	0:14:25	0:01:02

***Time showing in this table is counted just from students who completed all items at each time.

Regarding the identifying from name of school to log in and period of time were spent in the system, we analyzed that there were two possible formats of students' doing the exercise which are working individually and working in group. For the last case, we assumed that teachers might ask students to work in group to complete the exercise right after they learned the unit in the classroom.

The exercise was somehow motivating and challenging students as we remarked that many students visited the site more than once to retake it. According to the data shown in Table 4, Fahmai was a student who made the highest time of revisiting the website to redo the exercise of unit 2. Regarding the case of this student, at the very last time that she took the test she spent very short time staying in the system. We assumed that she might speedily response on the items that she was confident and just spend time on the items that she missed in the previous time. Other than Fahmai, we also found another 2 students that have similar trend of data.

Table 4 Times that one of the students has spent each time to complete the exercise

Time to get into the system	Name	School	Score	Time to complete the exercise (**hours**)
1	Fahmai	A	10	0:47:39
2	Fahmai	A	12	0:11:03
3	Fahmai	A	10	0:08:26
4	Fahmai	A	12	0:29:21
5	Fahmai	A	12	0:06:05
6	Fahmai	A	10	0:06:12
7	Fahmai	A	12	0:03:08
8	Fahmai	A	13	0:04:46
9	Fahmai	A	15	0:03:08
10	Fahmai	A	11	0:07:32
11	Fahmai	A	14	0:04:19
12	Fahmai	A	14	0:03:36

** the full score is 15

In the big picture, the scores that students earned in each unit were not very high. As shown in Table 5, students score in each unit was below 70%. Consequently, this may reflect that students in grade 7th still need to improve their own understanding in science concepts.

Table 5 Score students gained in each unit

Unit	Score				
	Full score	**Maximum**	**Minimum**	**mean**	**Percentage of the mean score the students gained**
2	15	15	2	10	66.67
3	10	10	0	5.90	59.00
4	15	15	1	8.84	58.93
5	17	17	0	9.40	55.29
6	14	14	1	7.78	55.57

While considering the score students performed in each unit, it could reflect level of their understanding to each concept as well as this information can tell us about the specific concepts that most students have a good understanding or ones that need to be improved, detailed in Table 6.

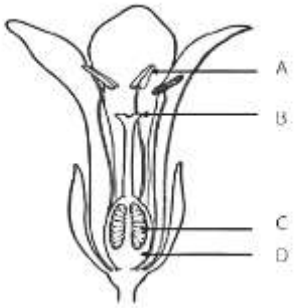
Table 6 Concepts and the number of students who can get the score

Unit	Concepts and Percentage of students who can get the score		
	70-100% (Good)	**46-69% (Moderate)**	**0-45% (Need to be improved)**
2 Pure substance	Atom, Boiling and melting points, Density of pure substance, Classification of pure substance	Properties of pure substance, Classification of elements and their usefulness, Density of solid	Density of pure substance, Density of gas

Unit	Concepts and Percentage of students who can get the score		
	70-100% (Good)	**46-69% (Moderate)**	**0-45% (Need to be improved)**
3 Cell as a unit of life	Organelle and its function, Osmosis	Organelle and its function, Light microscope, Cell structure and function	Diffusion
4 Plants	Plant sexual reproduction, Photosynthesis, Plant minerals	Plan sexual reproduction, Seed, Photosynthesis, Plant propagation, Seed germination, Vascular bundle and plan propagation	Plant asexual reproduction and seed dispersal, Plant sexual reproduction
5 Thermal energy	Models of particulate nature of matter, Heat transfer,	Heat and the change temperature of matter, Specific talent heat, Thermal equilibrium, Heat transfer, Heat and the change temperature of matter, Heat and the expansion and contraction of matter, Heat and the change of state	Experimentation, Heat transfer
6 Atmosphere and weather	Atmosphere, Weather forecast, Wind speed	Atmosphere, Weather phenomenon, Air pressure and wind, Weather temperature, Storm, Carbon cycle, Climate change	Cloud and rain, Weather temperature, Climate change, Weather forecast

On the ground of the data revealed in Table 6, it could reflect that there are many concepts classified in “Good” level as many students can do well on the exercise; some in “Moderate”; and some in “Need to be improved” which are the concepts that students could not perform well or still have misconception someway. For instance, Plant asexual reproduction, Seed dispersal, and Plant sexual reproduction in Unit 4 are the concepts that are challenging for many students. In addition, some concepts such as “density” which is the concepts presented more than one items in unit 2 and it was ranked in “Good”, “Moderate”, and “Need to be improved” as its difference in level of difficulty in each item. According to this, we found that students did well on the item that asked the concept in way of memorization while the item testing on calculating, students could not get the score; this trend is relatively similar with other concepts. Other than different level of thinking, some item performed in the exercise may not be fair and confused students. For example, one of the items taken from unit 4 asked students to complete another 5 more following questions.

Considering below picture, draw ○ over "yes" or "no" in each sentence is related to the concept of flowering plant reproduction.



Sentence	"Yes" or "No"	
1. A is a part of stamen where male gametes are produced.	Yes	No
2. B is a part of pistil where female gametes are produced.	Yes	No
3. The fertilization is occurred in C.	Yes	No
4. D is developed into a seed after fertilization.	Yes	No
5. Pollination is the act of transferring pollen grains from A to B.	Yes	No

To get 1 point, students have to correct all of those questions. Thus, this kind of item might not be fair to the students as they have to spend a lot of time with it, comparing with other items that may be easier to gain the same score. In addition, students were not familiar with this style of item as they also could not do it when it presented in other units.

Findings and Discussion

The results from the test are presented in relation to the following:

1. The digital-based exercise functions as a formative assessment tool to promote student learning. As it is accessible either using the QR code or web-link printed on the last page of the unit, students can simply take a test right after they are done with the unit and receive the response to their answer immediately. Giving feedback and short explanation right after students finished the test is the strength point using online testing technique. With this method, students can both assess and learn by themselves. Also, teachers can use the online testing as their own assessment tool after teaching to measure if students understand the concept in the unit they have been teaching.
2. On the ground of the result collecting from students across the country, it revealed that students still do not have much understanding in the science concept as the mean score students have gained in each unit was below 70% and most of them were just in between 55-60%. This can reflect that students still needed help or support in their science concepts' understanding. This message could be useful for the textbook authors in order to modify, redesign, or think of the new projects to support students learning in the point that they need. For instance, "density" "Heat transfer" "Climate change", are the concepts that students may need help, the textbook developer may rethink about ways to present in the future edition of the science textbook to be more understandable, or give more examples, or even develop any supplementary materials that can support students' learning and addressing the difficulties and misconception students may still have. In addition, this evidence can be also useful to the

professional developers to design effective professional development that meet the needs of each group of teachers as teachers are significant persons to directly supervise students learning.

3. As this is the first year that the new version of science textbook has been launching, some of the items in the test may still need to be modified. According to the analysis, we found that some items were easy and were not able to identify students' capability. Also, there were variety of format in the items; some of them were confused and some of them asked students to spend too much time but provided just 1 score rewarded. These might be factors affecting the results students did in the exercise. Moreover, students likely could not do well with the higher order thinking questions as they are familiar with memorizing questions. Thus, the authors may have to modify some items to make them more effective as well as enhance higher order thinking questions such as asking applying or critical thinking kinds of questions rather than just asking for the meaning of words or some kind of memorization to promote students higher order thinking skill.

4. The behaviors of the users who assess the digital-based exercise were different. The digital-based exercise motived students to both learn and have fun in somehow. As some of them got into the system and left in a short time, while some stayed in the system in a long time. Also, some kept visiting the site to retake the test until they got a satisfied result.

5. Despite the digital-based exercise is a good tool to assess student learning and also it can provide massive data to the textbook authors at the same time, we still found that there are some issues in terms of the system that needed to be improved. As the system is flexible for the students to log out the system anytime even they do not complete the test or even they spend a short time in the system which seems impossible for them to considerately read the item, this may affect the result as it cannot effectively interpret students' understanding to the concepts. According to this issue, IPST may need to modify the system so that being able to collect the result about students' learning achievement more effectively. Regarding the data we found, students spent approximately 1 min per each item. Thus, the system may be set the time for students to do the entire test and do not allow students to see the explanation until they the complete the whole test.

Conclusions

IPST has an online testing system that is performed in the digital-based exercise with the specific purpose. The digital-based exercise is an effective assessment tool in order to gather a large number of the exercise results from different parts of the country and also provide the users the response to their answer as soon as they finish the unit. Consequently, it is an effective tool to have better opportunity to evaluate overall students' understanding than the traditional way IPST usually have done before. Other than monitoring students' learning, the result from the exercise is being use to improve academic activities and enhance teaching and learning techniques. Thus, online testing is more than just assessing students' learning achievement; it would be more benefit to provide feedback to the learners and also it is useful for the textbook developers to improve the materials or activities in the textbook as well as the professional developers in order to rethink and revise their own work to support teachers and students effectively.

Acknowledgements

We would like to thanks for the staffs from IPST Compulsory Science unit for designing the content and exercise items in the science textbooks and also the staffs from IPST Learning Innovation Unit for their supporting in developing the online system and compiling the data for this study.

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