Interactive Projector as an Interactive Teaching Tool in the Classroom: Evaluating Teaching Efficiency and Interactivity

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ABSTRACT
This study reports on a measurement that is used to investigate interactivity in the classrooms and examines the impact of integrating the interactive projector into middle school science classes on classroom interactivity and students' biology learning. A total of 126 7th grade Taiwanese students were involved in the study and quasi-experimental research with two-group posttest-only design was employed. Students in the experimental group were taught by using interactive projector (n=61) and their counterparts were taught by general data projector (n=65). The results show that there was no significant difference in students' learning achievement between teaching through interactive projector and general data projector. More interactions were observed in the experimental group; however, its perceived teaching efficiency was not better than teaching with a general data projector. It is suggested that the integration of interactive technologies in the classrooms might not ensure better learning performance or teaching efficiency, although various types of interactive actions were observed. The possible interpretations and suggestions for future studies are provided.

Keywords: interactive teaching; interactive projector; middle school science; classroom interactivity

INTRODUCTION
Nowadays, the interactive whiteboard (IWB) is regarded as a powerful educational technology which not only supports clear and seamless instruction but also raises the level of interactivity in classrooms (Mercer, Hennessy, & Warwick, 2010; Mildenhall, Marshall, & Swan, 2010). Many researches indicate that students are more involved and motivated while information and communications technology (ICT) is present (Beauchamp & Kennewell, 2010; Chaudary & Sharma, 2012; Serow & Callingham, 2011). But taking the price and ease of use into consideration, the interactive projectors, which are more flexible and low-cost, seem to be a better choice than IWBs for us. However, does integrating interactive projectors into biology classrooms truly bring more interactions? What is the impact of interactive projectors on classroom interactivity and student learning outcomes? As interactive projector is a new technology released recently, its actual teaching efficiency and effectiveness have not been empirically addressed so far. This study therefore focuses on investigating the impact of integrating interactive projectors into biology teaching from the aspect of classroom interactivity.

Traditional IWBs have large display devices connected with computers, and when disconnection occurs, the instruction is disrupted and students' attention is interrupted. Furthermore, in order to easily manipulate computers and display boards, instructors or students are often restricted to stand in front of IWBs or other interactive technologies to utilize it. By using the interactive projectors, instructors and students can remotely control all objects displayed from a distance, with no need to change classroom settings whilst enjoying the functionalities that IWBs or computers provide. Most researches point out that interactive technologies, such as interactive projectors and IWBs, play a crucial role in improving teacher-pupil interactivity. However, some studies indicate that teacher-centered teaching is unexpectedly strengthened, when the educational media, especially interactive technologies, are newly introduced into the classes (Kennewell, 2004; Hennessy, Mercer, & Warwick, 2011).

How to measure and clarify the interactivity in the classrooms is an important issue. As some researches point out, the reason why ICTs can support teaching activities depends mostly on their intrinsic and constructed features (Kennewell & Beauchamp, 2007), and once these features are perceived and transformed into external representations, they become actions. Hence, this study attempts to investigate these actions as indices of interactivity in the classrooms and further to examine the perceived effectiveness.

THE STUDY
Participants
In total, four classes of 7th grade (aged 12-13 years) Taiwanese students (n=126) were involved in this study.

Two classes were taught by using interactive projectors (interactive group, n=61) as instructional tool, and other two classes were taught by general data projector (general group, n=65).

Materials

This study employed the unit of digestive system as the instructional content due to its complexity. The teaching materials were mostly identical between interactive and general groups. Both groups adopted video clips to motivate pupils' learning. However, to attempt to utilize the functions that interactive projectors provide, some materials were modified to make it more actively operable.

Research Procedure

Both groups (interactive and general) received 2 lessons (90 minutes) by the same instructor. In order to exclude novelty effect resulted from using new technologies, instructors started teaching with either interactive or general data projector two weeks prior to conducting this study. A knowledge assessment was administrated to students as a posttest after the lessons. The lessons were recorded by camcorders for further analysis.

Instruments

Knowledge assessment

The development of knowledge assessment for digestive system included two phases. The original version of assessment was acquired from the previous study (Yen, 2011). A biological education expert, a biology teacher and a graduate student majoring in biology were invited to review and modify the items to ensure expert and face validity. A pre-trail test (n=146) was conducted and several ill-suited items were further excluded from the assessment according to the results of difficulty and discrimination analyses. At the end, a knowledge assessment consisting of 31 multiple-choice questions for measuring participants' understanding of digestive system was formulated (Cronbach's α=0.92).

Coding system for interactivity analysis

A coding system for analyzing classroom interactivity was developed to investigate the impact of integrating interactive projectors into science classrooms in this study. Previous studies which investigate classroom interactions always focus on reporting the contents and frequencies of dialogues of teachers and students (Mercer, Littleton, & Wegerif, 2004). The potential drawback of using this method is that it merely takes down the interactions between teachers and students. However, when the educational technology is integrated into a learning environment, there are at least three subjects interacting with: teacher, student, and the technology (in this case, interactive projector). We argue that only by recording actions perceived in the classroom, can we illustrate the whole picture of classroom interactivity. That's the reason why we developed a new coding scheme instead of using an existing one.

Some researchers have emphasized that only when the special features of interactive technologies are perceived and performed by both teachers and students, can its influence be revealed (Kennewell & Beauchamp, 2007; Beauchamp & Kennewell, 2013). Hence, we further defined "classroom interactivity" as "actions which are performed by teachers and students once they perceive the supported features of educational technologies and regard the features as a facilitator for initiating reciprocal dialogue, constructing learning environment and scaffolding knowledge, and these actions can be observed in the classrooms."

According to the previous research, there are 20 actions that ICTs can provide to construct instructional content and reveal potential efficiency (Kennewell & Beauchamp, 2007). Referring to the theoretical framework they put forth, we distributed these 20 actions into three categories depending on the role that interactive technologies can play in the classes (Beauchamp & Kennewell, 2010): *object*, *participant*, and *tool*. ICTs are considered as *objects* when it has a passive role to perfectly present people's commands, mainly to display pre-prepared materials. Namely, people interact *about* ICTs. ICTs are considered as *participants* when people interact *with* them. ICTs then serve as a learning environment and may be initiators of action and may pose unanticipated feedbacks to students' responses. When ICTs play a role of *tools*, people interact *through* them and are considered as a media which helps to achieve final learning goals and prompt deeper thinking processes (Warwick, Mercer, Kershner, & Staarman, 2010). Table 1 represents the developed coding system which describes the roles ICTs can play and the actions they can provide under each category.

Table 1: Roles that ICTs can play and possible actions they can provide.

Action	Description
Object: Interact about ICTs	
Selecting	A resource or procedure can be chosen from a list.
Comparing	Different features of an object or different objects can be compared.
Retrieving	Resources or saved files can be opened or accessed to.
Apprehending	Contents displayed can easily be watched and understood.
Transforming	Teaching materials can be showed in different information types or through different media. (continued)
Revisiting	The same materials or concepts can be emphasized by using repeated processes of activity in the same class.
Undoing	The status of entire process can be returned to the previous step or the very initiation.
Repeating	A saved or automatic process can be repeated.
Participant: Interact with ICTs	
Focusing	Particular aspect or specific process of presentations can be paid attention to.
Role playing	Some roles can be assumed in learning activities in fictional settings as in real lives.
Annotating	Notes can be added to a process or presentation.
Modeling	Relationships between variables can be showed to simulate process.
Responding	Complete actions can be prompted or demanded through ICTs.
Questioning	Questions that ask for answers can be showed through ICTs.
Prompting	Some short sentences or movements that trigger someone to do something can be showed by ICTs
Tool: Interact through ICTs	
Composing	Ideas can be organized and recorded once they arise.
Editing	Information stored and demonstrated can be easily modified without traces.
Collating	Different facilities can be integrated into single resource.
Sharing	Resources and ideas can be easily interchanged and communicated.
Cumulating	Different resources can be integrated into single presentation content

Note. Modified from “The features of interactive whiteboard and their influence on learning” Kennewell & Beachamp (2007).

After the original version of the coding system has developed, one biological education expert and one graduate student who majors in biological education were invited to review and modify the definition of each category and the description of each interactive action. We met regularly to discuss whether the interactive actions belong to the classified category or the descriptions and definitions are clear enough and easy to be understood by coders until a common consensus was reached. The expert and facial validity were therefore ensured.

Data analysis

Classroom interactivity

Video recordings of classroom observations for both groups were edited for interactivity analysis and a one-minute video clip in 5 minute intervals were randomly created, generating 22 video clips for general group and 28 clips for interactive group. Two researchers (coders) participated in the coding procedure. Before coding, the developed coding system was clearly discussed and the definition of each action was carefully clarified by the two researchers. Then the coding task was conducted independently. Researchers recorded every different action they observed in the video clips and how many times the action happened, whilst also subjectively score the teaching efficiency brought by each action from 0 (no efficiency) to 4 points.

Two scores, *categorical* and *effective*, were calculated according to what actions were observed. For calculating *categorical score*, each action was given 1 to 3 points according to its category. Actions which show ICTs serving as *object* for directly responding to commands were scored 1 point each. If ICTs acted as *participants*, in that it is used not only for giving feedback to our manipulations but in initiating a discourse space for teachers and students, actions in this category were given 2 points each. Finally, when ICTs are used as a synergistic role to help teacher and students to construct knowledge, they act as *tools*. Actions in this category were given 3 points each. Categorical scores were generated by simply summing up the categorical points of observed actions. Teaching efficiency rated by researchers for each action was multiplied by the number of occurrences and then summed up, resulting in *effective score*.

Furthermore, researchers were additionally required to score the whole-class interactivity (from 1 to 10 points) for the sake of reciprocally verifying the reliability of the result. The final effective and categorical score and whole-class interactivity were obtained by respectively averaging scores between the two researchers.

Learning achievement
Students' responses to multiple-choice questions of the knowledge assessment were scored as correct or incorrect. They were given one point for each correct answer, which resulted in a maximal full score of 31 points. Analysis of covariance (ANCOVA) was run to examine if there was any difference in student performance on knowledge assessment between interactive and general groups. The obtained score of knowledge assessment was employed as independent variable and instructional treatment (interactive and general groups) was adopted as dependent variable. Students' performance in biology on the first midterm exam was used as the covariate.

FINDINGS

Interactivity

[Table 2] shows the coded actions. For general group, there were a total of 10 actions observed, with 9 of them coded by both researchers, whereas a total of 15 actions (and 12 of them were in common between researchers) were coded for interactive group. The result shows there were more actions observed in interactive group than general group for either all actions observed or actions coded in common by both researchers. [Table 3] represents categorical score, effective score and whole-class interactivity for both groups. The results reveal that effective score of general group (177.25) was better than interactive group (136.00); contrarily, categorical score of interactive group (70.25) was higher than general group (49.25). The scores of whole class interactivity were almost the same between the two groups (5.75 and 5.50, respectively).

Table 2: Actions observed by coders

	general group	interactive group
types of actions	selecting, comparing, apprehending, revisiting, focusing, responding, questioning, prompting, sharing, *transforming*	selecting, comparing, apprehending, undoing, focusing, annotating, responding, questioning, prompting, composing, editing, sharing, *retrieving*, *transforming*, *revisiting*
total actions observed	10	15

Note. Actions that were observed by both researchers were showed in normal and those observed by just one researcher were showed in italic.

Table 3: Effective score, categorical score and whole-class interactivity for both groups.

	effective score	categorical score	whole-class interactivity
general group	177.25	49.25	5.75
interactive group	136.00	70.25	5.50

Learning achievement

The results of ANCOVA for student performance on knowledge assessment were shown in [Table 4]. It is found that there is no significant difference in student knowledge acquisition between general group (Mean=19.20, SD=6.72) and interactive group (Mean=19.22, SD=7.28).

Table 4: The statistic results of ANCOVA for student performance on knowledge assessment.

component	sum of squares	df	mean square	F value
First midterm exam scores	2811.99	1	2811.99	104.42
Between	59.31	1	59.31	2.20
Within	3285.34	122	26.93	
Total	52582.00	126		

DISCUSSION

It was interesting to note that there was no significant difference in student achievement between teaching by interactive and general data projectors. However, Interactive group did have more classroom interactivity for all actions observed or actions coded in common, although the categorical score was higher for the interactive group. More interactive actions seem not appear to promise the perceived teaching efficiency as the effective score of interactive group was lower than general group. Namely, student learning outcomes and perceived teaching efficiency were not enhanced, although more interactive actions were observed in interactive group. The possible interpretations are as below.

Ceaseless interactive actions cause cognitive overload

According to the field notes of classroom observations made by researchers, the ceaseless interactive actions unexpectedly leaded students to become continually multi-tasking which frequently interrupts students' learning processes (Kirsh, 2000; Oliver, 1996). Instructor or students had to spend a lot of time interacting with the interactive projector, with some of these interactive actions being complex. This causes students to divert their attentions between the learning materials, instructors, peers and teaching media due to the use of interactive projector in the classrooms, resulting in extremely heavy cognitive load (Mayer & Moreno, 2003).

Recommendation

When an interactive technology is newly introduced into classes, pupils generally need a period of time to become accustomed (Clark, 1983). Hence the designed learning tasks should be appropriately scaffolded (Beauchamp, 2004), else students may spend too much time on writing and annotating rather than on learning.

In this study we developed a coding system for investigating classroom interactivity and primarily examined the effectiveness of the use of interactive projector on classroom interactivity and student learning outcomes. In future studies we would recommend that more research approaches, such as interviews and discourse analysis, could be conducted to further reveal the relationships between actions, interactivity, teaching efficiency and learning outcomes in the classroom.

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