INTEGRATION OF INTERACTIVE WHITEBOARD TECHNOLOGY TO IMPROVE SECONDARY SCIENCE TEACHING AND LEARNING

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Abstract: Brunei Darussalam, like many other countries, is concerned about secondary students' achievement in science subjects, as it relates to the demand and supply of professionals working in scientific areas regarded as essential for national development. This study describes the findings of an experimental research project that deals with the integration of interactive whiteboard technology in science teaching to improve students' learning outcomes, gender gap in learning outcomes and the implementation of the findings in Bruneian schools. The first stage of the project was designed to investigate whether or not the integration of interactive whiteboard technology in the Bruneian classroom would improve students' learning outcomes and minimize gender gap in learning outcomes, given that teaching and learning is a cultural activity. During this impact study, the mean gain in achievement score of an experimental group taught secondary science content using interactive whiteboard technology in a constructivist learning environment was significantly higher compared to that of a control group taught using the traditional approach. The learning outcomes were compared in terms of students' academic achievement. Moreover, non-significant and significant gender differences in mean scores for experimental and control groups respectively were observed. These results suggested that the integration of interactive whiteboard technology in Bruneian schools can gainfully improve science students' achievement and minimize gender gap in achievement to overcome the national problem experienced in Brunei. The implementation of these results on a large scale in schools required the training of teachers and making the interactive whiteboards available in classrooms. The perceptions of those teachers who have undergone training lend further support towards the suitability of the interactive whiteboard technology for teaching science. The finding of the experimental research and teacher perception of training can guide decisions of teacher trainers and ministry of education use this technology in teaching science.

Keywords: Interactive whiteboard technology, secondary science teaching & learning.

Introduction

The Brunei Deputy Minister of Education highlighted an existence of a gap in demand and supply of nationals in science related fields as more students are opting for arts rather than the science stream (Ahmad-Jumat, 2000). He also stated

that there are more girls than boys in the science stream. As a result Brunei has been heavily relying on the expatriate work force for some time to function effectively. Maimunah-Syed Zain (1999) asserted that many of the higher level professional jobs in Brunei are still dominated by foreigners and she also predicted that this domination will even continue even in 2011. In 2009, there were 28.9%, 52.8% and 17.3% of the jobs in professional fields, agricultural and fishery, the technical and associated-professional occupations are occupied by the expatriates. The Bruneian government is eager to train its nationals to replace the expatriates.

The problem of demand and supply of nationals in science related fields faced by the government is associated with the low number of students opting for science. This is because only those students who get good grades at the national examinations held at the end of lower secondary school (15-16 years old students) are opting for science subjects. Since the number of students passing with good grades (minimum C grade in science and mathematics) at lower secondary level is low, and heavy failure rates at upper secondary reduces the pool of students with background in science related fields. Furthermore, only a fraction of these students can join university for higher education. In the past it has been observed that the faculty of science have been training less than 10 graduates in physics and 10 in chemistry per year. The number of females who achieve the suitable grades to join institutes of higher education, including in science, is far greater than the males. Therefore, more female students are enrolled at institutes of higher education. For example, while considering the enrolment at the University Brunei Darussalam, there are only about 40 male students for every 100 female students. These issues are crucial for the Bruneian government to address.

The government has taken many initiatives to deal with this situation that is to improve students' achievement at high school level to increase the number of students opting for science stream and to minimize gender differences in achievement. These initiatives include, (a) Scholarships for bright students to study overseas, (b) Teaching bright students separately in a science college, (c) Educational assistance to all parents, (d) Increasing the number of universities in Brunei from 1 to 4; (e) Revising the educational system of the country; (f) Targeting future teachers to have master degree qualifications, (g) Emphasizing the importance of research in schools; (h) Allocating research funds and consultancies, (i) Incorporating information and communication technology (ICT) in teaching and many more.

The integration of ICT in teaching and learning in Brunei started in early 1980's. In 1984 computers were supplied to selected schools and in 1986, computer studies was introduced as subject at O-levels. In 1999 all primary and secondary schools were supplied with multimedia desktop personal computers, placed in a Computer Laboratory. In 2002 internet connections as well as notebooks were made available to schools. In 2005, a limited number of interactive

whiteboards were allocated to all academic institutions. Teachers were encouraged to develop their own resources and to share lessons from the interactive whiteboard users around the world using the Internet. The government also plans to implement the Knowledge Management System, e-Learning, Digital library, Virtual Library Information System projects to allow thousands of electronic resources, e-journals and references for the teaching and learning community to access information from anywhere the country. However this study concentrates on the impact of the interactive whiteboard on improving students' achievement and also minimizing the gender differences in achievement. Moreover, it describes the steps taken to train the pre-service and in-service teachers to use the interactive whiteboard in classes and also explores their perceptions about interactive white board training and importance of interactive whiteboard training in the teaching of science.

Literature Review

Academic achievement and gender issue has investigated in many educational research studies: For example in General Science (Beller & Gafni, 1996; Makrimi-Kasim, 2006; Monaliza-Abdul-Halim, 2001; Shahrizal-Emron, 2005; Young & Fraser, 1994), Biology (Burns & Bracy, 2001; Soyibo, 1999; Zoller & Ben-Chaim, 1990), Chemistry (Forrest, 1992; Klainin, Fensham, & West, 1989) and Physics, (Forrest, 1992; 1993). Most of these research studies have reported that traditional teaching is less effective in improving students' achievement (see Makrimi-Kasim, 2006; Monaliza-Abdul-Halim, 2001; Shahrizal-Emron, 2005). Research studies in the past have reported male dominance in achievement; however recently the situation is reversed. In Brunei too the female students outperform male students in general including in science; as a result more female students enter higher education institutions to study and the number of female students enrolled at institutions of higher education has increased remarkably (Makrimi-Kasim, 2006; Shahrizal-Emron, 2005). Although it is possible to argue that there is nothing wrong with it because every individual has a right to be the best that he/she can be, regardless of gender; however if this gap has adverse effects on the national socio-cultural development, then a need arises to minimize it. Jovanovic and Dreves (1998) have advocated a need to minimize the gender differences in students' academic achievement without compromising with achievement of one gender, which can help to avoid imbalances in social development.

Brain research studies have supported the finding that learning and gender differences in learning are associated with differences in brain development of male and females (Gunzelmann & Connell, 2006; Gurian, 2001; Kruglanski, 2007). Brain development is influenced by the environment and significant changes in protein synthesis responsible for long term memory have been observed in 10-30 minutes (Diamond, 2001; Mohammed, Zhu, Darmopil, Hjerling-Leffler, Ernfors, Winblad, Diamond, Eriksson, & Bogdanovic, 2002). This duration approximately matches with the one class period. Hence students' brain

development as well as achievement can be improved by modifying a learners' learning environment. Moreover, a learning environment that facilitates equal development of brain faculties in male and female should also minimize gender differences.

The whole education system is an example of the training of learners' brain faculties by creating a desired classroom environment, which is influenced by many factors including the use of technology. Connell and Gunzelmann (2004) proposed to create a supportive environment by including technology and providing equal opportunities in classrooms to help the males when they are lagging behind the females. The use of an interactive whiteboard in teaching has been reported to improve learners' learning environment by maintaining the pace of a lesson, increasing students' observation, communication, questioning, and, generating motivation of boys and girls to equal levels by adjusting the classroom learning environment (Passey, Rogers, Machell & McHugh, 2004), Researchers have reported many potential benefits of using Interactive Whiteboard in enhancing students' ICT competence and enriching their learning experiences (Smith, Higgins, Wall, & Miller., 2005). These benefits also include an increase in students' motivation (Smith, Hardman, & Higgins, 2006), engagement in learning because the interactive features attract their attention and increase concentration (Beeland, 2002; Dantzker, 2002; Kennewell & Beauchamp, 2003; Marzano, 2009; Slay, Siebörger & Hodgkinson-Williams., 2008;), achievement gains in various subjects (Jones, 2004, Kennewell, Tanner, Jones & Beauchamp, 2008; Quashie, 2009)and pedagogical benefits (Glover, Miller, Averis & Door, 2005; Smith et al., 2005; Slay et al., 2008) have been reported. However, the motivation effects rely heavily on teachers' attitudes and technological skills, and, most importantly, instructors' careful planning of IWB lesson activities (Glover, Miller, Averis & Door, 2007; Holmes, 2009).

It is known that technology itself might not contribute to students' performance unless teachers create a learning environment that stimulates students to be active, cooperative and take more responsibility in the learning process (Smeets & Mooij, 2001). This statement highlights the role of teacher training in using interactive whiteboard and fusing this technology with the lasted learning philosophy: constructivism. Ozdemir and Kilic (2007) identified inadequate knowledge and skills of the administrators, inspectors, computer coordinators, and classroom teachers as one of the problems with Information and Communication Technologies (ICT) integration in Turkey. Holmes (2009) also supported that providing appropriate training for teachers is one of the most important factors in the effective use of Interactive Whiteboards in classrooms. Short training often given to teachers might be enough for those confident in ICT but it is not adequate for most novice adopters (Smith et al., 2005). In other words, additional formal training sessions and informal learning channels should be arranged to make sure

that teachers catch the practical use of IWBs that is, providing opportunities for teachers to exchange ideas and work collaboratively in designing lessons related to the pedagogical practice of using Interactive Whiteboards. More important is the evaluation of effectiveness of training that has attracted little attention to ensure that teachers have achieved the intended standard. Recently Baran (2010) and Lai (2010) evaluated teachers' perception of training. Lai (2010) covered aspects associated with importance of Interactive Whiteboard training for teachers, and the effectiveness of Interactive Whiteboard in improving interaction and collaboration during teaching as well as simplifying the abstract concepts for teaching. In addition, Baran (2010) compared the pre-service computer teachers' familiarity with Interactive Whiteboard, anxiety in working with Interactive Whiteboard. Therefore, training teachers to become familiar with Interactive Whiteboard technology and to understand the best ways to use it are critical to assure the quality of technology integration in classrooms.

The studies on the impact of constructivist teaching on student learning suggest a significant positive improvement in students' achievement (Dhindsa & Anderson, 2004; Lord, Travis, Magill & King, 2000; Pratton & Hales, 1986; Santmire, Giraud & Grosskopf, 1999). In this study, it was hypothesized that the constructivist learning environment enriched with interactive whiteboard technology should stimulate active learning, discovery learning and higher-order thinking skills. The use of interactive whiteboard technology is relatively new in education. Its impact on male and female students' academic achievement when used in constructivist classroom environment is not clearly understood.

The above reported literature suggests that the traditional teaching is not an effective learning technique and also its effectiveness may be prone to creation of gender differences. The students' achievement can be improved and gender differences can be minimized by improving students' brain growth through modification of their learning environment. It was therefore hypothesized that it might be possible to improve students' achievement as well as to minimize gender differences in science achievement by changing students' learning environment by infusing interactive whiteboard technology and constructivism philosophy. The impact of constructivist-informed and interactive whiteboard technology-rich learning environment on improvement of academic achievement and minimization of gender differences in academic achievement is not clear. The authors therefore, decided to compare the achievements of two groups of students (including differences in male and female students' achievements) taught using (i) a constructivist teaching approach aided with interactive whiteboard technology for one group and (ii) a traditional teaching approach for the other group before integration of interactive whiteboard training to pre-service teachers training program and providing training workshops for in-service teachers.

Education and Cultural Context in Brunei

Brunei educational system consists of six years of primary education, six years of secondary education (3 years of lower secondary and 3 years of upper secondary), two years of pre-university and 4 years of undergraduate degree education at the university. There is a national examination at the end of primary school. Another national examination was at the end of lower secondary education, but recently it has been abolished. At the end of secondary education students take O-level; examination and at the end of pre-university students take A-level examination. O- and A-level examinations are conducted by Cambridge University, UK. Only selected students enroll in the universities to take four years honors degree programs.

Brunei, though small in size, is rich in cultural diversity. The major sources of cultural diversity in Brunei are the cultural variations within the Bruneian population as well as in temporary migrant populations. About 23% of the total population is temporary workers from many countries working in Brunei. A considerable fraction of migrant workers is involved in teaching in primary, secondary and tertiary institutions. Children of the migrant workers attend primary, secondary and tertiary educational institutions. Brunei is divided into four districts: Brunei - Muara, Beliat, Tutong and Temburong. The distribution of total population in Brunei - Muara, Beliat, Tutong and Temburong districts is 68.8%, 17%, 11.5% and 2.7%. The Tutong and Beliat regions have been named after the Tutong and Belait communities that have been living in these regions. The Bruneian population mainly consists of Malay, Kedayan, Tutong, Belait, Bisaya, Dusan, Murut, Iban, Kelabit and Chinese communities. The population (344500 estimated for 2001) of Brunei consists of 53% male and 47% female. On the basis of race, there are 73.8% Malays, 6% indigenous people, 14.8% Chinese and 11.4 % others. About 32% of the population is below the age of 15 years.

Objectives

The major objectives of the study were to investigate the effectiveness of the use of interactive whiteboard technology in constructivist learning environment to improve students' overall achievement in science as well as to minimize the gender differences in science achievement. This study also evaluated the perceptions of pre-service and in-service teachers' perceptions of interactive whiteboard training and its usefulness in teaching science. More specifically the research answered the following specific research questions.

(i) How effective was the interactive whiteboard technology used in constructivist teaching and learning environment to improve science achievement and to minimize gender differences in achievement?
(ii) How did the pre-service teachers perceive about their interactive whiteboard training during the methods of teaching course?
(iii) How did the in-service teachers perceive about their interactive whiteboard training during the workshop?

Methodology

This section is divided into two parts. The first part deals with research methodology associated with impact of Interactive Whiteboard technology on science student' achievement and gender differences in achievement, and, the second deals with pre-service and in-service teacher training.

Impact of Interactive Whiteboard on Science Student' Achievement and Gender Differences in Achievement

Subjects. The participants in the study were Form V (Grade 11) combined science students in four classes. Two of the four classes were taught with the traditional teaching approach and were called the traditional approach group (TAG). The other two classes were taught with the constructivist teaching approach with the aid of interactive whiteboard technology and were called the constructivist approach group (CAG). The traditional approach group had 58 students (25 boys and 33 girls) while the constructivist approach group had 57 students (23 boys and 34 girls). These groups were comparable on their mean science achievement in Form IV. However, to ensure that these groups were comparable on their prior knowledge of the topics content, a pre-test was given. In this way the boundaries of the study were set by the limited knowledge covered in the pre-, post-test and during intervention.

Over the past five years, about 1800 primary and secondary in-service teachers in the country have been trained to use the interactive whiteboard. Most of them were ICT teachers. During 2008, the training targeted science teachers and in 2010 target is to train mathematics education teachers. Moreover, 125 pre-service teachers have also been trained to use interactive white board. A sample of 30 pre-service and 30 in-service teachers' perception data on interactive whiteboard training were collected. A teaching practice also commented on a pre-service teachers' teaching, who used interactive whiteboard.

Achievement Test. The achievement test was used to evaluate students' topic related prior knowledge and the influence of the intervention. The test consisted of eight multiple-choice questions, five short-answer type questions and one descriptive type question. For each multiple-choice question, the students were required to select one correct answer out of four given response options. Short-answer type questions consisted of higher cognitive level questions. These questions required students to analyze graphs, tables and diagrams to answer questions that came with it. The essay type question required students to write an essay on a particular topic of Organic Chemistry. The students' responses to the pre- and post- tests were marked and the mean marks as well as mean gain scores were analyzed for gender differences in the total test marks as well as in the test sections using SPSS.

The achievement test was checked by two chemistry lecturers to match the relationship between taught and evaluated content as well as course objectives. To ensure the reliability and validity, the questions were selected from past O-level examination papers or were slightly modified versions.

Data Collection Procedure. This stage was conducted in three steps. During the first step, both groups were administered the achievement test as a pre-test. Step two involved teaching one group with the interactive whiteboard technology-rich constructivist approach and the other using traditional approaches. In step three, both groups were re-administered the same achievement test as a post-test. Using same test in pre- and post- situations may be considered as problematic however, it avoided a variable associated with the difficulty differences in two instruments.

Pre-service teachers were asked to grade (out of 10, 1 = lowest and 10 = highest) their training, practice and application during peer teaching. They were also asked write comments on these sections. Comments of a sample of 30 in-service teachers on their three days interactive whiteboard workshop training were video recorded and analyzed.

Content Taught. The content taught included lesson on fuels, name of compounds, homologous series, alkanes, alkenes and alcohols. More specifically, under the topic of Fuels: types of fuels (based on physical state at room temperature), uses of fuels, sources of fuels, processes involved from extraction of fuels from the ground to its use in cars, fractional distillation of crude oil and Cracking were discussed. Moreover, names, molecular and structural formulae, preparation, properties and uses of alkanes, alkenes and alcohols were also discussed.

Interventions. Chemistry lessons were conducted over a period of six weeks (one lesson per week). Each lesson conducted was a 60 minutes lesson. The teacher and students in the constructivist approach group utilized the interactive whiteboard and the ActiveStudio software, while the students in the traditional approach group did their lessons without the use of the computer technologies but using an overhead projector.

CAG students were taught in the ICT room where the interactive whiteboard and the software ActiveStudio were utilized in a constructivist teaching and learning environment. ActiveStudio software was used with both the interactive whiteboard and on students' computers. This software was also used to develop teaching materials on the topic of Organic Chemistry. The teaching material was designed to promote the constructivist teaching and learning environment, and, active participation of the students through collaborative work. For example, the content was arranged from known to unknown; the lesson started with the pictures of petrol station and students were asked to recall various types of fuels delivered at the petrol station. Similarly, the counting in malay satu (one), dua

(two), Tiga (three) were associated with carbon counting in organic chemistry meth, eth, prop and so on. In this way the students constructed their knowledge based on their activated prior knowledge. The students worked in small groups to answer the questions. For example, when students were asked to drag the words to label the fractional distillation plant, they were asked to complete this exercise on their computers before they were selected to complete it on the interactive white board. This helped them to challenge each other ideas before they agree to an answer; this helped them to minimize individual differences in their learning. The students were also given a set of worksheets and they were required to collaboratively complete the worksheet by making use of the teaching material available on their computers. The teaching material engaged the CAG students extensively and they were on problem solving tasks for most of their time. Before the end of every lesson, the CAG students were instructed to summarize the topic that they have learned in the lesson. Thereafter, the CAG students were asked to go over their summary as well as their class-notes to see what information they have missed out in their description. Then they shared their work with their peers to reorganize their constructed knowledge in order to minimize differences in the conceptions of different students.

The TAG students were taught the same organic chemistry content using a traditional teaching style. All the lessons were conducted in the Chemistry Laboratory. The teacher stood in front of class to deliver the content with the aid of the teacher's prepared transparencies and whiteboard. These two interventions represent two packages that are different in terms of use of technology as well as in the extent of constructivist teaching. The readers should note that this research reports the effects of these packages on the improvement of science achievement and the minimization of gender differences in chemistry achievement.

The success of an intervention depends upon the extent to which the planned activities are delivered in the classroom by the teachers. Therefore it was planned to verify the differences in teaching styles in control and experimental groups through observation of classes. The extent of above stated differences in CAG and TAG classes were verified through observation of teaching in these classes. An experienced teacher observed six lessons taught using a traditional approach and six lessons taught using constructivist informed technology rich approach. The teachers and students activities in these classes were observed and recorded using a systematic observation report format proposed by Flanders (1970). These observed teacher activities were summarized under five heading: Giving directions, Lecturing, Questioning students, Encouragement and Hands on activities. Similarly, the activities for students were also grouped under five headings: Answering questions, Asking questions, Interaction between students, Off Task and Silence. The mean incidences were recorded and compared to answer first question (see Table 1).

The students' data in the Table 1 show that significantly more questions were asked and less incidences of silence were observed in the CAG compared to TAG classes. The teacher data in the table also show a significantly (a) higher mean values for encouragement and hands-on and (b) lower for lecturing and questioning for CAG than TAG students. These results support that the extent of constructivist teaching in CAG compared to TAG classes was significantly higher. Also the CAG and TAG classes differed in terms of technology used. These results suggest that as planned the learning environments for two groups were significantly different with CAG students learning chemistry in interactive whiteboard technology-rich constructivist learning environment and TAG students in traditional setting.

Table 1: *Mean Number of Occurrences for Teachers' and Students' Participation and Interaction in the Classroom*

	Category	Mean ± SD		TAG vs. CAG	
	Type	TAG	CAG	F-value	p-value
Teachers	Giving Directions	3.4±2.0	5.3±3.3	2.19	.16
	Lecturing	15.6±4.8	5.0±0.6	28.58	.00
	Questioning Students	17.2±7.8	7.8±1.9	8.22	.01
	Encouragement	1.3±0.9	4.7±3.1	10.74	.01
	Hands-on	1.0±1.6	4.0±0.9	16.88	.00
Students	Answering Questions	12.4±5.7	9.2±1.0	1.82	.20
	Asking Questions	0.4±0.7	6.0±3.7	22.74	.00
	Interaction	2.0±2.2	4.5±2.8	3.93	.07
	Off task	1.3±1.2	0.3±0.8	3.18	.10
	Silence	4.1±1.4	2.5±1.4	5.09	.04

Statistical Analysis. Independent simple t – test was used to compare two groups. Effect size data were computed to classify statistically significant differences as low (ES=0.2), medium (ES=0.5) and high (ES=0.8) using Cohen's (1999) proposed scale.

Pre-service and In-service Training

Pre-service training: It was divided into three parts. The first part was a two hour session on the introduction to the interactive whiteboard (IWB) and its functions. An expert taught the students how to use various functions of IWB effectively for classroom teaching. The students were also introduced to a promethium website. The second part included a 4 hours practice session. During this time the trainees were asked to prepare a 10 minutes lesson for peer teaching (Not graded). They were encouraged to use the promethium site to practice IWB functions at home and in the computer laboratory whenever it was free. The third part required each

student to peer-teach a 25 minutes lesson. This lesson was graded as an assignment. The trainees were also encouraged to use the IWB during their one semester practice teaching in schools. Three of these lessons were graded.

In-service training. It involved a three days workshop. The expert taught the in-service teachers how to (a) use various functions of IWB effectively and (b) prepare IWB flip charts for classroom teaching. They also joined a community group headed by the expert. They uploaded their flip charts and the expert made suggestions for improvement. All members who join the community group could use the flipcharts available at site for their teaching.

Interactive-White-Board Facilities at the Schools. At this time, every school in Brunei has an IWB. Next year the government has plans to make IWB available in half of the teaching classes at primary schools and also in every science laboratory at secondary level. Each faculty at the university has at least two IWB. Other faculties than education are not using the board effectively. A workshop of how to use IWB effectively was conducted for lecturers in other faculties through the university teaching and learning centre.

Results

The results are discussed in two sections: (a) dealing with impact of interactive whiteboard technology on students' achievement as well as on gender differences in their achievement and (b) perceptions about the interactive whiteboard training of pre- and in-service teachers.

Mean Achievement of CAG and TAG Students

Table 2 shows the paired sample t-test analysis data for the pre- and post-intervention tests scores for the CAG and TAG students.

Table 2

Mean Pre- and Post-Intervention Achievement Test Scores for TAG and CAG Students

N	Mean ± S.D (%)		Pre- vs. Post-		Mean ± S.D (%)
	Pre-test	Post-test	t-value	*p*-value (ES)	Gain scores
42	30.82±2.73	56.29±7.45	-10.71*	.00 (2.16)	25.50±7.41
46	23.77±3.65	55.88±7.20	-14.94*	.00 (2.68)	32.08±6.99

* $p \leq .05$; ES: Effect Size; TAG: Traditional Approach Group; CAG: Constructivist Approach Group

The analysis of the gain in mean achievement data revealed a statistically significantly higher (p=.04) value for the CAG students compared to the TAG students with a large effect size of 0.91 despite their prior knowledge on the intervention content was lower than that of the TAG students. The mean gain in achievement scores for each of the TAG and CAG students was obtained by subtracting the pre-test scores from the post-test scores. These results suggest that the fusion of interactive whiteboard technology and constructivism improved the overall achievement of experimental students significantly more compared to traditional teaching. This finding gets further supports from effect size data for difference in pre- and post achievement scores for the CAG and TAG students. The effect size of 2.68 for CAG as compared to 2.16 for TAG students suggests that the improvement in the achievement scores from the pre- to the post-intervention was greater for the CAG students

The t-test analysis data show that there were statistically significant increments in mean scores from the pre- to the post-test for the students in both groups, with large effect sizes of 2.16 and 2.68 respectively. These results suggest that both teaching methods have helped the students to improve their learning. Similar results have been reported by Talib, Matthews and Secombe (2005). In the present study the post-intervention mean achievement scores for both the groups were above 50% suggesting the score to be in the pass range. These results are further supported by minimum (TAG = 28.13%, CAG = 27.08%) and maximum (TAG = 83.33%, CAG = 86.46%) marks for both groups. A mark of 80% or above is grade A in the Bruneian educational system. The standard deviation values also suggest that some students achieving mean test marks more than 60%, which is equivalent to a pass with credit in the local examination system.

Male and Female Students' Achievement

The data in Table 3 show that pre-test mean achievement scores of male and female TAG, as well as of male and female CAG students were statistically non-significantly different. These data suggest that the mean achievement of males and female students in CAG and TAG groups were comparable to start with and hence no gender differences in students' topic related prior knowledge. This finding is complementary to what is reported earlier that the mean science achievement scores in their previous class were comparable for these groups. However, the post-test mean achievement scores for both male and female TAG students were statistically significantly different (p = 0.000; ES = 2.48) in favor of female students. This difference was mainly caused by statistically significant higher gain score for female compared to male TAG students. The effect size value of 2.48 suggests that this difference is large and is of educational values. Hence the existing traditional teaching approach appears to be linked to the higher rate of enrolment of female students at institutions of higher education.

Table 3: *Pre- and Post-Mean Achievement Scores (%) on the Complete Test of Male and Female Students in Traditional and Constructivist Learning Environments*

Intervention		Gender		Male vs. Femal
Type	Status	Male	Female	p-value
Traditional	Pre	28.94±3.85	29.71±3.13	0.48
(TAG)	Post	47.92±7.66	63.92±5.09	0.00
	Gain	17.04±7.34	33.19±5.32	0.00
	N	20	22	
Constructivist	Pre	22.88±2.94	24.60±4.22	0.12
(CAG)	Post	55.77±6.99	55.94±7.55	0.94
	Gain	32.92±7.47	31.33±6.67	0.72
	N	22	24	

The data in Table 3 also show that the post-test mean achievement scores for male and female CAG students were also statistically non-significantly different. The mean gain scores for male and female CAG students were statistically non-significantly different, suggesting them to be comparable. These results suggest that the use of a fusion of interactive white board and constructivist teaching approach appeared to have encouraged both genders equally to minimize gender differences in achievement. The classroom observations revealed higher inter- and intra-gender communication in CAG group compared to TAG students and this might have contributed towards minimizing gender difference. Constructivist theory of learning supports that interactions among students help them to minimize differences in the information they have acquired during the lesson. Two ways ANOVA analysis supported that the minimizations of gender differences was caused by the significant interaction between the gender and teaching methodology. These results suggest that an interactive whiteboard technology-rich constructivist learning environment as defined in this study helps to minimize gender difference in students' achievement. Consequently, these results encouraged the incorporation of the interactive whiteboard training for pre- and in-service teachers. The perceptions of pre- and in-service teachers about training and its usefulness are reported in the following section.

Interactive Whiteboard Training for Pre- and In-service Teachers

Under this section perceptions of pre-service and in-service teachers about the interactive whiteboard training and use are reported.

Pre-service teachers' perception

Pre-service teachers were asked to grade (out of 10, 1 = lowest and 10 = highest) their training, practice and application during peer teaching. The mean marks for the training, practice and application sessions were 7.7±1.8, 7.0±2.3 and 8.3±1.1

respectively. These data suggest that pre-service teachers considered these session valuable. It is also important to note the highest mean for application of training during peer teaching. The comments from pre-service teachers and of a teaching practice supervisor are reported below.

Comments on training session

Comment A: "The training session was very informative and was delivered quite effectively as we are introduced to the use of interactive whiteboard which includes the ways of preparing flipcharts, actions, embedding videos and images as well as the use of resource packs and lesson from the website. The session offers great help to us because students as we are not familiar with the interactive whiteboard."

Comment B: "…..the speaker (conductor) made us amazed of how interactive whiteboard can make the lesson much more easy and fun. In addition, the students' can get involved too. The way he presented it caught our attention i.e. we did not feel sleepy."

Comments on practice session

Comment C: "The assigned time was quite adequate for students to practice the usage of interactive whiteboard and the option to use the room at any time makes it flexible and convenient for students to use the room during any time when they are free."

Comment D: "It is really beneficial as we are able to use the theory to practice. In the practice, we are able to undergo trial and error, so we are able to learn from the mistakes and find out how to rectify."

Comments on implementation session

Comment E: "This session provided opportunities for students to practice and use the interactive whiteboard before using it in schools. Therefore, students at least have knowledge on how to conduct a lesson using interactive whiteboard. Students as well have chances to improve the lesson by receiving comments from the lecturer and peers."

Comment F: "I guess using interactive whiteboard is very effective to be used during teaching except I need time to make the flipchart."

Comment G: "The session prepares the trainees before they do their teaching practice in schools. This help to make them to be aware of what they should or should not do, how to conduct lessons effectively and help them to self evaluate themselves. Students are also able to familiarize themselves with the active whiteboard when preparing their lessons."

Supervisor's Comments on implementation session during teaching practice

Comment H: "The use of the interactive board had a huge effect on the level of interest that the students showed in the content of the lesson. The seeming magic of the "board" used by a teacher, who was experienced in its effective use, had a kind of hypnotic effect on the students. They were really "switched on" and enthusiastic about what they were seeing and unconsciously learning."

In-Service Teacher's Comments

Comment I (Usefulness): "It is very useful. Teachers don't have to carry teaching materials from class to class. Preparing and editing the teaching materials in digital format is easy."

Comment J (Impact on teaching): "It provides opportunity to use a variety of teaching methods; increases participation of pupils; makes teaching more effective."

Comment K (Students' attitudes): "Pupils are eager to learn, enthusiastic and have fun in classroom when using IWB."

Comment L (Teachers liking of IWB): "preparation of lesson plan with the lesson development software provided with IWB."

Comment M (Overall): "Students get opportunities to use the IWB technology; Students are alert in their learning, they are very active when using the IWB; however the IWB should me made available in classrooms not only in special rooms."

Responses to Research Questions

How effective was the interactive whiteboard technology used in constructivist teaching and learning environment to improve science achievement and to minimize gender differences in achievement?

The results of this study revealed that the larger improvements in science achievement scores as well as in gain scores when the interactive whiteboard technology was used in constructivist teaching and learning environment compared to traditional teaching. Moreover, the use of interactive whiteboard technology also minimized the gender differences in achievement by helping the male students to achieve higher to catch up with female students.

How did the pre-service teachers perceive about their interactive whiteboard training during the methods of teaching course?

The pre-service teachers' quantitative and qualitative data support their positive perception of the implementation of interactive whiteboard training in their methods of teaching course. The observations of a teaching practice supervisor also supported these results.

How did the in-service teachers perceive about their interactive whiteboard training during the workshop?

The in-service teachers' qualitative data support that they have positive perception of the implementation of the interactive whiteboard workshop training.

Discussion

Classroom teaching and learning processes are complex and involve interactions among many variables (see Rennie, 1998) resulting in nonlinear accumulative effects. According to Dhindsa, Makarimi-Kasim and Anderson (2010) it is well known that teachers in a classroom do not use a single teaching technique, which adds to the complexity. Despite the above stated facts, a significant amount of research has been published to examine the effects of single variables in a classroom setting. As a contribution toward a more holistic view of these complexities, we have chosen to examine the roles of several coherent variables including interactive whiteboard technology and constructivist strategies in our experimental intervention. Therefore, the learning outcome of the study is the combined effect of use of interactive white board technology and constructivist teaching approach. It should not be interpreted as the impact of interactive white board alone.

According to Theroux (2004), the role of teachers has not only shifted towards being a facilitator and student motivator but also to structure the learning environment so that the students are able to take ownership of their own learning. The present study used a fusion of constructivist theory of learning and technology (ActiveBoard) to help students work collaboratively and actively acquire in small groups to construct and organize knowledge. Results of the study have shown that the use of technology in a constructivist teaching and learning environment has significantly improved the students' achievement scores on a chemistry topic. The mean gains in achievements for the CAG students were statistically significantly larger when compared to the TAG students. These results are different from what is reported by Mohamd–Zamri (2004). He reported no effect on students' science achievement when power point technology was used in traditional teaching environment. However the findings of the study reported in this paper are in line

with other study in which Smeet and Mooij (2001) stated that for the technology to contribute to students' performance, the teachers should create a collaborative learning environment in the classrooms. Interactive white board provides opportunities for pupils to collaborate in pairs or teams using subject-specific ICT resources and they are able to challenge each other's understanding and learn from such collaborations (Cox, Webb, Abbott, Blakeley, Beauchamp & Rhodes, 2003). Thus, if teachers intend to integrate technology in the curriculum as a tool for teaching and learning, special attention needs to be given to the classroom environment. The technology rich learning environment should allow the students to learn collaboratively in order to acquire, construct and reorganize their own knowledge. The observation data revealed that this aspect was emphasized during intervention for CAG students. Moreover, this aspect was also emphasized during the training of the teachers.

Owens and Waxman (1998) stated that one of the challenges of using technology in education is achieving gender equity in the achievements of students where inequities related to the use of technology by students have an effect on their academic outcomes. In this study the constructivist teaching approach with the aid of Interactive white board technology, unlike the traditional teaching approach, did not create gender difference in students' achievement. The results of this study are in line with finding reported by Kumar and Helgeson (2000). They reported that the use of Hyper equation software on Macintosh computers to solve stoichiometric chemistry problems helped to narrow down the gender gaps in achievements. It is suggested that application of the results of the present study will help the nation to improve the students' overall achievement in science and also minimize the gender difference.

According to Gerace, Dufresne and Leonard (1999), the use of technology to create a learning environment based on the constructivist epistemology, the students and teacher interaction was greatly enhanced and in turn affected learning, attitudes and motivation towards science. In the present study interactive whiteboard technology was used in a constructivist learning environment. The results of the present study are in line with those reported by Gerace, et al. (1999). The constructivist-informed and technology-rich learning environment used in the present study has not only helped to improve the overall gain score of the CAG students compared to TAG students but also has helped to minimize the gender differences in achievement. Moreover, the perception data of the pre- and in-service teachers provide valuable support for the use of this technology in the classroom situation.

According to Ozdemir and Kilic (2007) inadequate knowledge and skills of the classroom teachers as one of the problems with Information and Communication Technologies (ICT) integration in Turkey. Holmes (2009) highlighted the importance of appropriate training for teachers for the effective use of IWB in classroom. Smith et al., (2005) stated that short training often given to teachers might be enough for those confident in ICT but it is not adequate for most novice adopters. In the present study we have divided the training session for in-service teachers into three aspects dealing with training by an expert, practice session and peer teaching lessons using interactive white board. Also for in-service

teachers training involved expert introduction to tools of the interactive white board, preparation of flipcharts, the joining a community group, sharing their flipcharts followed by suggestion by the expert on teachers lesson preparation. The procedure reported above covered the concerns raised by the above researchers.

Lai (2010) while reporting teachers' perceptions of interactive white board training in Taiwan stated that teachers felt that IWB training for teachers is important in improving interaction and collaboration during teaching as well as in helping in teaching abstract materials. The findings of the present study concur with above finding. The in-service teachers also reported that interactive white board is a useful tool that not only helps them deliver quality lessons but also improves the students' eagerness, enthusiasm and enjoyment to learn. The teaching practice supervisor's comments lend further support for the interactive white board training and it use in classroom for effective teaching.

Ozdemir and Kilic (2007) stated that the inadequate attention has been paid to the professional, organizational, and cultural changes needed to realize the implementation of interactive white board project in Turkish schools. Science learning is also a cultural activity (Jegede, 1999). These authors emphasized that science learning and acceptance of technology are culturally sensitive. Therefore research done in one culture may not produce similar results in another culture. It is therefore important to evaluate the effectiveness of the interactive whiteboard technology in a culture before implementing it at large scale. The authors have combined evaluation of effectiveness of interactive whiteboard and its implementation aspects in Brunei context in the research reported here.

Based on the results of this study, teachers are encouraged to implement this new teaching technique to optimize achievement as well as gender equity in students' achievement. The use of interactive board requires teaching materials to be prepared differently than for simple whiteboard, therefore the Curriculum Development Department can use this study as a reference to modify the national curriculum and to prepare teaching materials. Teacher educators at University Brunei should include this strategy/methodology in their methods of teaching courses to train future teachers as well as to deliver their other courses Moreover, the Ministry of Education can use this research in the decision making to increase the number of trained local human resources in science related fields that are gender equilibrated.

Limitations

The present study involved 4 classes (two experimental and two control classes). Some readers may consider the sample size to be small. However, this is not a serious limitation as there are studies in the literature that used similar sample size (Dhindsa & Anderson (2004). The readers should consider that findings are limited to academic achievement only. The experimental and control students were comparable based on their previous years results. However, their pretest scores representing their topic related prior knowledge were different. A pure statistician

would recommend ANCOVA analysis. In this study the mean pretest score for the experimental group was lower than that of the control group. Based on constructivist theory adopted for teaching in this research, the construction of knowledge for experimental group should be slower than the control group as their topic related prior knowledge was lower. A higher level gain score with lower prior knowledge supports the effectiveness of the intervention. Therefore, simple statistics of comparing mean gain achievement using t-test was selected.

Conclusions

Improving the students' achievement in science related fields and minimization of the gender differences in achievement has been taken very seriously by researchers and practitioners working in the field of education including in Brunei. The constructivist-informed and interactive whiteboard technology-rich teaching and learning techniques reported in this study has improved the students' mean achievement and also have minimized the gender differences in achievement. This technique appears to be a potential solution to overcome these two problems experienced greatly in Brunei. The interactive whiteboard training at pre- and in-service teachers levels have been viewed positively by teachers. However the authors feel that the implementation is slow and more funds need to be allocated for implementing technology in schools. More research using students from different cultures, grades, different science topics as well as subjects is recommended to verify the results of this study. There is also a need to evaluate the impact of teachers' interactive whiteboard training on their students learning outcomes; this aspect is in planning. Future research to evaluate if this technique empowers girls in those cultures/countries where they are lagging behind the boys is recommended.

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