Using interactive whiteboard technology-rich constructivist learning environment to minimize gender differences in chemistry achievement

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In Brunei, more girls are enrolled at the institutions of higher education than boys. The aim of this study was to evaluate if a constructivist teaching approach, enriched with interactive whiteboard technology could empower males to minimize gender differences in achievement in Chemistry. Two groups of students were taught for six weeks: one group using the constructivist teaching approach enriched with interactive whiteboard technology and the other group using a traditional teaching approach. The results of the study demonstrated statistically significant gender differences in pre-test mean achievement scores of both the groups. There were statistically significant gender differences in post-test mean achievement scores for group taught traditionally, however, mean achievement scores of male and female students taught using constructivist approach were statistically non-significantly different. It is believed that this technique has potential to minimize gender difference in chemistry achievement. Implications of this research in Bruneian context are discussed and future research in this area is recommended.

Keywords: male empowerment, gender differences, chemistry

Introduction

Gender issue has been an intriguing factor that is being investigated in many educational research studies. For example gender differences in General Science (Beller & Gafni, 1996; 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) achievement scores have been reported. Research studies in other areas of science learning such as learning factors (Haynes, Comer & Hamilton-Lee, 1988), attitudes to science (Catsambis, 1995; Dhindsa & Chung, 2003), learning environment (Riah & Sabli, 2005), cultural learning environment (Dhindsa, 2005; Dhindsa & Fraser, 2004), student teacher interaction in classroom (Jones & Wheatley, 1990), achievement in different race groups (Catsambis, 1995), stereotypes of science and scientists (She, 1998), examination-type preferences (Dhindsa, Omar, & Waldrip, 2007; Zoller & Ben-Chaim, 1990), and choice of science subject (Ventura, 1992) have also reported gender differences. Most of the above studies report male dominance however in Brunei

situation is reversed. 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 female student enrolment number at the institutions of higher education has increased remarkably (Ahmad, 2000; MOE, 2005). For example recent statistics show that for every male students there are about 2.2 females at the Universiti Brunei Darussalam. At other institutions of higher education too, the number of female students is much greater than that of males. Although it is possible to argue that there is nothing wrong with it because every individual have right to be the best that he/she can be, regardless of gender, however if this gap has adverse effect on the national socio-cultural development, then a need arises to minimize it. Jovanovic and Dreves (1995) have advocated a need to minimize the gender differences in students' academic achievement, which can help to avoid imbalance in social development. There is a special need to consider this issue in Brunei because authors' informal discussion with past students presently employed revealed that female teachers are finding it difficult to find compatible partners. This view is in line with what Stephen (2007), a renowned local journalist, stated four years ago. However it is important to understand what causes gender differences in academic achievement before an attempt to its minimization.

The biological make up and socio-cultural environment in which males and females develop have been highlighted in literature as the major causes of gender differences. Brain development, compared to the development of the rest of the body of males and females is more important in an educational setting because the growth of dendrites of neurons and the interaction between neurons to develop brain structures occur during learning experiences (see a review by Kruglanski, (2007) of Prof. Bruce Wexter's book on Brain and Culture). Moreover, the development of brain is influenced by the environmental factors (Kruglanski, 2007). An environment in traditional classroom might encourage for development of lower quality memory structures for males than for females; which could result in gender differences in achievement. It is also known that genes and hormones do not fully account for sex differences in children's brains. The left and right hemispheres of male- and female-brains develop differently and they seem to vary in use of different parts of their brains effectively, each with some stronger left-hemisphere capacities and some stronger right-hemisphere capacities (Gunzelmann & Connell, 2006; Gurian, 2001). However, the recent developments in neuro-cognitive theory highlights that the idea that left hemisphere is exclusively the locus of analytical and verbal representations, and the right hemisphere is holistic and spatial are no longer tenable (Longo, Anderson & Wicht, 2002). Neither hemisphere is said to be the seat of mental imaginary (Brown & Kosslyn, 1993). Rather a broader view supports inter-hemispheric cooperation (Luh & Levy, 1995). It means that limitations of one hemisphere can be to some extent overcome by advantages of the other. A person can live a reasonably normal life with one hemisphere. It is known that in patients with half of their brain removed, the remaining half brain takes the responsibilities of the removed half with some training at the initial stage. Recent research also highlights that both genetic and environment play influential role in the development of the brain and a well designed experience physically changes the brain structures. According to Mohammed, Zhu, Darmopil, Hjerling-Leffler, Ernfors, Winblad, Diamond, Eriksson, and Bogdanovic (2002) enriched environment can increase the dimensions of the cellular constituents of the cortex at any age, and more specifically, it increases the glial/neuron ratio by increasing glial cells. They reported this ratio to be very high in Einstein's brain. The glial cells are metabolic cells and provide structural support to neurons. These changes therefore, appear to be associated with intelligence, learning and hence academic achievement. They also reported that enriched and stressed classrooms can increase and decrease the cortical dimensions respectively. ScienceDaily (2005) published a review of Prof. Daniel Johnston's research and reported, "Theta-bursts mimic the electrical stimulus that shoots through

neurons when animals perform a learning task. The researchers found that when stimulated with theta bursts, hippocampus neurons showed h-channel plasticity and a rapid increase in synthesis of h-channel proteins. The proteins were produced in the rat hippocampal neurons with in 10 minutes." Since h-channel protein synthesis is associated with long term memory storage, it is therefore possible to change memory organization with short learning experiences. Diamond (2001) reported that a short period as 40 minutes of enriched environment has been found to produce significant changes in RNA and in wet weight cerebral cortical tissue in mammals. Hence the development of the brain can be influenced by modifying a learners' learning environment and the individuals can be trained to use both hemispheres of brain effectively. Moreover, traditional teaching environment could influence the development as well as training of the brain differently in both genders. If we can create an effective learning environment that facilitates the development of brain faculties to almost equal level in males and females and by providing them training to use both hemispheres collectively and effectively, we hope to be able to minimize gender differences.

In addition to the role of biological makeup of males and females on their science achievement, there are other factors that contribute to students' achievement and gender differences in their achievement. For example seating arrangement in a classroom, teacher's biased behavior towards students from different cultures and even to male or female students, teaching technique, resources determine the nature of learning environment that contribute to gender differences in students' achievement (Delpit, 1988; Grossman, 1995; Harris, 1989; Lawrenz & Gray, 1995; Parker, Rennie & Harding, 1995; Santagata & Stigler, 2000). The research literature also reports that males and females students in coeducational science classes also experience instances of additional stress; it can affect their science achievement to different extents. Some of these instances include distraction from opposite sex students/teachers as well as teachers' authoritarian behaviour and negative attention (Hamilton, Blumenfeld, Akoh, & Miurta, 1991; Herr & Arms, 2004; Myhill & Jones, 2006; Popcorn & Hyperion, 2000). It has also been reported that female teachers demonstrate more negative perceptions of male students and the intensity of perception increased when teacher and student are from different ethnic groups (Dee, 2005). There are more female than male teachers in Bruneian schools. Research studies also report that male students are less accurate in interpreting non-verbal cues (Hyde, 2005; Larkin, 2003). This may be a reason male students are perceived disruptive as they are unable to interpret teachers non-verbal signals. By nature, male students like more active life style and participate in sports; therefore they can spare less time to study after school hours than their females counterparts (Chung, 1999). Moreover, they are likely to drift off or "space out" during a lesson when abstract science information was taught using traditional teaching approach to them as passive learners. The female students might also experience similar setbacks; but the impact of these conditions on male and female students may be different (Not known). It might have contributed to lower achievement of male students. However, it is known that male students are able to stay engaged in visual and/or hands-on learning (Dee, 2006; Gurian, 2001). Dee (2006) also reported that male students can be helped by tapping into their visual-spatial strengths using hands-on materials and technology. The boys are also known to be drawn more to computers because of their nature and also because of parental support and other environmental factors (Camp, 2002; Klawe, 2002).

Connell and Gunzelmann (2004), proposed to create a supportive environment by including technology and providing equal opportunities in the classrooms to help the males when they are lagging behind girls. However, there are studies that report no or little effect of the usage of technology and instructional material on science achievement and minimization of gender difference in achievement (Mohd-Zamri, 2004; Wang, Wang & Ye, 2002). These researchers fused techno-

logy in traditional teaching/learning environment. These studies suggest that benefits of using technology in traditional learning environment are reduced. However, when the use of technology in students centered environment was evaluated, the improvement of students' achievement and minimization of gender differences have been reported. For example, Shutte and Gawlick-Grendell (1994) compared the degree to which the computerized instruction (Stat-Lady) contributes to learning when compared to traditional paper and pencil instructions using workbooks. They reported that Stat-Lady encouraged active interaction in the learning process by using graphics, animations, speech and sound effects. This provided the students with a more appealing environment with colorful displays and sound effects that helped the students to perform better than students learning from the workbook. Kumar and Helgeson (2000) reported that the use of HyperCard Program for teaching how to solve stoichiometric chemical equations related problems produced no significant gender difference in academic achievement. They argued that the non-significant difference might be due to feedback provided by the interactive software. Barnea and Dori (1999) used computerized molecular modeling (CMM) for teaching and learning chemistry specifically in building molecules (An active learning process) to an experimental group and compared the performance to conventional teaching. They reported that CMM has improved students' cognitive aspects and showed no significant difference between the male and female students. Cantrell, Liu, Leverington & Taylor (2007) reported no gender differences in science achievement when three levels of interactive technology were integrated in learning. However, the study did not report the results on students learning without interactive technology.

The above studies tune with a published research that suggests that technology itself might not contribute to students' performance, unless teachers create an interactive learning environment that stimulates students to be active, cooperative and take more responsibility in the learning process (Smeets & Mooij, 2001). These are the characteristics of constructivist learning. The following studies lend further support to the above researchers' claim. For example, Balfakih (2003) reported a reduction in gender differences in chemistry achievement when traditional learning was replaced with an active cooperative group learning technique: student team-achievement division (Constructivist to some extent). A Harvard study on interactive engagement techniques in calculus based introductory physics classes for non-majors also found that the gender achievement gap completely disappeared with the integration of interactive engagement classes (Crouch, Lorenzo, & Mazur, 2006). These studies suggest that pupil-centered active learning technology rich learning environment may be required to minimise the gender differences.

Establishing student-centered active learning technology rich learning environment requires a shift from the traditional practice in classrooms to innovative lessons in which technology use is integrated into student-centered learning environments. Achievement of science students taught using constructivist –based teaching was far superior to those taught traditionally (Bimbola & Daniel, 2010)**.** Constructivist teaching involved linking of new knowledge to students' prior knowledge through their active participation in large and small group discussion to minimize differences in their cognition. Lord, Travis, Magill and King (2000) reported that student-centered learning not only have a higher average grades on their weekly quizzes but also showed more student participation, high levels of satisfaction, willingness to answer or ask questions and a better interest towards science when compared to students in the teacher-centered environment (Traditional). Santmire, Giraud and Grosskopf, (1999) also reported that students in a middle school environment who were involved in a social-constructivist approach to education achieved higher gains in standardized test scores than those students who were in the more classroom-based "abstract" instruction. Pratton and Hales (1986) reported that the mean science

achievement of the class taught with active participation was greater than the class taught without active participation. Dhindsa and Anderson (2004) reported that conceptual change approach can be a useful way to educate chemistry teachers to be flexible in their thinking and to reorganize their ideational networks which may help them become more capable of dealing with individual student's cognitive differences and experiential diversity in their classrooms. This study highlights the role of constructivist teaching/learning in training the brain faculties by altering the learning environment. Makarimi-Kasim (2006) compared the achievements of two groups of students taught physics using constructivist teaching approach enriched with mind- mapping (G1) and traditional teaching (G2) approaches. His data (multiple choice questions) demonstrated highly significant gender differences in post-intervention test scores for G2 but not for G1: thus highlighting the value constructivist teaching/learning technique in minimizing gender differences in science achievement. These studies support that constructivist teaching involve students in active learning that is not available to students in traditional learning. The male students who are passive learners in traditional environment are expected to become active learners in constructivist learning environment. Therefore the use of constructivist teaching/learning approach was selected in this research. It involves learning in large and small groups to minimize differences in students' cognition of scientific concepts. However, integration of this approach with appropriate technology is essential.

The interactive whiteboard is a latest interactive technology. Its use in classroom can help us present the objects and events more closely to the real world to simulate the learners' environment very close to the real world. It has been reported that with the use of interactive whiteboard technology, researchers have managed to maintain the pace of a lesson, increase students' observation and interaction, communication and questioning, and, generate motivation of boys and girls to equal levels (Passey, Rogers, Machell & McHugh, 2004). Other studies suggest that an interactive whiteboard is a superior technology for classroom practices (Dantzker, 2002) to help gain and keep students' attention because of the large visual display with a variety of representation and increased students' participation (Kennewell & Beauchamp, 2003). In other words students remain engaged when interactive whiteboard is used. Beeland (2002) reported that the use of the interactive whiteboard in the classroom leads to increased student engagement and the effectiveness of the whiteboard was highly correlated with the type of media that was used. These studies suggest that interactive white board technology can provide improved and conducive learning environment to engage male students for effective learning to catch up with females.

The above discussions suggest that the interactive whiteboard technology-rich constructivist learning environment could stimulate active learning, discovery learning and higher-order thinking skills. A shift from the traditional teaching style to constructivist teaching enriched with interactive whiteboard technology would provide more opportunities at equal level in learners' own socio-cultural contexts of living environments to both genders in a classroom situation. It will generate an environment in which the both sexes can benefit to almost equal extent in training their brain faculties as well as improving their academic achievement. It was therefore, hypothesized that the use of interactive whiteboard technology in a classroom teaching using constructivist approaches can influence classroom environment that will help similar cognitive development in both male and female students to minimize gender differences in their academic achievement in all areas including science subjects.

Since interactive whiteboard technology is relatively new, its role in minimizing gender differences in academic achievement when used in constructivist classroom environment is not well understood. Therefore, it was decided to evaluate the role of constructivist teaching approach enriched with interactive whiteboard technology in minimizing the gender differences. To

achieve this, it was decided to teach two groups of students (the authors are aware of that it is impossible to get comparable groups, which is the major limitation of educational experimental research; however, in this study an attempt was made to account for differences in the groups during intervention) using (i) a constructivist teaching approach aided with interactive white-board technology for one group and (ii) a traditional teaching approach for the other and to compare the extent of gender differences in mean achievement gain scores. These two approaches were distinctly different in the extent of use of technology and constructivist teaching. The differences in teaching and learning in the classes of these two groups of students were evaluated by an experienced independent observer using a systematic observation report format (Flanders, 1970). More details on these teaching approaches are provided in the methodology section of this report.

Aims

The purpose of this study was to investigate the effectiveness of using a (a) interactive white-board technology-rich constructivist teaching approach and (b) traditional teaching approach in minimizing the gender gap students' mean achievement scores. The mean achievement score was obtained using an achievement test in organic chemistry consisting of multiple choice (MCQ), short answer and essay questions. The present study attempted to answer the following research questions: (i) how does the effect of gender on students' achievement compare in constructivist-informed technology-rich and traditional learning environments? and (ii) How do the effects of gender on students' achievement on MCQ, short answer and essay questions compare in constructivist-informed technology-rich and traditional learning environment?

Rationale of the Research

According to the Deputy Minister of the Education of Brunei, there are more girls than boys in Science streams (Ahmad, 2000). Moreover there are more female students enrolled at institutes of higher education. The data in the Figure 1 supports this concern. The data in the figure shows that the number of boys enrolled per 100 girls is higher at primary level and almost equal at secondary level and lower thereafter. For example, during 2005 overall male enrolment at Universiti Brunei Darussalam was about 40% of female students. Moreover, the male enrolment at the institutions of higher education over the past three years has shown a declining trend (MOE, 2005). A gradual decrease in number of male students at Religious Teacher Training (RTT) and the institutes of technology is also demonstrated in Figure 1.

Gender difference with respect to science knowledge has been clearly established (Kahle & Meece, 1994). For example, boys in United States are doing better than girls in problem solving (Longo, Anderson & Wicht, 2002). However, they reported no gender differences in conceptual understanding. In Asian countries like Thailand and Brunei, girls compared to boys are doing better academically (Klainin, Fensham, & West, 1989; Fraser-Abder, 1990; Chung, Riah, & Dhindsa, 2001). This gender gap does have social and economical implication. Therefore it is important to minimise this gender gap by improving classroom practices.

Methodology

Subjects

The participants in the study were grade 11 (16 Years old) 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 white board 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). When their grade 10 (15 Years old) science achievement scores were considered, these groups were comparable on their mean achievement; however, to ensure that these groups were comparable on their topic related prior knowledge of 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.
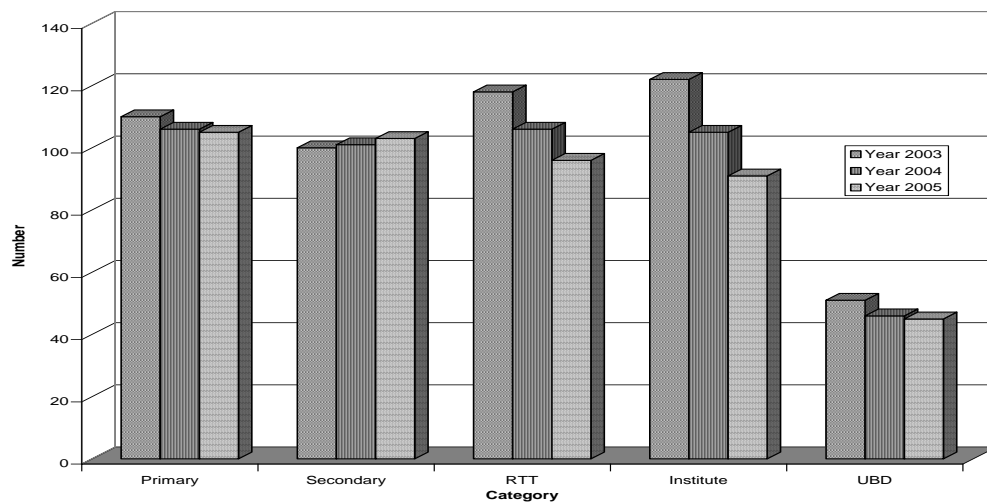

Figure 1. Number of male students (Number) enrolled per 100 female students. RTT = Religious
        Teacher Training; UBD = Universiti Brunei Darussalam (data from MOE, 2005).

Achievement Test

The achievement test used to evaluate students' topic related prior knowledge and influence of the intervention consisted of eight multiple-choice questions (Example: Given the structure of ethene, the students should select the hydrocarbon group to which it belongs to), seven short-answer type questions (Example: Given a graph showing boiling points range (-200 $^{\circ}$C to 150 $^{\circ}$C) on X-axis and Number of carbon atoms (1-8) on Y-axis; the students should (a) describe the trend; (b) find the boiling point of an alkane with 9 carbon atom; (c) indicate on the graph the alkanes in liquid phase at room temp 25°C) and one descriptive type question (Example: the students should write an essay on alkanes.). The overall content taught is described in the following section. The test was developed by the authors. The rationale for the selection of three types of questions was to cover the taught syllabus and to provide a variety of questions to students. The selection was also guided by Hamilton's (1998) research, who reported that per-formance gaps between males and females varied across formats (multiple-choice versus constructed-response). For each multiple-choice question, the students were required to select one correct answer out of four given response options. They were also required to write the logic for selecting their responses in the multiple-choice section so that more information can be

obtained on the students' understanding of chemistry concepts. 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 analysed 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. Most of the questions were from past O-level examination papers or were slightly modified versions.

Content Taught

The content taught included lesson on fuels, name of compounds, homologous series, alkanes, alkenes and alcohols. More specifically, under Fuels topic, types (based on physical state at room temperature), uses, sources, processes involved from extraction from ground to its use in cars, fractional distillation 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 utilised the interactive whiteboard and the ActiveStudio software, while the students in the traditional approach group did their lessons without the use of the technologies using overhead projector.

CAG students were taught in the ICT room where the interactive whiteboard and the software ActiveStudio were utilised 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. The students were 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 summaries 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 reorganise their constructed knowledge in order to minimise 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 minimization of gender differences in chemistry achievement.

Data Collection Procedure

The interventions using both the constructivist-informed technology-rich and traditional approaches were conducted in three stages. In the first stage, both groups were administered the achievement test as a pre-test. Stage two involved teaching CAG students with interactive whiteboard technology-rich constructivist approach and the TAG students using traditional approaches. In stage 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 (effect of pre-exposed questions) however, it avoided a variable associated with the use two instruments that are rather difficult to be of equal difficulty.

Observation data

An experienced teacher observed 6 lessons taught using a traditional approach and 6 lessons taught using constructivist informed technology rich approach. He observed and recorded the teachers and students activities in these classes 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 observed 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 statistically using N value of 6 to show the differences two data sets were of educational importance and to answer first question. The authors are aware of N value being small, but similar values have been used to make statistical comparisons in the literature (Dhindsa & Anderson, 1992)

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	Effect size
Teachers	Giving Directions	3.4±2.0	5.3±3.3	2.2	.16	-
	Lecturing	15.6±4.8	5.0±0.6	28.6	.00	2.6
	Questioning students	17.2±7.8	7.8±1.9	8.2	.01	1.4
	Encouragement	1.3±0.9	4.7±3.1	10.7	.01	1.6
	Hand On	1.0±1.6	4.0±0.9	16.9	.00	2.0
Students	Answering Questions	12.4±5.7	9.2±1.0	1.8	.20	-
	Asking questions	0.4±0.7	6.0±3.7	22.7	.00	2.3
	Interaction	2.0±2.2	4.5±2.8	3.9	.07	-
	Off task	1.3±1.2	0.3±0.8	3.2	.10	-
	Silence	4.1±1.4	2.5±1.4	5.1	.04	1.1

TAG = Traditional Teaching Group; CAG = Constructivist Teaching Group; N = 6 for CAG as well as for TAG groups.

Differences in students' learning and teacher' teaching in classes for both groups

The observation data on teachers' teaching in the Table 1 shows that the mean occurrences for lecturing and asking questions to students were higher and for hands-on lower for TAG than

CAG students. This is typical for traditional teaching where teachers spent most of the teaching time in lecturing and transmitting knowledge to students who are seated in gender segregated rows. The CAG teachers compared to TAG teachers encouraged their students to a greater extent because CAG teachers were guiding the students during hands-on activities and they were visiting various groups rather than lecturing from the front of the class. All these differences were statistically significant with large effect size values.

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 students. Though differences were non-significant, however classroom student interaction was higher and student off-task incidences were lower for CAG than TAG students. These results support that the extent of constructivist teaching in CAG than TAG classes was significantly higher. Moreover, the CAG and TAG classes differed in terms of use of technology. These results suggest that as planned the learning environments for two groups were significantly different with CAG group learning chemistry in interactive whiteboard technology-rich constructivist learning environment and the other in traditional one. This extent of difference in learning environment appears to have influenced the achievement scores of CAG and TAG students reported in the following sections.

Statistical analysis

Since it involved comparison of two groups, therefore an independent simple t-test was used. The 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.

Results and Discussions

The results in this section are discussed in three sections to answer the research questions reported in the aims section.

How does the Effect of Gender on Students' Achievement Compare in Constructivist-informed Technology-rich and Traditional Learning Environments?

This section deals with overall test data for TAG and CAG male as well as female students. Moreover the gender differences in gain scores are also compared. The data in Table 2 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 there were 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 favour of female students. The effect size value of 2.48 suggests that this difference is large and is of educational values. The mean scores for CAG and TAG female students were non-significantly different. Hence the existing traditional teaching approach appears to be linked to the higher achievement scores for female students that appeared to have increased their numbers at the institutions of higher education.

Table 2. Pre- and post-mean achievement scores (%) on the complete test of male and female students in traditional and constructivist learning environments

Intervention Type	Status	Gender		Male vs Female	
		Male	Female	p-value	Effect size
Traditional (TAG)	Pre	28.9±3.9	29.7±3.1	0.5	0.2
	Post	47.9±7.7	63.9±5.1	0.0	2.5
	Gain	17.0±7.3	33.2±5.3	0.0	2.5
	N	20	22		
Constructivist (CAG)	Pre	22.9±2.9	24.6±4.2	0.1	0.45
	Post	55.8±7.0	55.9±7.6	0.9	0.0
	Gain	32.9±7.5	31.3±6.7	0.7	0.2
	N	22	24		

N value under each set was applied to Pre, Post and Gain data categories.

The data in the table also show that the post-test mean achievement as well as gain scores for male and female CAG students were also statistically non-significantly different, suggesting them to be comparable. These results suggest that the constructivist teaching package appeared to have encouraged both genders equally to minimize gender differences. The higher inter and intra-gender communication as planned for CAG group than for TAG students might have contributed towards minimizing gender difference. These results suggest that interactive whiteboard technology-rich constructivist learning environment as defined in this study helps to minimize gender difference in students' achievement. However, it is important to investigate how the male and female students from TAG and CAG groups differed in achievement on MCQ, Short answer and Essay questions.

The pre- and post-test mean scores in Table 3 show statistically significant ($p=0.0$) difference in mean achievement scores for MCQ section for all the six data sets of TAG and CAG students. These results suggest significant gender differences in pre- and post-intervention mean achievement data for both teaching packages. In case of traditional teaching, the effect size value for the post- compared to pre- intervention increased from 2.6 to 14.2 suggesting an increase in gender differences in mean achievement scores in favour of girls. This is also reflected in mean gain scores, where the mean gain in achievement score was statistically significantly higher for female compared to male students. However for CAG students the effect size value decreased from pre (5.4) to post (4.9) suggesting interactive whiteboard technology-rich constructivist learning environment helped to minimise the gender differences in mean achievement to some extent. The effect size for mean difference in gain scores for males and female students was higher for TAG (2.5) compared to CAG (1.1) students. The gain score for TAG female compared to male students was higher; however the trend was reversed for CAG students, where the mean gain score for male students was higher by about 2 points.

These results suggest that the package comprising of interactive whiteboard technology-rich constructivist learning environment helped to minimise gender differences in mean achievement score when MCQ responses were recorded to be correct without accounting for their correct logic for selecting a response, which is commonly practiced to mark the MCQs. This practice is based on the teachers' assumption that students understand the knowledge required to answer the question. Since it is well known that while answering MCQ, students can select correct response

with partial knowledge, it was therefore decided to evaluate the data when students' logic for selecting responses was considered. The next section reports the data when students' response and logic was correct. Hence the mean percent achievement scores are lower suggesting a gap between conceptual understanding and selecting correct response for MCQ questions.

Table 3. Pre- and post-mean achievement scores (%) on the mcq without logic section of the test of male and female students in traditional and constructivist learning environments

Intervention Type	State	Gender		Male vs Female	
		Male	Female	p-value	Effect size
Traditional	Pre	50.6±1.5	47.0±1.3	0.0	2.6
(TAG)	Post	71.9±1.7	90.9±0.8	0.0	14.2
	Gain	21.2±1.9	43.9±1.7	0.0	2.5
	N	20	22		
Constructivist	Pre	36.9±1.5	43.8±1.6	0.0	5.4
(CAG)	Post	84.6±1.2	89.6±0.8	0.0	4.9
	Gain	47.8±2.0	45.9±1.5	0.0	1.1
	N	22	24		

N value under each set was applied to Pre, Post and Gain data categories.

The TAG students' data in Table 4 show statistically significant gender differences in pre- and post-test mean scores. Moreover a significant gender difference is also present in the mean gain scores. The differences in pre-test scores were in favour of male students, however in post-test and gain scores, the differences were in favour of female students. The effect size data suggest that the differences are large and they increased from pre- to post-data. However for CAG students, the statistically significant gender differences in achievement scores (large based on effect size value of 2.3) that existed in the pre-intervention data decreased to statistically non-significant. Moreover, for CAG students the mean gain scores were also comparable as reflected by statistically non-significantly different mean values. These results also suggest that in Brunei, to some extent the traditional teaching technique is associated with creation, whereas the interactive whiteboard technology-rich constructivist learning environment with the minimization, of gender differences in academic achievement when evaluated using MCQ and students' correct understanding of chemistry concepts. The readers should also note that the mean gain score for TAG females was significantly higher that for CAG females. These are the responses of students for whom both the response to question are logic were correct. It is not clear if traditional teaching to more effective than constructivist approach used in this study for such students when learning is evaluated using response to MCQs with logic for choosing the response. This issue can be addressed under a different research project.

The TAG students' data in Table 5 show statistically significant (p=.00, ES = 1.24) large gender difference in pre-test mean scores for short answer section of the achievement test. This difference increased in the post-test data as reflected by an increases in effect size value (P= 0.0, ES = 1.6). However, the mean gain scores were statistically non-significantly different. These differences in pre- and post-test data were in favour of females students. However, for the CAG students, the pre-test mean scores of males and females were statically non-significantly different

(p=.1, ES = 0.6) suggesting non-significant gender differences to start with. However, the p-value of 0.1 suggests the borderline difference. The post-test data though suggest a statistically significant gender difference (p=0.0, ES = 1.1) in the favour of male students, but the effect size value is lower than that for TAG students. The mean gain scores for male and female CAG students, though higher than for TAG students, were statistically (p=.2, ES = 0.4) non-significantly different (comparable).

Table 4. *Pre- and post-mean achievement scores (%) on the mcq with logic section of the test of male and female students in traditional and constructivist learning environments*

Intervention		Gender		Male vs Female	
Type	State	Male	Female	p-value	Effect size
Traditional	Pre	19.7±2.1	18.0±2.0	0.0	0.8
(TAG)	Post	42.1±5.2	64.0±3.6	0.0	5.0
	Gain	23.4±5.5	47.0±4.5	0.0	5.0
	N	20	22		
Constructivist	Pre	13.3±1.8	18.0±2.3	0.0	2.3
CAG	Post	51.9±5.3	54.5±4.8	0.1	0.5
	Gain	38.6±5.5	36.5±4.9	0.1	0.4
	N	22	24		

N value under each set was applied to Pre, Post and Gain data categories.

Table 5. Pre- and post-mean achievement scores (%) on the short answer questions section of the test of male and female students in traditional and constructivist learning environments

Intervention		Gender		Male vs Female	
Type	State	Male	Female	p-value	Effect size
Traditional	Pre	37.6±2.8	40.7±2.3	0.0	1.2
(TAG)	Post	51.5±2.7	55.3±2.2	0.0	1.6
	Gain	13.9±1.9	14.6±2.3	0.3	0.3
	N	20	22		
Constructivist	Pre	32.5±1.9	31.2±2.6	0.1	0.6
(CAG)	Post	50.6±2.2	48.2±2.4	0.0	1.1
	Gain	18.1±2.6	17.0±2.5	0.2	0.4
	N	22	24		

N value under each set was applied to Pre, Post and Gain data categories.

The TAG students' data in Table 6 show statistically significant gender difference in mean scores on the essay section of the achievement test for pre-test, post-test and the gain scores. An increase in effect size value from 1.60 to 15.16 suggests an increase in gender difference in pre-

to post-test data for TAG students. The mean gain and the post-test scores for females were higher than for males. However, for the CAG students, the gender differences in all the three sets of data (pre, post and gain) were statistically non-significant with low effect size values.

Table 6. Pre- and post-mean achievement scores (%) on the essay answer questions section of the test of male and female students in traditional and constructivist learning environments

Intervention		Gender		Male	vs
				Female	
Type	State	Male	Female	p-value	Effect size
Traditional	Pre	3.6±0.4	3.0±0.4	0.0	1.6
(TAG)	Post	24.0±1.1	41.8±1.2	0.0	15.2
	Gain	20.0±1.1	38.2±1.2	0.0	15.8
	N	20	22		
Constructivist	Pre	0.7±1.1	0.7±1.2	1.0	0.0
(CAG)	Post	43.6±1.6	44.2±1.6	0.2	0.4
	Gain	43.6±1.6	44.2±1.6	0.2	0.4
	N	22	24		

N value under each set was applied to Pre, Post and Gain data categories.

In summary, the above results revealed that in general the gender differences in achievement on the total test as well as on its sections for students who learned the organic chemistry content using traditional teaching technique either increased or persisted after intervention. However, for the students who learned the same content using the interactive whiteboard technology-rich constructivist technique, gender differences in achievement mostly decreased. In general, the decrease in differences in mean achievement scores of male and female students have occurred by empowering mainly male students without lowering much of the gain scores for female students except in case of MCQ data in Table 4. This is what Brunei needs. These results suggest that interactive whiteboard technology-rich constructivist technique can be used to minimize gender differences in achievement by helping the male students achieve better.

Discussion

The results of this study revealed that the use of constructivist teaching approach with the aid of technology minimized the gender difference in achievements unlike the traditional teaching approach. Owens and Waxman (1998) sated 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 the present study, equal opportunities to use the interactive white board technology were provided to both genders. The interactive white board allows the use of colour and sound effects for presentations, simulations, videos and interactive activities that match closely with the real life situations. The students find these activities interesting and they stated engaged during teaching. In this way, the use of constructivist teaching approach enriched with interactive white board technology, created a classroom environment in which all students were actively engaged though out the lesson that

encouraged active learning. The active learning environment encourages the growth of and interaction between neurons for the development of brain structures linked to long term memory (Kruglanski, 2007). Male students by nature prefer action. It appears that the impact of such teaching/learning environment could have helped the male students to develop their memory structures that matched with that of females; thus minimization of gender differences occurred. 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. However, these results are different from those where technology in traditional learning environment demonstrated no effect on the male and female students' achievement (Mohamd-Zamri, 2004).

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 that affected learning, attitudes and motivation towards science. The present study encouraged large and small group discussions before students were involved in individual learning activities. Moreover, inter-gender interaction was encouraged for CAG students. This learning environment was more cooperative learning. The cooperative learning comparative to traditional has been reported to reduce gender differences in chemistry achievement (Balfakih, 2003). The use of interactive whiteboard technology and constructivist teaching approach provided conditions for active learning that not only helped the male and female students' overall chemistry achievement but also minimsed gender differences in achievement by improving the learning environment for male students to learn effectively. The impact of interactive whiteboard technology, constructivist learning approach and their interaction used in the present study appears to have improved the overall gain score of the CAG students compared to TAG students as well as it also has helped to minimise the gender difference in achievement. The results of the present study are in line with those reported by Gerace, et al. (1999). They reported that the use of technology to create a learning environment based on the constructivist epistemology, the students and teacher interaction was greatly enhanced that affected learning, attitudes and motivation towards science.

The effect size data in this study revealed that the extent of gender difference in achievement and its minimization for TAG and CAG students was different for multiple choice, short answer and essay type questions. Similar findings have been reported by Hamilton (1998). He reported that performance gaps between males and females varied across formats (multiple-choice versus constructed-response). These findings suggest that gender differences in achievement may also be linked to our evaluation techniques and type of questions asked. Wimmer & Dhindsa (2010) reported that the quality of response is influenced by the type of question asked by the teacher. A response to a question would require activation, retrieval and transport of appropriate concepts from long term memory to frontal lob, where concepts are connected using connectives (is, am, are etc) to make a sentence and to add context before it is conveyed orally or in written format as a piece of information. A demand on our central nervous system for activation of highly connected concepts increases in the following order: MCQ (without logic) < MCQ (with logic) < short answer < essay type of questions. A diverse set of responses in a multiple choice question often require activation of concepts in partially or unconnected memory structures; whereas, essay type question would requires a large number of connected concepts. Is this demand on our central nervous system created by the type of question asked and response required responsible for creating gender differences in achievement; how it can be minimized in both genders? These questions need to be investigated in future.

According to Parker, Rennie and Harding (1995) female students receive less attention than boys from their teachers in classroom, which encourages gender inequity. This may be the effect

of seating arrangement, because seating arrangement not only influenced the teacher attention but also students' active participation in the classroom activities. The TAG male and female students sat in different rows, which is a common practice in Bruneian schools and is an accepted practice in the local culture like many other cultures of the world. However, the CAG students were seated differently to the traditional classroom where the mixed seating arrangement allowed more inter- and intra-gender interactions and collaborative work. Thus, it can be argued that by allowing the male and female students grouped together under teacher supervision to create a learning environment that allows them to work collaboratively in constructing their knowledge would minimise gender differences in achievements that have emerged in the traditional teaching approach. Although local culture limits the mixing of opposite genders, however, under the supervision of teacher it should be acceptable (Dhindsa, 2005). Therefore, it is also recommended that teachers use this teaching approach to achieve gender equity in their classes to help more students achieve better grades in science subjects and in turn will encourage them to pursue their studies further in science related fields. Further studies on the effects of increased inter-gender communication on students' achievement and gender difference in achievement are recommended.

Teachers can use the results of this study to implement this new teaching technique to optimize achievement as well as gender equity in students' achievement. Since the use of interactive whiteboard requires teaching materials to be prepared differently than the use of simple whiteboard, therefore, curriculum department can use this study as guide to modify the national curriculum. The teacher trainers can include this methodology in their methods of teaching courses to train future teachers. They can also adapt this technique for their own teaching needs. Moreover, this research enriches the Ministry of Education to make educational decisions to increase trained national human resources in science related fields that are gender equilibrated.

Conclusions

Minimization of gender differences in achievement has been taken very seriously by researchers and practitioners working in the field of education. In Brunei, this gender differences has created a gender gap in enrolment (more girls than boys) at the institutions of higher education. Interactive whiteboard technology-rich constructivist teaching and learning technique reported in this study has minimised the gender differences in achievement. This technique appears to be a potential candidate to overcome gender differences in science achievement. However, more research using students from different cultures, grades, different science topics as well as subjects is recommended to verify the results of this study. Also future research is recommended to evaluate if this technique empowers girl students in those cultures/ countries where female students are lagging behind the boys.

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Kimya başarısında eşey farkılığının en aza indirilmesi için etkileşimli beyaz tahta teknolojisi-zenginleştirilmiş oluşturmacı öğrenme ortamı

Brunei'de yüksek öğretimde erkeklere nazaran daha fazla kız bulunmaktadır. Bu çalışmanın amacı kimya başarısında eşey farklığını en aza indirerek erkeklere anantaj sağlayacak etkileşimli beyaz tahta teknolojisi-zenginleştirilmiş yapılandırmacı öğretme yaklaşımını değerlendirmektir. İki grup öğrenci altı hafta öğretime tabi tutulmuştur: birinci grupta etkileşimli beyaz tahta teknolojisi-zenginleştirilmiş yapılandırmacı öğretme yaklaşımı, ikinci grupta geleneksel öğretme yaklaşımı kullanılmıştır. Çalışma sonuçları her iki grubun öntest başarı puan ortalamaları ile ilgili olarak istatistiksel anlamlı eşey farkını göstermiştir. Yapılandırmacı yaklaşımın kullanıldığı grupta erkek ve kız öğrencilerin son test ortalama başarı puanları arasında istatistiksel olarak anlamlı bir farklılık bulunmazken, geleneksel öğretime tabi tutulan grupta son test başarı puanları arasında istatistiksel olarak anlamlı bir eşey farkı vardı. Bu tekniğin kimya başarısında eşey farkını en aza indirmek için bir potansiyele sahip olduğuna inanılmaktadır. Brunei bağlamında bu araştırmanın etkileri tartışılmış ve bu alandaki gelecek araştırmalar için önerilerde bulunulmuştur.

Anahtar kelimeler: erkek gücü, kimya eğitimi, etkileşimli beyaz tahta teknolojisi