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Scientific Inventive Thinking Skills among Primary Students in Brunei

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Abstract

The main purposes of this study are to determine the inventive thinking skills of students in Brunei and to compare the inventive thinking skills with regards to gender and school location. This study, which employed cross sectional surveys method involved some 500 Primary school students from Brunei. Analysis of the finding revealed that primary students in Brunei demonstrated low mean scores on creativity, higher order thinking and sound reasoning. It is also shown that there exist statistically significant differences in inventive thinking skills among students with regard to gender and school location.

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Keywords: Inventive thinking skills; science, self direction, curiosity, creativity

1. Introduction

The 21st century different in the capabilities people need for work, citizenship, and self-actualization than 20\textsuperscript{th} century. Therefore, society’s educational systems must transform their objectives, curriculum, pedagogies, and assessments to help all students achieve the outcomes required for a prosperous, attractive lifestyle based on effective contributions in work and citizenship. Many groups providing advice on the topic of schooling for the 21st century (ETS, 2002; NCREL/Metiri, 2003; Partnership for 21st Century Skills, 2006; Leitch Review of Skills, 2006; AACU, 2007). The 21st century has seen a dramatic shift in the economic model for industrialized countries (Dede, Korte, Nelson, Valdez, & Ward, 2005). According to Chang (2003), systems of economic development based on geography, trade rules, and scientific and technological discoveries, rapid product innovation, and rapid global deployment and movement of capital and the means of production. Hence, in the early 21st century, income and wealth come from applying technology and new ideas to create new products and processes. Moreover, adding value to products and processes is the key to growing jobs and incomes in this new economic environment (Aubert & Reiffers, 2004). Stevens & Weale (2003) stressed that in this new economic environment known as the New Economy requires education plays an important role in maintaining national prosperity and stimulating economic

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growth. The New Economy is driven by entrepreneurs, technology, and innovation. New ideas, discoveries, and technologies have produced new industries and products. Consequently, innovation is now more important and essential for income and wealth generation (Sianesi & Van Reenan, 2002). Moreover, OECD (2004) confirmed the application of information technology to the very core of business operations has caused a profound change in the needed skills and talents of New Economy workers. Markets in the New Economy are rewarding those who have high educational achievement and technical skill (Task Force on the Future of American Innovation, 2005). As a result, the worker of the 21st century must have science and mathematics skills, creativity, fluency in information and communication technologies, and the ability to solve complex problems (Business-Higher Education Forum, 2005). Therefore, to accomplish this we must transform children’s learning processes and engage student interest in gaining 21st century skills and knowledge. Linking economic development, educational evolution, workforce development, and strengthened social services is essential to meeting this challenge (National Academy of Science, 2006). But what are 21st century skills? Why is 21st century imperative to our education and the students?

The main objective of this paper is to determine the inventive thinking skills of Science students in Brunei. Thus, the study will contribute on knowledge of Science students’ performance in inventive thinking skills. In addition this study will also provide the relevant authorities such as Ministry of Education in Brunei and other countries information regarding the students’ achievements and also level of inventive thinking skills of the students in Science. Correspondingly, it is anticipated that these findings will provide a framework for the development of policy for pedagogical methodology and curriculum innovation and adaptations for schools in Brunei Darussalam.

2. Literature review

2.1 Science Education in Brunei Darussalam

Science subject is one of the core subjects for upper primary school in Brunei Darussalam since 1982. In 1987, The Primary Science Curriculum was reviewed. As a result, the outcome was the development of a separate Upper Primary Science Syllabus that was implemented in 1990. In 2000, the syllabus has been revised and now been replaced by a new Upper Primary Science Curriculum. The learning process emphasised more on the development of communication through enquiry, conceptualising, reasoning, and problem solving learning skills. Traditionally, the mode of instruction emphasis on teacher as a transmitter of specialised information, but with new syllabus, teacher act as a facilitator of learning using a variety of instructional techniques. Process skills such as analysing, classifying, communicating, comparing, evaluating, inferring, measuring, and observing were taught through the activities in the new syllabus and various projects done by the schools.

In order to developing thinking skills amongst the learners, the Brunei Ministry of Education (MOE) has introduced CoRT (Cognitive Research Trust) Thinking Programme as a pilot project in 1993 to six secondary schools. The project was then extended to include all secondary schools through workshops conducted in 1997 and 2000. Several efforts have been made by the MOE to introduce and make thinking explicit in the teaching and learning. The Curriculum Development Department has also conducted several thinking skills workshops for subject teachers, Geography (2000), History (2001), Science (2002), English Language (2003) and Commerce (2004). In addition, CORT, KWL, Graphic organizer, mind mapping were some of the strategies that had been implemented in Brunei to integrate thinking skills in the teaching and learning process. Yet, previous research done by researchers revealed that students in Brunei were low in problem solving and critical thinking skills.

Furthermore, several researches were also conducted in Brunei on students’ achievement, teachers teaching strategies used in Science and Scientific thinking skills. According to Sonia (2006), only 18% of the secondary school students were enrolled in Science subjects and the numbers tend to decrease yearly. The decrease of the students in Science subjects was due to several factors such as lack of motivation and poor achievements in Science at secondary level. In addition, research conducted by Fauziah and Dhindsa (2006) on 857 students of Form 1 and Form 2 elite schools in Brunei Darussalam with regards to students scientific skills namely; observing and measuring, interpreting of data, inferring, predicting and concluding, investigating, reasoning and problem solving. The results of the finding revealed that the scientific skills such as reasoning and problem solving skills had low mean score and it need to be improved. The findings of the study also revealed that in spite of the students’ high achievement in their academic performance as well as co-curricular activities, the reasoning and problem solving skills of the students was at the lowest level amongst the scientific skills. Moreover, Md Noor (2007) had conducted
a study on teaching thinking skills to teachers in Brunei Darussalam. The result of the study confirmed that teachers need more training and exposure on strategies of teaching thinking skills. The results of the study revealed that students prefer their teachers to use traditional teaching strategies in their class. 87% of the respondents agreed that thinking skills were not able to be integrated to their lesson because of time constraint while 86.75% of the respondents asserted that they were not able to implement due to exam oriented type of curriculum. As result of that, Brunei introduced Ministry of Education’s Strategic Plan 2007-2011. This signals the ministry’s intentions to upgrade and reform Brunei Darussalam’s education system and its achievements in education.

The Ministry of Education’s commitment towards excellence in education, as reflected in its vision and mission statements are seen as imperatives in view of the current climate of rapid change and increasing competition in the educational environment. Critical and fundamental changes to the education system have been introduced through a newly proposed system known as the National Education System for the 21st century or in Malay, Sistem Pendidikan Negara Abad Ke-21 (SPN 21). In line with this aspiration, the SPN 21 curricular documents are aimed at meeting the goals of the Ministry of Education’s Strategic Plan on Quality Education. Existing curricular programmes have been restructured to bring them in line with 21st century needs and skills. The SPN 21 curriculum sets out to provide a holistic education that can meet the all round development of the individual. The national education system of Brunei Darussalam (SPN 21) is aimed at maximising the intellectual, spiritual, emotional, social and physical potential of every individual. This can be achieved by developing the learners’ thinking skills and equipping them for life-long learning necessary in an ever-changing world. The emphasis on the needs and importance of developing thinking skills amongst our youth was pointed out by His Majesty The Sultan during the Teacher’s Day celebration in 2007. In relation to that, thinking skills is one of the essential skills highlighted in the new National Education System for the 21st century or Sistem Pendidikan Negara Abad Ke-21 (SPN 21). It is to be made explicit in the teaching and learning for all levels of schooling, either at primary or secondary level. The emphasis of thinking skills in teaching and learning would lead to a change in the teaching pedagogy.

Thinking skills is not a new thing in the teaching-learning process. It has been there for ages. However, it is not explicitly taught to the learners. Studies indicated that mere exposure to tasks that require thinking does not on its own have a significant impact on learners’ thinking abilities (Beyer, 2000; Swartz, 2000). Those skills need to be taught explicitly through modelling, guided practice and training. The rationales of thinking skills in SPN 21 curriculum are:

i. The capacity for lateral and systematic thinking amongst the learners can be improved and enhanced in order to dig sideways and escape from imprisoning ideas and develop new ideas;

ii. Thinking can be developed directly and explicitly with simple and systematic approaches rather than as by-product of attention to specific subject areas;

iii. Excellent academic achievement does not necessarily mean that the learners’ thinking has been developed effectively and fully. In fact, their achievement can be enhanced if their thinking skills are more developed; and

iv. Learners need to be equipped with the necessary key, tools, problem solving and decision making skills for life-long learning in an ever-changing world. They need to be critical and creative in exploiting stimulants, information and ideas.

Therefore, Ministry of Education in Brunei hopes that by implementing the SPN 21 it will improve students’ achievements and their inventive thinking skills in Science.

2.2 Inventive thinking skills

The elements of the 21st century learning outcomes are the skills, knowledge and expertise students should masters to succeed in work and life in the 21st century. According to the enGauge, 21st century skills (NCREL, 2003) consist of of digital age literacy, inventive thinking, effective communication and high productivity. Digital age literacy refers to basic literacy, scientific literacy, economic literacy, and technological literacy, visual literacy, and information literacy, multicultural and global awareness. While effective communication refer to teamwork and collaboration, interpersonal skills, personal responsibility, social responsibility and interactive communication. Inventive thinking skills consist of adaptability and managing complexity, self direction, curiosity, creativity, risk taking, higher order thinking and sound reasoning. EnGauge (2003) stated that high productivity refer to prioritizing, planning, managing for results, effective use of real world tools and ability to produce relevant and high quality
products. According to the Partnership definition, 21st century learner must learn the following subjects and complementary skills:

i. Core academic subjects include English, reading or language arts, world languages, arts, Maths, Economic, Science, Geography, History, government and civics;

ii. Interdisciplinary themes to be woven into each subject such as global awareness, financial, economic, business and entrepreneurial literacy, civic and health literacy;

iii. Learning and innovation skills woven into each subject include creativity, innovation, critical thinking, problem solving, communication and collaboration;

iv. Information, media and technology skills required of today’s students include information literacy, media literacy, communications and technology literacy and career skills such as “soft skills” needed to navigate in today fast paced, high technology world. They include flexibility, adaptability, initiative and self direction, social and cross cultural skills, productivity, accountability, leadership and responsibility.

According to enGauge 21st century skills, inventive thinking is comprised of adaptability and managing complexity, self direction, curiosity, creativity, risk taking, higher order thinking and sound reasoning. Adaptability and managing complexity of inventive thinking skills refer to the ability to handle multiple goals, tasks, and inputs, while understanding and adhering to constraints of time, resources and systems. This ability enable the students to recognize and understand that change is a constant, and to deal with change positively by modifying their thinking, attitude or behaviour to accommodate and handle this new environment. While self direction refer to students’ ability to set goals related to learning, plan for the achievement of those goals, independently manage time and effort, and independently assess the quality of learning and any products that results from the learning experience. Curiosity refers to the students’ desire to learn more about something and is an essential component of lifelong learning. Next, creativity is the acts of bringing something into existence that is genuinely new and original, whether personally (original only to the individual) or culturally. These imply that students’ are able to produce something new or original that is either personally or culturally significant. The student’s willingness to think about a problem or challenge, to share that thinking with others and to listen to feedback is known risk taking. Risk taking also defined as a willingness to go beyond a safety zone to make mistakes, to creatively tackle challenges or problems with the ultimate goals of enhancing personal accomplishment and growth. Whilst higher order thinking and sound reasoning refer the cognitive processes of analysis, comparison, inference and interpretation, evaluation and synthesis applied to a range of academic domains and problems solving contexts. The students are able to compare analysis, make inference and interpretation, evaluation and solve problem solving in the tasks given to them and in their everyday life.

Therefore, an inventive thinking skill is one of the important components of 21st century skills both in enGauge 21st century skills and Partnership for 21st century skills. Consequently, 21st education should equipped students with inventive thinking skills. Partnership for 21st century skills affirmed that we must move from primarily measuring discrete knowledge to measuring students’ ability to think critically, examine problems, and gather information, collaboration communication, creativity and innovation required for success in their future.

3. Methodology

3.1 Research design

This study employed cross sectional surveys method to determine Science inventive thinking skills of students in Brunei. This study has been implemented to Year 5 primary school students in Brunei. While the inventive thinking skills consists of six domains namely adaptability and managing complexity, self direction, curiosity, creativity and higher order thinking and sound reasoning.

3.2 Sample of the study

500 (215 male, 285 female) of Year 5 students in Belait district are involved in this study. The researcher employed stratified sampling to ensure equal distribution of sample according to gender and school location.
The questionnaire was divided into seven sections. Section A consisted of questions on student’s background and demographic namely, age, gender, level of class, race and student’s grade in Science. While section B consists of 34 items on inventive thinking skills which comprised of 5 items on adaptability and managing complexity, 4 items on self direction, 5 items on Curiosity and creativity, 3 items on risk taking and 10 items on higher order thinking and sound reasoning. Cronbach’s alpha coefficients were calculated to estimate the internal consistency of the instruments. Values obtained for the various scales ranged from 0.58 to 0.73 (see Table 1). The instrument was considered suitable for the purpose of the present study. Furthermore, these values were comparable to data reported in the literature (Francis & Greer 1999, Fraser 1989, Jegede & Fraser 1989). Fraser (1989) reported that the alpha coefficients in the range of 0.58 to 0.81 indicate the instrument has satisfactory reliability. Therefore, the values of the alpha coefficients suggested the instrument displayed adequate internal consistency.

<table>
<thead>
<tr>
<th>Dimension</th>
<th>No. items</th>
<th>Cronbach’s Alpha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adaptability and managing complexity</td>
<td>5</td>
<td>0.58</td>
</tr>
<tr>
<td>Self direction</td>
<td>4</td>
<td>0.61</td>
</tr>
<tr>
<td>Risk taking</td>
<td>3</td>
<td>0.59</td>
</tr>
<tr>
<td>Curiosity</td>
<td>5</td>
<td>0.70</td>
</tr>
<tr>
<td>Creativity</td>
<td>6</td>
<td>0.69</td>
</tr>
<tr>
<td>Higher order thinking and sound reasoning</td>
<td>10</td>
<td>0.73</td>
</tr>
</tbody>
</table>

N = 500

The alpha reliability coefficient for the overall items in the instruments was 0.75. This high values of the reliability coefficients indicated all the six items in the instrument possessed internal consistency. High order thinking and sound reasoning had the highest alpha reliability coefficient of 0.73 while the lowest alpha reliability coefficient was adaptability and managing complexity which was 0.58.

3.4 Data processing and analysis

Data collected is descriptively analysed, which specifically focused on students’ inventive thinking profiles. Subsequent to that, t-test analysis was operated to determine whether students’ inventive thinking skills differed according to gender and school location.

4. Finding and Discussion

The findings of the study indicated several outcomes as succinctly described in Table 2. The findings revealed students (N=500) scored satisfactory mean value in adaptability and managing complexity in Science (M=3.09, SD=0.48). This result also confirmed that students in Brunei has achieved significantly satisfactory on adaptability and managing complexity of inventive thinking skills. The students were able to handle multiple goals, tasks, and inputs. These abilities enable the students to recognize and understand that change is a constant, and to deal with change positively by modifying their thinking, attitude or behaviour to accommodate and handle this new environment.
<table>
<thead>
<tr>
<th>Dimension</th>
<th>Mean</th>
<th>SD</th>
<th>level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adaptability and managing complexity</td>
<td>3.09</td>
<td>0.48</td>
<td>satisfactory</td>
</tr>
<tr>
<td>Self direction</td>
<td>2.95</td>
<td>0.47</td>
<td>satisfactory</td>
</tr>
<tr>
<td>Risk taking</td>
<td>2.79</td>
<td>0.52</td>
<td>satisfactory</td>
</tr>
<tr>
<td>Curiosity</td>
<td>2.42</td>
<td>0.45</td>
<td>satisfactory</td>
</tr>
<tr>
<td>Creativity</td>
<td>1.72</td>
<td>0.69</td>
<td>low</td>
</tr>
<tr>
<td>Higher order thinking and sound reasoning</td>
<td>2.15</td>
<td>0.61</td>
<td>low</td>
</tr>
</tbody>
</table>

Results analysis on self direction (M=2.95, SD=0.47) and risk taking (M=2.79, SD=0.52) of inventive thinking skills also showed that the students scored satisfactory mean value. This imply that they were able to set goals related to learning, plan for the achievement of those goals, independently manage time and effort, and independently assess the quality of learning and any products that results from the learning experience. Furthermore, results on risk taking thus confirmed that students were more willing to go beyond a safety zone to make mistakes, to creatively tackle challenges or problems with the ultimate goals of enhancing personal accomplishment and growth. Moreover, they were willing to think about a problem or challenge and to share that thinking with others and to listen to feedback given by their peers. According to Osman (2009) student should be engage in discussion about numerous approaches and potential solutions and also a safe place that enable them to share ideas, reflect on and discuss perspectives and learn new things. In addition, result on curiosity revealed (M=2.42, SD=0.45) students’ desire to learn more about new lesson and activities that were given to them. However analysis on creativity asserted that students in Brunei scored low mean value (M=1.72, SD=0.69). The results on creativity affirmed that students in Brunei were not able to acts of bringing something into existence that is genuinely new and original, whether personally (original only to the individual) or culturally. These also imply that majority of the students were not able to plan and produce something new or original that is either personally or culturally significant. Therefore, teachers must engage students in creative, constructive and student centred learning activities. Moreover, students should be given more freedom and opportunity to explore in their learning process through student centred approach. A creative classroom should allow more time for open-ended questioning, digression from the text, and for the development of creative thought (Bredekamp & Copple, 1997; Jones, 1993; Wassermann, 2000). The results of the study above concluded that creativity of the students should be emphasised in the classroom. The students who were exposed to varieties of activities that can enhance creativity and were given freedom to explore in their learning process had increased in their creativity.

Higher order thinking and sound reasoning refer the cognitive processes of analysis, comparison, inference and interpretation, evaluation and synthesis applied to a range of academic domains and problems solving contexts. From Table 2, the results revealed that the students scored mean value on higher order thinking and sound reasoning (M=2.15, SD=0.61). Therefore, the results affirmed that students very poor in comparison, inference and interpretation, evaluation, synthesis and problem solving skills. Many researchers in science education concluded that students often have the domain knowledge but still lack the skills to solve science problems (Chi et al, 1981; Hobden, 1998; Osborne adn Dillon, 2008). The results of this study are similar to findings previous researches by some researchers in Brunei. Research done by Fauziah and Dhindsa (2006) on 857 students of form 1 and form 2 elite schools in Brunei Darussalam indicated that the scientific skills such as reasoning and problem solving skills had low mean score and it need to be improved. The findings of the study stressed that in spite of the students’ high
achievement in their academic performance as well as co-curricular activities, the reasoning and problem solving skills of the students was at the lowest level amongst the scientific skills. A study was employed by Sokol et al. (2008) which aimed at the development of student’s inventive thinking skills through Thinking Approach (TA) in language teaching and learning. The study was conducted among upper secondary students of two schools in Latvia. The results of the study suggested that students working with the TA demonstrate a significant increase in inventive thinking skills in comparison with the control group (t=3.32, p=0.001).

Table 3. The effect of gender and school location on inventive thinking skills

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Interaction</th>
<th>Significant value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inventive thinking skills</td>
<td>Gender</td>
<td>0.003</td>
</tr>
<tr>
<td>Inventive thinking skills</td>
<td>School location</td>
<td>0.001</td>
</tr>
</tbody>
</table>

Significant at p<0.01

From Table 3, the results of the findings confirmed that there are significant differences on students’ inventive thinking skills with regards to gender and school location. The female students performed better in their science inventive thinking skills compare to male students. Additionally, students in urban areas achieved better result in science inventive thinking skills than rural areas. Study conducted by National Assessment of educational progress (NAEP, 2005) confirmed that gender differences in science achievement have been thought to keep female from pursuing advanced courses and career in science (Katz et al, 2006). Progress in International Reading literacy study of 2001 also revealed that fourth grade females scored higher than fourth grades males in 33 countries worldwide (Mullis, Martin, Gonzales & Kennedy, 2003; Ogle et al, 2003). Several researchers such as Campbell, Hombo & Mazzeo (2001), Marx and Roman (2002), and Hargreaves (2005) support this argument. However, Halpern et al. (2007) argued that biological factors, students’ attitudes, motivation, educational history on students’ conceptual learning, educational policy and cultural context affect the number of women and men who pursue advanced study in Science.

5. Conclusion

This study determined the science inventive thinking skills of students in Brunei with regards to gender and school location. The results of the finding affirmed that students in Brunei achieved satisfactory level on four dimensions of inventive thinking skills namely adaptability and sound reasoning, risk taking, self direction and curiosity. On the other hand, the students had scored low mean on creativity and higher order thinking. Thus, the students should not confine to the traditional method of teaching and learning and inventive thinking skills should be cultivated among the students at an early age. The most important aspect of teaching pupils an inventive problem solving is to create a climate of thinking and problem solving in the class. Beyond the direct teaching of terms, thinking schemes and heuristic related to inventive thinking and problem solving, it is important to give the pupils the time and opportunity to develop their own thinking methods and explain or justify their ideas. Since an inventive thinking skill is one of the important components of 21st century skills. Students in 21st century need to apply inventive thinking skills as well as developed new skills to cope and thrive in this changing society. Therefore, 21st education should equipped students with those skills to ensure that education plays an important role in maintaining national prosperity and stimulating economic growth. The New Economy is driven by entrepreneurs, technology, and innovation. Markets in the New Economy are rewarding those who have high educational achievement and technical skill (Task Force on the Future of American Innovation, 2005). As a result, the worker of the 21st century must have science and mathematics skills, creativity, fluency in information and communication technologies, and
the ability to solve complex problems (Business-Higher Education Forum, 2005). To accomplish this we must ensure students are equipped with those skills and engage their interest in gaining 21st century skills and knowledge.

References


