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Promoting thinking skills: an evaluation of effectiveness of invention project

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ABSTRACT

This study looks at the students' perceptions on the effectiveness of the invention project showcased at USIM Young Inventors Fair in promoting critical and creative thinking among the First Year Bachelor students of Universiti Sains Islam Malaysia (USIM). 350 students were involved in this quantitative study which aimed to assess the students' perceptions on the effectiveness of using an invention project in promoting their thinking skills. An invention project was assigned whereby students were to reflect on the critical and creative thinking skills they have acquired while completing the project. Results revealed that the students perceived that the invention project has indeed contributed in promoting their critical and creative thinking skills. Most of them reported that they had benefited through their involvement in the invention project. All 18 assessed statements have mean scores below 2 and the standard deviations are less than 1. Thus, using the invention project is indeed an effective way to promote critical and creative thinking skills of the students.

Introduction

Thinking is undoubtedly an important activity in our daily life. Yet, we often hear complaints, especially from teachers, that our students simply do not think. The absence of thinking is somehow over taken by rote learning, where students tend to memorise, imitate and 'regurgitate' what they have learnt, rather than attempting to produce fresh and more creative ideas.

What then, are the attributes of a good thinker? Based on Costa and Lowery (1989), there is a list of attitudes of effective thinkers. Tishman, Jay and Perkins (1992) also highlight seven central good thinking dispositions. In fact, there are many ways to make thinking visible. According to Tishman & Perkins (1997), one way is for teachers to use the language of thinking like hypothesis, reason, evidence, possibility, imagination, perspective.

The need to acquire thinking skills is very much in line with the National Education Philosophy which states: *"Education in Malaysia is an on-going effort towards further developing the potential of individuals in a holistic and integrated manner, so as to produce individuals who are intellectually, spiritually, emotionally and physically balanced and harmonic, based on a firm belief in and devotion to God. Such an effort is designed to produce Malaysian citizens who are knowledgeable and competent, who possess high moral standards and who are responsible and capable of achieving high level of personal well-being as well as being able to contribute to the harmony and betterment of the family, the society and the nation at large".*

Here, it is evident that developing more holistic, critical and creative learners is indeed one of our major educational concerns. Hence, it is the responsibility of educators to promote thinking skills, directly or indirectly.

The ability to think critically and creatively is essential for students to live, work, and function effectively in the current and changing society. Students need to choose, evaluate and judge many aspects in the activities of their daily lives, which include obtaining information and taking actions. And as adults living in a complex, yet democratic world, they need to effectively select, process and use information. All these require critical and creative thinking. Nonetheless, at the same time, national and state evaluations have indicated that a high percentage of students in schools are not able to use critical and creative thinking skills effectively. Business and industry too continue to report that many fresh graduate employees are not able to think critically and creatively in job situations. From a report on My3S (*Malaysian Soft Skills Scale*) by the Ministry of Higher Education, the score for Critical Thinking & Problem-solving (CTPS) element is the lowest compared to the scores of other elements. This is true to all public universities in Malaysia, including Universiti Sains Islam Malaysia (USIM). The Ministry has then called upon some effective measures in handling this phenomenon. In response to this, an invention project, a component in the English Language Support Programme 3 (ELSP 3), was designed to promote thinking skills. The inventions were showcased at the USIM Young Inventors Fair.

English Language Support Programme (ELSP)

There are three parts of the ELSP, namely ELSP 1, ELSP 2, and ELSP 3. It is a compulsory programme for all first year students of every faculty at USIM main campus. ELSP 1 is conducted in the first semester during the orientation week for new first year students. It is an 18-hour programme which focuses on communicative English. Activities like drama, role play, literary appreciation, grammar and study skills are included. Other components involve motivational talks, dictionary skills and classroom-based lessons that aim to uplift the interest of new undergraduates in using the English language. The main objectives are to provide exposure, and generate interest in English which is hoped to create awareness and liking toward the language. By inculcating this positive attitude, it is expected that students can master the English language. The ELSP 2, as the name suggests, is the second phase of the ELSP which directs the students toward the practice of particular elements of the MUET (Malaysian University English Test) examination. Various strategies and techniques

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concerning MUET are planned for the students, with much hope that they will be more prepared to sit for the examination. ELSP 2 includes study skills activities, presentations, poster presentation, forum, public speaking, interview skills and debate. This 30-hour programme is very much geared towards MUET in order to give students the early and much needed exposure to the national entry exam. ELSP 3 is the final string of the ELSP programme which comprises 28 hours of face-to-face meetings, extended over 7 weeks. This programme serves as a platform for students to learn and apply all the four skills of the English language- namely listening, speaking, reading and writing, in a freer and informal context. Many consolidation and enrichment activities are carried out so as to encourage students to use English extensively. The finale is a group (or class) masterpiece where each group is to present an assigned final project in the form of presentation (or production) of related issues. In ELSP 3 2008/2009, the final project was an invention project, exhibited at the USIM Young Inventors Fair. It is through this project that thinking skills were encouraged among students. As mentioned earlier, the ELSP3 took place over a period of 7 weeks, filled with consolidation and enrichment activities. One of them was the invention project whereby the students were required to produce inventions. The task was an invention project, where as a class, the students were required to create or design an invention (in various categories such as home improvement, house wares, automotive, apparel, industrial, medical, garment care, cleaning, hardware, lawn and garden etc.)

Thinking skills are increasingly being promoted in schools and also tertiary institutions. But, what is the actual meaning of 'thinking'? There are various definitions on thinking. Nickerson (1988) cited in Rajendran (2008) suggests that, "if there is one point on which most investigators agree, it is that thinking is complex and many faceted and, in spite of considerable productive research, not yet very well understood" (p.18). As described by Ruggerio (2007), thinking is any mental activity that helps formulate or solve a problem, make a decision, or fulfill a desire to understand. It is a search for answers, a reach for meaning. Referring to Edward de Bono (1976), he describes thinking as related to lateral thinking that can lead to problem solving and looking at things in different perspectives in order to solve problems, while Mayer (1977) believes that thinking involves the organization of certain mental operations in the mind or the cognitive system of an individual that wishes to solve certain problem/s. Chaffee (1988) mentions that thinking is a unique and complicated process in solving problems and making decisions. John Barrel (1991) defines thinking as "a search for meaning and understanding that can involve the adventurous generation of options, the attempt to arrive at logical, reasonable judgments, and reflection on the process". Thus, thinking can be considered as activities of the mind, with some control exercised. Thinking is a habit that does not need a high Intelligent Quotient (IQ) (E.Paul Torrance, 1962), and thinking can also be visible through some routines (Perkins, 2003).

According to Fischer (in press), thinking skill is a practical ability to think in ways that are judged to be more or less effective or skilled. They are the habits of intelligent behavior learned through practice, for example children can become better at giving reasons or asking questions the more they practice doing so. A thinking skill is any cognitive process broken down into a set of explicit steps which are then used to guide thinking (Johnson, 2000).Therefore, taking into consideration all of the above explanations, thinking skill can be stated as a structured cognitive process that helps in making, understanding, and solving problem and issue to reach a decision with some strategic tools and instructions provided.

Although thinking is a complex phenomenon, researchers and specialists agree that such skills are the basic tools of effective thinking. According to theorists and researchers such as Barry Beyer (1987) Edward de Bono(1991) and Reuven Feuerstein (1980), continuing systematic instruction in explicit skills using procedures over an extended period of time is especially effective in helping children of all abilities to develop increased proficiency in carrying out the skills. It is mentioned that thinking skills and processes are aplenty. Rajendran (2008: p.66) provides a framework to explain how those numerous skills link with each other. Evidently, to be successful problem solvers, learners must own a set of balanced critical and creative thinking skills. Creative thinking involves generating many unique ideas, while Critical thinking involves skills that enable one to sort, analyze, and refine creative ideas.

Critical thinking skills include *cognitive skills* and *dispositions*. As for the cognitive skills, which are the mental abilities, the skills include the ability to do interpretation, to analyse, to evaluate, to make inferences, to explain, and to engage in self-regulation. Equally important when describing critical thinking skills is the disposition toward critical thinking which are actually the attitudes or habits (Facione, 2006). They include being inquisitive, judicious, systematic, analytical, open-minded, confident in reasoning and a truth seeker.

In a study conducted on over 1100 college students, findings show that scores on a college level critical thinking skills test significantly correlated with college GPA. It has also been shown that critical thinking skills can be learned, which suggests that as one learns them one's GPA might well improve. These findings regarding the effectiveness of critical thinking instruction, and correlation with GPA and reading ability are reported by Facione (1990) in three reports.

Meta-cognition refers to the knowledge and control people have over their thinking and learning activities (Flavell, 1979). It involves thinking about thinking. Cognition or thinking refers to the intellectual functioning of the mind with regard to the learner's ability to attend, acquire, represent, and recall information. Meta-cognition, which refers to the knowledge and control people have over their own thinking and learning activities (Flavell, 1979), deals with the 'individual's knowledge about the task, possible strategies that might be applied to the task and the individual's awareness of their own abilities in relation to these strategies' (Taylor, 1983, p.270).

In relation to the acquisition of critical thinking skills, meta-cognition refers to what a learner knows about his or her thinking processes (conscious awareness) and the ability to control these processes by planning, choosing, and monitoring. Basically, there are two components of the meta-cognitive process: awareness and action. Awareness of one's cognitive behavior during a task includes awareness of the purpose of the assignment, awareness of what is known about the task, awareness of what needs to be known, and awareness of the strategies and skills that facilitate or impede understanding. Action is the ability to use self-regulatory mechanisms or cognitive monitoring to ensure the successful completion of the task, such as checking the outcome of any attempt to solve the problem, for example, planning one's strategies for learning, and remediating any difficulties encountered by using compensatory strategies.

According to Sanacore (1984), meta-cognition is ‘knowing what you know,’ ‘knowing what you need to know,’ and ‘knowing the utility of active intervention.’ However, this meta-cognitive skill is apparently not developed in all students. To be an efficient and effective thinker, the learner should be able to monitor his or her degree of understanding, be aware of the knowledge possessed, be conscious of the task demanded, and know the strategies that facilitate thinking.

According to Halizah Awang & Ishak Ramly (2008), at the simplest level ‘creative’ means bringing into being something that was not there before and has been brought into being. The word ‘creativity’ covers a wide range of different skills. Creative skills needed to change concepts and perceptions. In most descriptions of problem solving, there is usually a step called ‘search for alternatives’. This implies that creativity is needed in this step. Creativity is poorly understood and difficult to teach but there are positive techniques that everyone can learn. Edward de Bono (1993) notes creative techniques such as focus, challenge, alternatives, concepts etc. Creative thinking will make students move ‘sideways’ to try different perceptions, different concepts, and different points of entry. Students can use various methods including provocations to solve the problems. Creative thinking has very much to do with perception to put forward different views. The different views are not derived each from the other but are independently produced. In this sense, creative thinking has to do with exploration just as perception has to do with exploration. Hence, citing Facione (2006), c*reative* or *innovative thinking* is the kind of thinking that leads to new insights, novel approaches, fresh perspectives; whole new ways of understanding and conceiving of things. The products of creative thought include some obvious things like music, poetry, dance, dramatic literature, inventions, and technical innovations.

It is believed that one of the ways to promote critical and creative thinking skills is through the use of project-based learning. A variety of terms such as *project work* (Shoring, 1995), *project method* (Kilpatrick, 1926), *project approach* (Diffily, 1996), *project-oriented approach* (Carter & Thomas, 1986) and *project-based learning* (Peterson & Myer, 1995) are used in general education and in the L2 education literature. A project is defined as a long-term (several weeks) activity that involves a variety of individual or cooperative tasks such as developing a research plan and questions, and implementing the plan through empirical or document research that includes collecting, analyzing, and reporting data orally and/or in writing.

The major benefits listed in the general education literature include opportunities that it provides for intrinsically motivating students to learn, fostering problem-solving, and developing independent and cooperative working skills. It is also believed that project based instruction allows students to develop critical thinking and decision making skills and engage in in-depth learning of subject matter (Adderly, Ashwin, Bradbury, Freeman, Goodlad, Greene, et al., 1975; Berliner, 1992; Krajcik, Blumenfeld, Marx, & Soloway, 1994; Ladewski, Krajcik, & Harvey, 1994; Vithal, Christiansen, & Skovsmose, 1995).

Krajcik et al. (1994) report on a group of 11 experienced US science teachers learning the project approach to teaching. One of the research goals in this study was to investigate the challenges the teachers might face in learning to implement project-based instruction. The analyses of the videotaped observations, informal interviews, and teachers' reflection journals during their implementation of two six- to eight-week projects showed that the teachers liked teaching science through the project approach. They reported that compared with traditional methods, project-based science was more effective in promoting critical thinking, observation, and group work skills. The teachers said that in project-based science individual student thinking was continually affected by the input of others. Students were pushed to consider increasingly broader perspectives, instead of narrowing their thinking as the unit progressed.

In four case studies, Marx, Blumenfeld, Krajcik, Blunk, Crawford, KelJy, & Meyer (1994) explored how four experienced US middle-grade teachers learned to teach project-based science. They reported discovering project-based instruction resulting in more active involvement, more independence from teachers, and more cooperation among students. They also reported notable improvements in students' learning of new concepts. Students learned new concepts faster, retained them longer, and were able to use them in class discussions particularly for problem solving which required critical and creative thinking.

Renuka, Christiansen, & Skovsmose, (1995) explored how teachers and students interpreted project-based mathematics education in a Danish university where students are required to engage in project work for 50% of their time. They reported that in project work they could ‘do mathematics,’ could apply mathematics to other fields (‘can see the connection’), and could learn from the process itself (e.g., problem-solving skills). They also said that project-based instruction allowed them to learn math thoroughly through in-depth study.

Beckett (1999) investigated the implementation of project-based instruction in a Canadian secondary school ESL class. Analysis of data collected through observations and interviews of two teachers indicated that the teachers favored project based instruction because it allowed them to take an integrated approach to language teaching (i.e., integrating language, content, and skills). It allowed them to foster critical thinking and problem-solving skills and promote independent as well as cooperative learning skills.

Thomas (2000) defined the issues about the positive side effects of project based learning for learners as the development of positive attitudes toward their learning process, work routines, abilities on problem-solving, and self-esteem. Similarly, Green (1998) emphasized that participants in project-based learning learn better and are more actively acting in their learning. Instructors work backstage as learners work on their projects. This turns participants into active problem solvers on the projects, rather than passive receivers of knowledge.

Preuss (2002) noted that as learners complete their projects, they think reflectively on their experiences about project-based learning processes individually. Besides, learners realize similarities between what they are learning and what is going on outside the school walls. This was also reported by Ramey (1997) who studied a group of US high school students who voluntarily enrolled in a project-based calculus class. The participants believed project-based instruction enabled them to find real-world applications for their calculus. They believed they had improved their problem-solving and critical thinking skills by conducting projects. They also believed project based calculus was intrinsically motivating and helped develop their skills for working in cooperative group settings.

Shepherd (1998) reports that problem-based learning can have a positive effect on students' acquisition of critical thinking skills. Shepherd describes a nine-week project in which students work on defining and finding solutions for a problem related to an apparent housing shortage in six countries. Although the number of students involved in the study was quite small (20 students in the experimental group and 15 in a control group), Shepherd found a significant increase on the part of the experimental group, as compared to the control students, on a test of critical thinking skills (The Cornell Critical Thinking Test). Additionally, experimental students reported increased confidence and learning, as a result of the nine-week project, on a self report measure given after the program.

Boaler (1997) describes a longitudinal study of mathematics instruction conducted in two British secondary schools. The study has several features that make it a significant study of Project-Based Learning effectiveness. The two schools were selected for their differences with respect to traditional versus project-based methods of instruction. One of the schools (referred to here as "traditional") was characterized as incorporating a more teacher-directed, didactic format for instruction.

Mathematics was taught using whole class instruction, textbooks, tracking, and the frequent use of tests. At the second school (referred to here as "project-based"), students worked on open ended projects and in heterogeneous groups. Teachers taught using a variety of methods with little use of textbooks or tests, and they allowed students to work on their own and to exercise a great deal of choice in doing their mathematics lessons. The use of open-ended projects and problems was maintained in the project-based school. Students at the project-based school outperformed students at the traditional school on the conceptual questions as well as on a number of applied (conceptual) problems developed and administered by Boaler. They also developed more flexible and useful forms of knowledge and were able to use this knowledge in a range of settings.

A study conducted by the Cognition and Technology Group at Vanderbilt (1992), reported the significance of the study was that it demonstrated that a brief Project-Based Learning experience can have a significant impact on students' problem-solving skills, metacognitive strategies, and attitudes towards learning. Results from the attitude surveys were similar to those reported by Boaler (1997).

Tretten and Zachariou (1995) conducted an assessment of Project-Based Learning in four elementary schools using teacher questionnaires, teacher interviews, and a survey of parents. According to teachers' self-reports, experience with Project-Based Learning activities had a variety of positive benefits for students including attitudes towards learning, work habits, problem-solving capabilities, and self esteem. Horan, Lavaroni, and Beldon (1996) observed Project-Based Learning classrooms at two time periods during the year, once in the fall and once in the spring semester. At both occasions, they compared the behavior of high ability to low ability PBL students in group problem-solving activities. Observers looked at five critical thinking behaviors (synthesizing, forecasting, producing, evaluating, and reflecting) and five social participation behaviors (working together, initiating, managing, inter-group awareness, and inter-group initiating). The interesting finding was that lower ability students demonstrated the greatest gain in critical thinking and social participation behaviors, compared to the high-ability students.

There is ample evidence that PBL is an effective method for teaching students complex processes and procedures such as planning, communicating, problem solving, and decision making, involving a lot of critical and creative thinking. Teachers in general favour using project-based instruction as they felt that students benefit from the instruction in many ways. However, some students expressed mixed feelings about it. Despite the fun they had while conducting the projects, they felt doing the project was a waste of time as it was time consuming and they had a lot of work to do for project completion. They also preferred the traditional approach as they felt that they really learned. Some thought otherwise though.

Project-based learning offers an engaging instructional method to make learners active constructors of knowledge. Rooted in constructivism, constructionism and cooperative/collaborative learning, project-based learning has strong theoretical support for successful achievement. It is based on these that this present study is carried out – to investigate learners' perspectives on the effectiveness of using invention projects in promoting their critical and creative thinking skills.

Therefore, the purpose of the study is to evaluate the perceptions of USIM students on the effectiveness of using an invention project to promote critical and creative thinking. In doing so, the study is guided by three research questions which are:

1. What are the students' perceptions on the use of invention projects in promoting their analytical-critical and creative thinking habits?
2. What are the students' perceptions on the use of invention projects in promoting their meta-cognitive thinking and behaviour?
3. What are the students' perceptions on the effects of using invention projects to their application of critical and creative thinking skills?

Methodology & Materials

The study involves data-gathering in relation to students' perception of their critical and creative thinking skills upon the completion of the invention project assigned to them. This chapter explains the procedural parts of the study, which involves the description of the invention project, sampling, data collection and data analysis strategies.

350 first year undergraduate students from different faculties of USIM (Faculty of Major Language Studies, Faculty of Quranic and Sunnah Studies, Faculty of Syariah and Law, Faculty of Economics and Muamalat, Faculty of Leadership and Management and also Faculty of Science and Technology) were the respondents of this study. The students were of mixed gender.

A quantitative approach is used, through an evaluation survey (Appendix 2), which was administered to 350 students of 1st year Bachelor degree. The questionnaire was administered during the last session in class, before the USIM Young Inventors Fair took place. The students were given ample time to reflect on the preparation they did for the Fair, and their thinking experiences while completing the project.

The questionnaire in this study was adapted from http://www.aare.edu.au/01pap/tan01755.htm. It consists of 18 statements, using a four-point Likert scale of Strongly Agree, Agree, Disagree and Strongly Disagree. They are self-reflection questions, where the first 10 statements (Q1-Q10) are to check if the students have acquired analytical-critical and creative thinking habits. For example, the ability to focus on problematic issues and thinking of different strategies to analyse problems. Then, there are 6 statements (Q11-Q14 and Q17-Q18)) regarding meta-cognitive thinking and behaviours, like being aware of their strengths and weaknesses, and another 2 statements (Q15-Q16) on practical thinking like whether the students apply thinking skills after they have completed the project.

The quantitative data derived from the questionnaire was analysed using the Statistical Package for the Social Sciences (SPSS) computer software. Descriptive statistics like the mean, standard deviation and correlation were used to corroborate the data. The standard deviation, a measure of variability, helps in giving information that the mean score alone cannot provide. It has helped in making more informed conclusions about the data obtained. In addition, the correlation has allowed us to ascertain the strength of connections among the different variables. A full discussion of how these descriptive statistics help to validate the data is put forward in the following section.

Findings and Discussions

The key focus of this research is to evaluate the perceptions of USIM students on the effectiveness of using an invention project to promote critical and creative thinking. The following discussion looks at the perceptions of the students on how effective the invention project is in encouraging the use of critical and creative thinking skills in them. As a recap, the study is guided by three research questions namely:

1. What are the students' perceptions on the use of invention projects in promoting their analytical-critical and creative thinking habits?
2. What are the students' perceptions on the use of invention projects in promoting their meta-cognitive thinking and behaviour?
3. What are the students' perceptions on the effects of using invention projects to their application of critical and creative thinking skills?

In general, the students showed very positive view towards the invention project. Most of them reported that they have benefited through their involvement in the project. This is illustrated in the low mean scores of the 18 statements from the questionnaire.

Most of the mean scores are below 2, and the standard deviation of all 18 statements is less than 1. This indicates that the distribution of scores is small, and all of them group around 'strongly agree' and 'agree' rankings.

RQ1: What are the students' perceptions on the use of invention projects in promoting their analytical-critical and creative thinking habits?

Students collectively approved that they have enhanced their critical thinking, as marked in Statements 1 and 2 with means and standard of deviations of 1.77/0.53 and 1.84/0.46. Thus, it is clear that the students have obtained a satisfactory level of critical thinking as they are good at identifying problems and using different strategies to solve them. Related to this, will be Statements 7 and 8 with the mean scores of 1.75 correspondingly, and the standard deviations of 0.51 and 0.56. This has shown that the students have improved their creative thinking abilities when they are involved in a group project (Preuss, 2002). The results prove that the range of scores is small and again, they cluster at 'strongly agree' and 'agree' ratings.

Looking at Statements 2 and 7, there seems to be a moderate correlation of 0.273. This shows that by using different strategies, students have improved their thinking skills, or vice-versa.

Statement 3, with a mean of 1.82 and standard deviation of 0.51, has shown very positive feedback from the students. It can be said that through the invention project, students have gained a valuable thinking disposition that is being persevere in facing challenges, which is an attribute of a good thinker (Costa and Lowery, 1989). This indicates that they are motivated (Adderly, Ashwin, Bradbury, Freeman, Goodlad, Greene, et al., 1975; Berliner, 1992; Krajcik et. al., 1994; Ladewski, Krajcik, & Harvey, 1994; Preuss, 2002; Vithal, Christiansen, & Skovsmose, 1995) in completing the task assigned. It is also found that the students are open to new ideas or viewpoints (Krajcik et. al., 1994). This is validated by the mean scores of statement 5 at 1.59 and statement 6 at 1.92. Another interesting finding is the correlation between statements 7 and 8. There is a moderate correlation of 0.362, which indicates that due to their improved ability to generate new ideas and solutions, they like the challenge of thinking of new ideas. This portrays that there is an improvement in the students' creative thinking habit. The two dispositions are also in accordance with the central good thinking dispositions highlighted by Tishman, Jay and Perkins (1992).

Another finding which illustrates that students have improved their analytical-critical and creative thinking habits can be seen through the mean and standard deviations of Statements 9 and 10 (Table 3). This matches Tretten and Zachariou's (1995) assessment of Project-Based Learning, which discovered that Project-Based Learning activities had positive benefits for students including attitudes towards learning, work habits, problem-solving capabilities, and self esteem.

RQ2: What are the students' perceptions on the use of invention projects in promoting their meta-cognitive thinking and behaviour?

The students are ready to engage in meta-cognitive thinking. This is shown in Statement 11 with a mean score of 1.92. This appears to match with the attributes of a good thinker proposed by Costa and Lowery (1989) and Tishman, Jay and Perkins (1992). Another finding shows that students are ready to engage in meta-cognitive thinking process whereby they are able to learn to listen and respect alternate viewpoints, which can be seen through the correlation between Statements 5 and 11 and also Statements 6 and 11.

It is also indicated that students are less afraid to make mistakes and less afraid to express their thoughts and ideas. Statements 17 and 18 show means/ standard deviation scores of 2.13/0.03 and 2.04/0.03 respectively (Table 3). This positively shows that by being involved in an invention project, students are more likely to express their thoughts and they are not afraid in making mistakes throughout the process (Rajendran, 2008).

Statement 8 and 17 established 0.197 correlation score, which means, student shows that they less afraid of expressing their thought due to mindset of favoring challenges.

Statistically, there is also a moderate correlation of 0.188, between statements 1 and 14. This means that students have learned how to formulate the right questions, which also shows their meta-cognitive skill.

RQ3: What are the students' perceptions on the effects of using invention projects to their application of critical and creative thinking skills?

The finding from Statement 15 (refer Table 3), indicates that the thinking skills the students acquired through the invention project would help them in their academic learning. This corroborates with Facione (2006) who reported a study on the correlation between thinking skills and college GPA. The mean and standard deviation for Statement 16 (refer Table 3) shows that students perceived that they would apply thinking skills they acquired through the invention project to real life situations, which according to Costa and Lowery (1989), is one of the attributes of a good thinker. This finding is similar to the several studies conducted on the benefits of project-based instruction (Renuka, Christiansen and Skovsmose, 1995; Preuss, 2002). It can also be seen that there is quite a strong correlation of 0.219 between applying thinking skills to real life situations and enjoying problem-solving (Table 9). This implies that students do enjoy applying thinking skills to classroom situations and even more so to real life situations.

Conclusions and Recommendations

Believing that one of the most important skills for the future is the ability to think critically and creatively, an invention project has been described. Findings from the current study demonstrate promising results, thus making project-based learning activities highly recommended in enhancing students' critical and creative thinking skills. While it may not be the best way, it is certainly perceived very positively by the participants. The invention project has indeed provided an opportunity for them to employ their creative and critical thinking skills in a meaningful way.

The study looks at the perceptions of students on the effectiveness of an assigned invention project, in encouraging the use of creative and critical thinking. In ensuring that creative and critical thinking skills are internalized and applied, it is insufficient to just expose students to related theories. It is imperative that classroom activities are designed to be student-centered with more hands-on and practical work involved. And one of the ways is by using the invention project described earlier, and proven to be perceived positive. The findings of the study are noteworthy to the interests of classroom practitioners in conducting their teaching and learning activities. It provides a platform to understand the characteristics of good thinkers. It is believed that this knowledge can help improve their teaching approaches in equipping students with creative and critical thinking abilities. This in turn, will help students cope with the demanding surrounding society.

Curriculum developers as well as course designers also benefit from the findings of the current study. Courses should include project-based activities which have the elements of student-centeredness and more hands-on and practical work. By going through the process of completing the project assigned, students will improve their critical and creative thinking skills.

Undoubtedly, there are some limitations in this research. One of the limitations is the sample size of the survey. Not all of the First Year Degree students were involved in the data collection process because of resources and time constraint. Only 350 students were involved in the study. Thus, it is not representative of the whole First Year Degree students of USIM. The researchers also did not set up a control group. This is not possible because it is compulsory for all First Year Degree students at USIM to undergo the ELSP 3. For that reason, without an experimental and a control group, no actual comparison can be made. The research was carried out via questionnaire, and did not include any interviews to further verify the precision of the statements in the survey.

Based on the study, some suggestions and recommendations are made in order to enhance students' critical and creative thinking skills. Project-based learning activities, such as the invention project, should be included in more of the university's courses irrespective of the fields of study. Not only the students would be better thinkers, they would also learn to work cooperatively, strengthen positive work habits, gain new knowledge and skills, and develop linguistically. These qualities are indeed very much sought-after in potential employees in the working world.

It is not easy to conclude that the improvement in the students' thinking abilities depend only on the invention project, and not by other factors such as attitudes or the teachers. Thus, future studies can be done to identify other factors involved. Other methods of data collection can be employed. This includes interview sessions, or even video-taped sessions of students' interaction and behaviour during discussions prior to the USIM Young Inventors Fair, which can also provide other scope for future studies.

In the study, many traits of a good thinker are pointed out. The implicit way of improving students' critical and creative thinking skills can be promoted through a project-based activity, in this context the use of an invention project. Here, it is important to have activities that engage students to interact and communicate their ideas. The process students have to go through to complete the project will provide positive opportunities for the students to be better thinkers. The study proves that the students have internalized the skills by transferring their ideas into inventions. This indirectly reveals that the skills are utilized beyond the walls of the classrooms. They have acquired the ability and inclination to think, in other words they are motivated thinkers who are able to think out of the box – an important trait to enable one to shine in a challenging world.

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Table 1: Mean and Standard Deviation scores for the 18 Statements

No.	Statements	Mean	Standard Deviation
1.	I learned how to focus on issues/problems by asking the right questions to my friends and teacher.	1.77	0.53
2.	I improved my ability to use different strategies to problems.	1.84	0.46
3	I do not give up easily and learn to persevere when answers to issues/problems are not evident.	1.82	0.51
4.	I become less impulsive by taking my time to reflect on answers/arguments before giving them.	2.11	0.56
5.	I learn to listen and respect alternate viewpoints.	1.59	0.54
6.	I am able to evaluate the merits and demerits of new ideas.	1.92	0.44
7.	I improve my ability to use different thinking skills to generate new ideas/solutions.	1.75	0.51
8.	I like the challenge of thinking of new ideas.	1.75	0.56
9.	I enjoy problem-solving/decision-making.	1.78	0.59
10.	I improve my ability to detect errors/bias.	1.86	0.52
11.	I am more ready to describe/draw/write down my own thinking strategies.	1.92	0.52
12.	In the competition, I learn about my own strength and weaknesses by reflecting on my actions.	1.79	0.53
13.	I am more aware of things around me and ask more questions so as to understand something better.	1.88	0.55
14.	I learn to probe by asking more specific questions.	1.91	0.54
15.	The thinking skills that I learn have helped me in my academic learning.	1.63	0.56
16.	I apply the thinking skills learned in class to real-life situations.	1.90	0.53
17.	I am less afraid to express my thoughts/ideas.	2.04	0.59
18.	I am less afraid to make mistakes.	2.13	0.64

Table 2: Correlations between Statements 2 and 7

		2) Improved ability using different strategies	7) Improved thinking skills
2) Improved ability using different strategies	Pearson Correlation	1	,273(**)
	Sig. (2-tailed)		,000
	Sum of Squares and Cross-products	76,933	23,617
	Covariance	,208	,064
7) Improved thinking skills	Pearson Correlation	,273(**)	1
	Sig. (2-tailed)	,000	
	Sum of Squares and Cross-products	23,617	97,186
	Covariance	,064	,263

** Correlation is significant at the 0.01 level (2-tailed).a Listwise N=350

Table 3: Correlations between Statements 7 and 8

		7) Improved thinking skills	8) Liked challenges
7) Improved thinking skills	Pearson Correlation	1	,362(**)
	Sig. (2-tailed)		,000
	Sum of Squares and Cross-products	97,247	38,060
	Covariance	,262	,105
	N	372	365
8) Liked challengers	Pearson Correlation	,362(**)	1
	Sig. (2-tailed)	,000	
	Sum of Squares and Cross-products	38,060	117,124
	Covariance	,105	,317
	N	365	370

** Correlation is significant at the 0.01 level (2-tailed).

Table 4: Correlations between Statements 5 and 11

		5) Learn to listen	11) More ready to describe own thinking strategies
5) Learn to listen	Pearson Correlation	1	,193(**)
	Sig. (2-tailed)		,000
	Sum of Squares and Cross-products	106,507	20,008
	Covariance	,291	,055
	N	367	367
11) More ready to describe own thinking strategies	Pearson Correlation	,193(**)	1
	Sig. (2-tailed)	,000	
	Sum of Squares and Cross-products	20,008	103,284
	Covariance	,055	,275
	N	367	377

** Correlation is significant at the 0.01 level (2-tailed).

Table 5: Correlations between Statements 6 and 11

		6) Able to evaluate new ideas	11) More ready to describe own thinking strategies
6) Able to evaluate new ideas	Pearson Correlation	1	,146(**)
	Sig. (2-tailed)		,005
	Sum of Squares and Cross-products	70,727	12,492
	Covariance	,192	,034
11) More ready to describe own thinking strategies	Pearson Correlation	,146(**)	1
	Sig. (2-tailed)	,005	
	Sum of Squares and Cross-products	12,492	103,232
	Covariance	,034	,280

** Correlation is significant at the 0.01 level (2-tailed).a Listwise N=350

Table 6: Correlations between Statements 8 and 17

		8)Liked challenges	17)Less afraid to express thought
8)Liked challenges	Pearson Correlation	1	,197(**)
	Sig. (2-tailed)		,000
	Sum of Squares and Cross-products	117,124	23,466
	Covariance	,317	,064
	N	370	369
17)Less afraid to express thought	Pearson Correlation	,197(**)	1
	Sig. (2-tailed)	,000	
	Sum of Squares and Cross-products	23,466	128,402
	Covariance	,064	,342
	N	369	376

** Correlation is significant at the 0.01 level (2-tailed).

Table 7: Correlations between Statements 1 and 14

		1) Focus by asking right questions	14) Learn to probe by specific question
1) Focus by asking right questions	Pearson Correlation	1	,188(**)
	Sig. (2-tailed)		,000
	Sum of Squares and Cross-products	104,330	18,570
	Covariance	,278	,051
	N	376	363
14) Learn to probe by specific question	Pearson Correlation	,188(**)	1
	Sig. (2-tailed)	,000	
	Sum of Squares and Cross-products	18,570	106,360
	Covariance	,051	,293
	N	363	364

** Correlation is significant at the 0.01 level (2-tailed).

Table 8: Correlations between Statements 9 and 16

		9) Enjoy problem solving /decision making	16) Applying thinking skills in real life situation
9) Enjoy problem solving/decision making	Pearson Correlation	1	,219(**)
	Sig. (2-tailed)		,000
	Sum of Squares and Cross-products	124,514	24,694
	Covariance	,341	,068
16) Applying thinking skills in real life situation	Pearson Correlation	,219(**)	1
	Sig. (2-tailed)	,000	
	Sum of Squares and Cross-products	24,694	102,055
	Covariance	,068	,280

** Correlation is significant at the 0.01 level (2-tailed). a Listwise N=350