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Project-Based Learning for Academically Talented Students at a Math and Science Camp

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Abstract: Academically talented students went through a process of project-based learning (PBL) at a math and science camp in Malaysia. Students prepared a portfolio report about a science project that they had carried out individually prior to attending the camp. At the camp, they were put in groups of five to six students in which to carry out individual presentation and for group PBL activity. Two facilitators were assigned to each group to observe and evaluate students' PBL outcomes and generic skills. It was observed that students produced excellent products and delivered excellent presentations. These activities provided evidence that the selected students were capable of learning by PBL methods and of working effectively in new environments with new friends. Teachers should be encouraged to conduct PBL for academically talented students as an effort to nurture these students' thinking ability and fulfill their unique learning needs. Problem-solving ability that enhances lifelong learning ability is one characteristic that can be effectively fostered via the PBL method.

Key words: Project based learning · Academically talented · Math and science camp · Lifelong learning

INTRODUCTION

Academically talented students are defined as those students who show excellent performance in academic activities [1]. These students need special teaching and learning activities that suit their better-than-average learning ability. Among their needs is the flexibility to explore knowledge at their own learning pace. Curriculum content needs to challenge these students. The learning process for these students should also nurture problem-solving skills and develop tolerance for ambiguity [2].

It is suggested that 10% of students in an average population can be considered gifted or academically talented [1]. However, in Malaysia, these students are not identified and no special educational program is conducted for them. There is no gifted education provision in public schools. However, some academically talented students were selected based on their academic performance to enrol in special boarding schools. A few private schools have gifted education program for their gifted students. Schools often do not provide suitable educational opportunities for these students [3]. School curricula are not specifically designed to meet the educational needs of gifted students. This includes curriculum content as well as delivery methods. As mentioned earlier, academically talented students need special challenges in their learning process. One of the delivery methods that has been identified as sufficiently challenging for the learning needs of academically talented students is known as *project-based learning* (PBL) [3].

PBL engages students in learning necessary knowledge and skills as perceived by the learner. This leads those students to be more self-directed in their strategies and efforts in the learning process. Students involved in PBL were seen to show higher intrinsic motivation than students who were not [4]. They were given complex and authentic questions and tasks to be answered and performed. They face open-endedness and ambiguity in these learning endeavours, tolerance for which is important in developing creativity [1]. Besides this, students have to solve problems throughout the PBL process. Problem-solving skills are also important for lifelong learning; those who embark on a process of continuous knowledge-seeking will need good problem-solving skills to thrive in their learning endeavours.

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The PBL approach has been developed over the last 25 years to test theories of learning that emphasise activities and social interactions among learners. Studies have suggested that students actively construct meaning through exploration and interpretation, learning to criticise and create [5] and through processes of enquiry and deep learning. This is in line with a *constructivist* view of learning. Corresponding methods of instruction have been seen to help students improve self-regulatory behaviour and the quality of their output [6]. This approach to teaching and learning for academically talented students can be seen as an aspect of educational enrichment to suit these students' learning needs. Today's education must prepare students for *lifelong learning*, or continued development for personal fulfilment, social inclusion and performance of the roles of an active citizen and employee. Key competencies for lifelong learning include *learning to learn* in accordance with one's own needs and developing a *sense of initiative*. The PBL method of teaching and learning can provide a platform for the development of these competencies.

It is interesting to investigate the extent of self-development by involvement in schoolwork that academically talented students will be able to achieve via the PBL method. This research seeks to explore the types of individual projects embarked upon by academically talented students. The students in this study were given a task to prepare a portfolio for submission prior to attending a three-day math and science camp on a university campus. They were given instructions to decide for themselves on a project of their choice. The projects would either be scientific investigations, or would focus on developing a product. Brief written instructions were sent to the selected students, explaining what was expected. Students needed to write a portfolio explaining their projects, including a list of the questions that the student wanted to investigate or the product that they wanted to develop, the results of the investigation or the student's analysis of the product and the student's reflections on the learning endeavour as a whole. It is also the aim of this research to assess aspects of the students' group work at the camp, including their generic skills.

MATERIALS AND METHOD

Participants: A total of 312 academically talented students, aged 15 years, were selected to attend a math and science camp at a public-university campus in Malaysia. These students were selected based on their excellent performance in an online test of mental ability. The selected students received an offer letter to attend the camp.

Data Collection Procedure: This research was conducted to observe two kinds of project-based learning: individualised project-based learning and group project-based learning.

Prior to attending the camp, students were required to prepare a portfolio consisting of a report on their chosen projects. They were given the option either to conduct a product-based project or to carry out a scientific investigation on a topic of their interest. They were required to carry out the project individually. Students were required to bring their products and portfolio to the camp. They were to present and defend their projects to a group of peers and to two teachers who were trained to evaluate their projects and presentations.

At the camp, the students were also given a task to tackle in a group. They could suggest hypothetical projects or products as means to solve a problem given to them. The problems were designed to address world issues, such as food scarcity, global warming, futuristic endeavours and congestion of the transportation system. They were provided with stationery, cards, balloons and straws as means to present their solution.

Two teachers were assigned to each group as facilitators and also to evaluate the students' performance using Forms A, B, C and D. The teachers were also required to qualitatively observe and analyse the group dynamics as well as the generic skills and the flexible thinking demonstrated in performing the task.

The teachers were trained to assess each student's project and portfolio (Form A), individual presentation (Form B), problem-based group work (Form C) and generic skills (Form D). The portfolio assessment included the evaluation of the overall structure of the portfolio, the innovation and creativity of the project, the sharing of products and the project owner's reflections on the whole process. The individual presentations were assessed based on students' presentation of the main ideas; creativity and uniqueness of those ideas; effective body language; confidence in the delivery; and clarity of language, arguments and elaboration. The group problem-solving assessment included evaluation of the product, problem-solving process, teamwork and group self-management. Teamwork assessment evaluated the team's collaborative effort, while the assessment of group self-management evaluated the group's structure and its

management. Assessment of generic skills was continuous and included social responsibilities, environmentally friendly behaviour, analytical and critical thinking, interpersonal and communication skills and leadership.

RESULTS AND DISCUSSION

It was found that the mean score for Form C—assessment of group problem solving during PBL-was highest (M = 81.53, SD = 12.72, n for all means = 312). This is followed in order by those for Form D, continuous assessment of generic skills (M = 77.64, SD = 14.67); Form B (M = 71.03, SD = 15.43), assessing student individual presentations of their projects; and the lowest mean, that for Form A (M = 63.90, SD = 15.47), assessing the portfolio.

The highest mean, for group problem solving (Form C; M = 81.53, SD = 12.72), assessed students' products, processes, teamwork and group self-management. This showed that these students tended to work better in groups than alone. Although most of the students did not know each other prior to attending the camp, they proved able to work in a team. Group activities encouraged the sharing of ideas and insights among them. They were empowered to think and do the best for the group. This helped them to develop teamwork skills which are necessary for lifelong learning. Learning in a group allows students to exercise tolerance, understanding and mutual respect which is a pillar of a learning society and supports lifelong learning [7]. When faced with problems in real-life situations, these students should be able to generalise the problem-solving skills that they learned at camp. Among those skills were identification of a problem and brainstorming solutions. The students also learned the skills to manage their own activities and collectively manage other people, and to work in a team, complementing and tolerating each other. Managing oneself and others requires self-regulatory behaviour. This refers to self-control or self-discipline in completing a task. The result obtained for this research support the findings in [6].

The second-highest mean was for continuous assessment of generic skills, as measured by Form D (M = 77.64, SD = 14.67). These skills include assessment of one's social responsibility, environmental awareness, interpersonal and communication skills, leadership and analytical as well as critical thinking skills. Students showed good interpersonal and communication skills with their group members and with friends at the camp in other groups as well. This could be due to the fact that these students needed to communicate with each other in order to be able to carry out the group task effectively. Consciously caring for the environment, students cleared up their place of work and the nearby area. They collected pieces of paper and other materials to maintain the cleanliness of the environment in which they had been working. Credit should also be given to their respective schools' culture. The school system had managed to instil good behaviour among these students in terms of maintaining a clean environment. Regarding generic skills, students who have good generic skills will be able to thrive better in the future, be it in pursuing their career or their studies. This development of generic skills and care for the environment is important in promoting lifelong learning, not only among academically talented students but also among other students.

The lowest mean was for portfolio assessment, using Form A (M = 63.90, SD = 15.47). Next-lowest was the mean for individual presentations, using Form B (M = 71.03, SD = 15.43). This showed that these academically talented students performed better in project-based learning carried out in groups than individually. As noted, the mean for group problem solving, using Form C, was the highest. Thus, it can be seen that confidence levels appeared better when students presented their work in groups than when they presented individually. Working in groups allowed students to get positive feedback and encouragement from peers. This could be described as a supportive learning environment for academically talented students [8].

Individual and Group Projects: Students' individual projects were analysed to see the types of projects that they had conducted and the forms and sources of support they had in completing the individual task. This is referring to the support that was provided to the students as they worked on the projects. The students had embarked on two types of projects: product-based and investigation-based. The product-based projects produced products that fell within the domains of electronics, architectural design, botany and chemicals. The investigation-based projects covered many fields in the sciences: biology, chemistry, physics and mathematics. Students' portfolios consisted of photos from the experimental sites and descriptions of procedures. Data were presented in Tables and charts. Students also wrote personal reflections on the projects. The students showed their ability to embark on critical and analytical thinking about their findings.

Table 1: Mean and Standard Deviation on the assessment of Project Based Learning

Assessment Forms and their Subcomponents	Mean	SD	N
1. Form A: Portfolio	63.90	15.47	312
Design and basic foundation of portfolio			
General evaluation of portfolio			
Product/Proof			
Reflection on the learning process			
2. Form B: Presentation of the project	71.03	15.43	312
Clear presentation of main ideas			
Fruitful arguments and elaborations			
Fluency and use of language			
Effective body language			
Sharing of unique ideas			
3. Form C: Group problem solving during PBL	81.53	12.72	312
Product			
Process			
Teamwork			
Management			
4. Form D: Continuous assessment of generic skills	77.64	14.67	312
Social responsibility			
Environmental awareness			
Interpersonal/communication skills			
Leadership			
Analytical and critical-thinking skills			

Some students acknowledged receiving assistance from their teachers at school and some got very good support from their parents, receiving feedback and resources. These observations show that academically talented students are capable of carrying out project-based learning activities if they are given a task that requires them to learn by exploring. They showed an interest in exploring topics or issues that often were not laid out in the formal curriculum, demonstrating self-directedness and intrinsic motivation to conduct their projects. Intrinsic motivation is one of academically talented students' behavioural characteristics [9]. The finding that showed that PBL had a positive impact on students' intrinsic motivation was in line with the findings of previous research conducted with a group of students at a polytechnic in Malaysia [4].

Group activities were conducted to observe students' generic skills and the flexibility of their thinking while participating in project-based learning. Students were given current global problems to be solved in a group. They were observed to embark on brainstorming and to be thinking through various possibilities to solve the given problems. The students first approached the problems by analysing the situation from many angles. The output of the discussions was put on big sheets of paper for presentation. As well, students managed to make some interesting models of the proposed products. These included models of housing, transportation and garbage-disposal systems. A replica of the solar system was designed for one of the presentations. Empowerment in their learning process had encouraged the students to be flexible in their thoughts, think creatively and be innovative in solving the given problems. A lot of interactions were observed to take place within and between groups. Presentations spurred many questions from the other groups. Students who continue to pursue their study will become adult learner with untapped resources. They need to be empowered to give positive contribution towards the learning process. The ability to handle questions and discussion is an essential skill for lifelong learning. Adult learning honours what people know and engages them in participatory process [10]. Group activities were focussed on getting solutions for the problems given and this solution-mindedness is also an important skill for lifelong learning.

CONCLUSION

Academically talented students need pedagogical approaches that suit their mental ability. Project-based learning (PBL) is a pedagogical approach that is suitably challenging for those students. It was observed that these

students were capable of doing project-based learning individually, as well as in a group. They managed to do extensive reading on topics of their interest before embarking on a project of their choice. This could be seen from the quality of their reports and products. Recent advancements in technology have contributed to the success of the PBL approach. The students in this study were capable of independent learning and were no longer dependent on teachers' instructions.

The teachers' role in this study was to empower, guide and support academically talented students in their learning. Students need support and encouragement, especially when faced with open-ended situations such as embarking for the first time on their own independent projects. Tolerance for ambiguity and lack of outside direction is one of the important qualities that need to be developed for the mind to be creative and innovative. Educators should inhabit the role of facilitators and supports for these students, so as not to kill their inquisitiveness of mind. Instead, academically talented students should be allowed to enquire and hypothesise on phenomena in the world around them. These are some important elements that need to be considered in teaching and learning approaches for academically talented students.

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