Function takes priority -- Ingenuity-teaching via the building bricks elements[1]

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Abstract

This report presents the results from our guided teaching of a variety of student groups from 10- to 15-years old and university students to try to develop their ingenuity. To stimulate the students' engagement and involvement, the researchers used ready-to-assemble 'Gigo' bricks as the main development aids. To induce the students to show their ingenuity and ideas, we gave them a functional aim instead of a particular product to assemble. This principle gave each student group a different experience from a set of assembly bricks. Each group assembled their unique product to achieve the functional aim with a variety of 'Gigo' bricks elements, and also show their ingenuity and logic. Every child had to discuss his or her ideas in a peer group, and the researchers joined them when a difficult problem occurred. Hence, students could share their own ideas in a group, learn the way of team work, and certainly enjoy presenting the product of their ingenuity through 'Gigo' bricks. From the variety of products that resulted from each functional aim, we found that "function takes priority" is a valuable principle for the guided-teaching of students' ingenuity. From the results of our study, we offer the concept and strategy of ingenuity-teaching, and offer clear methods and steps to practise your own ingenuity-teaching.

Keywords—Function, ingenuity-teaching, concept, strategy, innovation, logic, bricks.

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INTRODUCTION

Background

Since Ray & Margaret (2003) underlined "… … (problem-solving) looks at their ability to use their knowledge and skills to meet real-life challenges. This orientation reflects a change in curricular goals and objectives, which are increasingly concerned with what students can do with what they learn at school … …" in the report of PISA (Programme for International Student Assessment) which was led by OECD (Organization for Economic Co-operation and Development), the emphasis of education has been shifted from didactic knowledge and cultivation of sensitivity to ability in problem-solving. Followed this trend of education, the Taiwanese government put forward new course outlines for the 12-year Basic Education which emphasised: "As a spontaneous and active learner, school education emphasizes the ability to guide students' motivation and enthusiasm, and to develop self-interaction with others, with society, and with nature." The new course outlines also stated "Learning should not be limited to subject knowledge and skills, but should focus on the combination of learning and life, and demonstrate the whole development of learners through practice." They defined "core literacy" in education as "The knowledge, ability and attitude that a person should have in order to adapt to the present life and face the challenges." (Ministry of Education 2014)

There has been much discussion about ways of carrying out the new course outlines in teaching. The methods of assessment aroused most argument. Wu and Zhan (2018) mentioned "… … the ways of assessment should shift from amount of knowledge and ability of cognition, to integrated multi-directionality including observation, peer evaluation, practice evaluation, situation-adapting and so on." The new way of assessment will lead teachers to cultivate students' ability to understand situations, evaluate their own requirements and choose alternatives, in other words, their ability to solve problems. Ince (2018) defined "problem" as "a situation, which requires effort and the use of available knowledge and experience". Huitt (1992) defined "problem-solving" as "a person's ability to cope with a problem", and noted that "the process required overcoming the difference between the desired situation and the current situation in a situation affected by variables which were encountered or were not encountered previously". Thus, the new course outlines oriented teachers to adapt to ingenuity-teaching, which is especially important in the scientific disciplines.

Goal of the study

As the emphasis of education has shifted from didactic knowledge to the ability to solve problems, ingenuity-teaching has become an essential method to approach the “core literacy” of the new course outlines. The success or failure of innovative teaching depends on the formulation of the teaching structure and strategy.

This study is based on the results of previous related research, in order to build up an effective structure and strategy for ingenuity-teaching. We used various ‘Gigo’ [2] bricks elements as the main development aids instead of a set of assembly-ready bricks in various school age classes, and gave them a functional aim instead of a particular product to induce the students to show their ingenuity and ideas. From observations of the whole process by which the students achieved their aim, and studies of the variety of their products, we can discuss whether our structure and strategy are workable and effective or not.

LITERATURE & RESEARCH

Ingenuity-teaching in playing

Play and games can always attract students / kids and offer students / kids different situations from their daily life, and encourage them to conquer difficulties as a team. Students / kids have to observe, adapt to particular situations, evaluate their own requirements, choose alternatives, and pass peer and practice evaluation to complete the game. These requirements all match the assessment of the new course outlines. Chang & Lin (2014) studied the effectiveness of learning from MMORPG (Massively Multiplayer Online Role-Playing Games) in primary school students, and concluded: “In general, ‘Jointly hard work for hard fun’ is the core content of the team mental model. We found ample evidences that members explicitly recall shared

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[2] Gigo has developed 599 kinds of functional building bricks and has more than 100 world patents. The 599 components can match with each other perfectly and thus produce thousands of creations.

motivational beliefs of team mates and emotional–motivational events in gaming." This suggests learning from games or play engages and involves students, and allows them to express their ingenuity and ideas in team situation.

Höchsmann (2003) mentioned the playground is a sort of field of dynamic and cooperative learning, which functions more like a well-operated working place rather than a normal classroom. In the atmosphere of cooperative learning, learning from peers and interaction among work partners is more important than one-way learning from a teacher. Hence, tutors should encourage students exploring and thinking through teamwork. Huang & Chu (2013) even expected that students can "transfer learnt knowledge into vivid wisdom through exploration, and improve their ability of problem-solving". Students come across problems and challenges during the process of learning, and eventually reach a divergence point where they either break through to a solution or give up. Through game-learning and team work, students can think through and adapt to a problem, and practise and put forward their ideas during the whole process.

Li and colleagues (2018) studied literacy-oriented teaching via Gigo bricks elements. They found the flexibility and extensibility of Gigo bricks elements are suitable for the presentation of innovative ideas, and also let the team cooperate and communicate effectively in a short time. Whether it is the construction of a simple mechanism, or an animal skeleton, students using bricks-building can learn more and deeper scientific knowledge from their experience of correcting of errors, and thinking of the details of structures (Li et al. 2018).

Concept

The basic aim of this study was to integrate science literacy-teaching, ability to solve problems, adaptation to new situations, and teamwork into a project in ingenuity-teaching. The whole picture of the concept is shown in Figure 1.

To induce the students to show their ingenuity and ideas, we set up a particular playing situation and mission. The playing situation should be a non-standard environment (not in a normal classroom) where all partners can be involved and engage with each other. The playing mission should be a functional aim instead of a particular product. Every child had to discuss his or her ideas in a peer group, and the researchers joined them when a difficult problem occurred. In the whole process, students could show their ingenuity, logic and scientific literacy via the ways in which they solve problems, discuss as a team, and create a variety of products with the same functional aims.

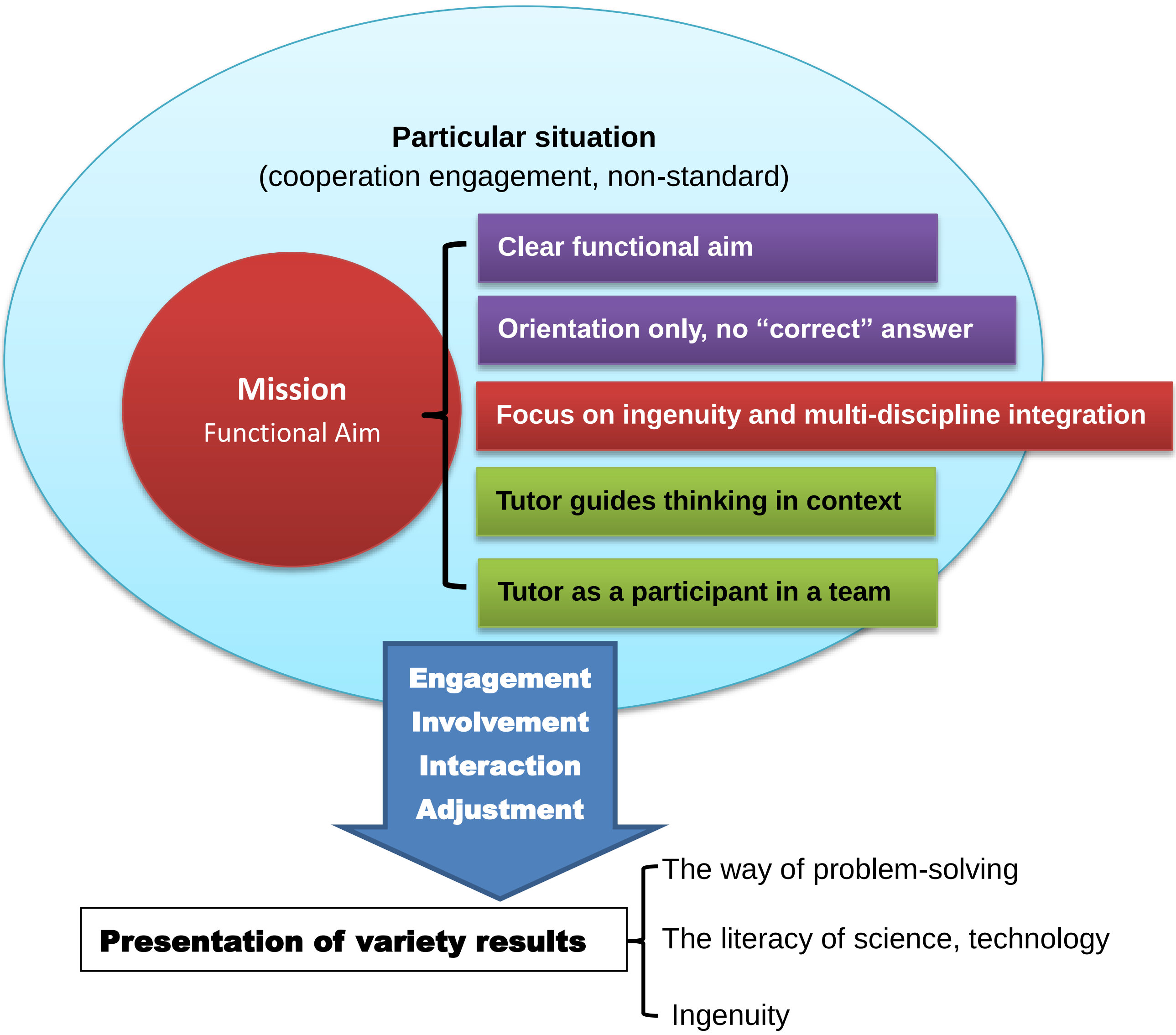

Figure 1. The structure of the concept of ingenuity-teaching. The particular situation is shown in pale blue. The mission is a functional aim, and the aims of the mission are

shown in purple squares. The red squares point out what the mission should emphasise. The green squares give the role of a tutor in ingenuity-teaching. Students should form a team and have to engage, involve, interact and adjust their product during the whole process. A variety of results is then produced by different teams.

The mission should be one that has no "correct" answer, but which provides a clear functional aim and orientation. A tutor is a participant in a team who guides the group thinking in a particular context at the beginning, then joins the discussion, observes the whole process, and gives suitable guidance when the team come across difficulties. Because there is no "correct" answer, student groups can have a variety of ways to achieve the mission. The results can show different ways of problem-solving, student ingenuity and their grasp of science and technology.

Strategy

We divided the strategy into 5 stages and included different stages for different groups to guide students to achieve the functional aim (see table 1). Tutors have to clarify what prior knowledge, life experiences and skills related to the mission students already have before they set up the functional aim, and provide the necessary requirements of the mission. If the students have no experience of Gigo bricks elements, the tutor has to plan an activity to let students become familiar with the different elements.

Table 1. The strategy of ingenuity-teaching for different age or skill groups

Group	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
I. Lack of experience of Gigo bricks, not much knowledge related to the mission.	V	V	V	V	V
II. Familiar with Gigo bricks, not much knowledge related to the mission.		V	V	V	V

III. Familiar with Gigo bricks, has limited knowledge related to the mission.			V	V	V
IV. Familiar with Gigo bricks, with considerable knowledge related to the mission.				V	V

Stage 1. Activity to familiarize students with Gigo bricks.

Stage 2. Imitation of a prepared product.

Stage 3. Practice of the principles of the previous stage.

Stage 4. Assignment of a mission/ functional aim.

Stage 5. Presentation of the variety of results showing the students' ingenuity.

Even though students are acquainted with Gigo bricks elements, they may not have enough knowledge and skill related to the mission. According to the level of students, the tutor should arrange the imitation and practice stages relevant to the principles of the mission.

We will give two cases in the next section, the ingenuity-teaching of group I and group IV (see table 1).

CASE STUDY

In the table 1, we divided the students groups into 4 categories: 1). Lack of experience of Gigo bricks, not much knowledge related to the mission. 2). Familiar with Gigo bricks, not much knowledge related to the mission. 3). Familiar with Gigo bricks, has limited knowledge related to the mission. 4). Familiar with Gigo bricks, with considerable knowledge related to the mission.

For the sake of students, we also divided the ingenuity-teaching into 5 stages: 1). Activity to familiarize students with Gigo bricks. 2). Imitation of a prepared product. 3). Practice of the principles of the previous stage. 4). Assignment of a mission/ functional aim. 5). Presentation of the variety of results showing the students' ingenuity. (see also table 1)

Group I

Group 1 (see also table 1) consisted of 10~15 years old students who lacked experience of Gigo bricks, so we planned a competition among all groups to stack the Gigo bricks, the higher the better. During the process of brick-stacking, students could soon become familiar with the variety of Gigo bricks elements (fig.2).

Students in group 1 did not have enough knowledge to complete the mission yet, so we added stages 2 and 3 into the whole activity. In stage 2, we prepared a windmill to show how the set of gears and chains function in the windmill. Students imitate the prepared windmill to become acquainted with the function of the set of gears and chains (fig.3). Then in stage 3, we assigned "lift", "bicycle" and "crane" as the practice items to induce students to think how to build up their own product using the functions of gears and chains (figs 4-6).

Figure 2. Students competed stacking bricks and become familiar with a variety of bricks in stage 1.

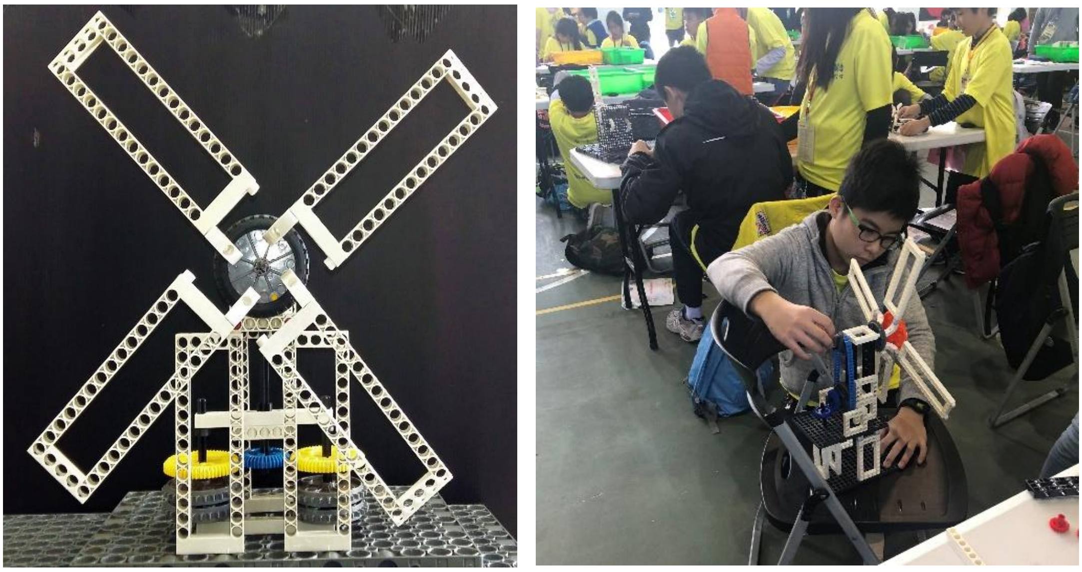

Figure 3. Students imitated the prepared windmill (left) to experience the functions of the set of gears and chains.

Figure 4. Students practised the principles of gears and chains in the assignment, lift.

Figure 4. Students practised the principles of gears and chains in the assignment, bicycle.

Figure 6. Students practised the principles of gears and chains in the assignment, crane.

After students practised the function of the set of gears and chains in stage 2 and 3, we moved forward to stage 4, and assigned the mission. The mission is moving a ball from A to B, with a distance of about 100cm between A and B. The results of stage 4 are displayed in stage 5, and demonstrate the variety of ideas and ingenuity of the students (fig.7).

Figure 7. Students present the results of their teamwork, and we can enjoy their ingenuity and ideas in the variety of products.

Group IV

Group IV (see also table 1) consisted of university students who already had considerable knowledge related to the mission and were already familiar with Gigo bricks via assembly bricks sets.

In this sort of experienced group, we only assigned them two missions to train their integration of all the mechanical principles that they already knew. The first mission was to construct a 5-stories shock-resistant structure, in which both length and width are 25cm, and each story is 15cm high. The structure has to be able to stand on the seismic station for 5 minutes through the strongest shock. The second mission was to construct a vertical structure to move a certain weight from the ground to the top of the bench.

Even the university students enjoyed solving the missions, and they discussed and presented their variety of ideas of the missions (figs.8&9).

Figure 8. University students worked out the shocking-resistant structures in the first mission.

Figure 8. University students worked out the vertical movement structures in the second mission.

CONCLUSION

From the results of the two cases, we confirm the ingenuity-teaching concept fits the new course outlines and the main stream of modern education. The strategy of ingenuity-teaching allowed concepts to be carried out easily, while the strategy also helps teachers practise the new course outlines.

The aim of our concept and strategy of ingenuity-teaching is “function”. In stage 4, all missions should be given a clear functional aim and orientation. There is no so-called “correct” answer for a mission. This lack of ‘correct’ answers is what happens in real daily life, and it is something we should teach students. This is why we employ a variety of Gigo bricks instead of a ready-to-assemble set.

From the variety of products that resulted from each functional aim, we found that “function takes priority” is a valuable principle for the guided-teaching of students’ ingenuity. From the results of our study, we offer the concept and strategy of ingenuity-teaching, and provide clear methods and steps to practise your own ingenuity-teaching.

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