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Full Length Research Paper

An exploration of developing active exploring and problem solving skill Lego Robot Course by the application of anchored instruction theory

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In recent years, researches had shown that the development of problem solving skill became important for education, and the educational robots are capable for promoting students not only understand the physical and mathematical concepts, but also have active and constructive learning. Meanwhile, the importance of situation in education is rising, since studies had declared that knowledge's acquirement always occurs when people experience in a particular situation. The situation is indivisible from one's learning activities. In this study we tried to integrate four theories: the anchored instruction which originated from the situated cognition; the web-based learning which is the main way of searching information today; the problem-based learning which focus on development of students' problem solving skills; and the flow theory which is the best way to understand motivation.

Key words: Lego mindstorms NXT robotic course, anchored instruction, active exploring, problem solving skill, flow theory.

INTRODUCTION

Researchers had declared that it was increasingly important for teachers to help students develop skills to problems solving as an ultimate educational goal since several years ago (Jonassen, 1997). In recent years, researches has shown that using robots to support learning is capable of promoting children to understand physical and mathematical concepts and makes them have active and constructive learning (Mitnik et al., 2008). The Lego Mindstorms NXT is considered the widely used educational tool that has been employed to introduce problem solving, teach basic and engineering technologies (Kim and Jeon, 2009; Barak and Zadok, 2009; Jimenez et al., 2010).

According to Fenwick (2003), knowledge acquirement always occurs when someone experiences in a particular situation. Brown et al. (1989) had indicated that the situation is indivisible from people's cognition. It is a part of learners' learning activity (Greeno, 1997).

LITERATURE REVIEW

From these perspectives, it is necessary and meaningful to explore creating an appropriate condition for students to immerse in the NXT's learning environment to promote their interest in exploration and higher-order thinking in robotic courses.

The situated learning perspective has been reflected in several pedagogies such as problem-based learning (Barrows and Tamblyn, 1980), cognitive apprenticeship

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(Collins, 1991) and anchored instruction (Cognition and Technology Group at Vanderbilt, 1993). Anchored instruction, by following several designing principles, uses a model to create problem contexts which enables students to actively explore in the conditions knowledge (Williams, 1992). Anchored instruction's goal is to overcome the problem which are in schools, knowledge is somehow to be presented in an inert way (Mary, 2005). It enables students to understand how experts use knowledge as an instrument or a tool in problem solving.

The main objective of the paper aims to integrate anchored instruction, the web-based learning theories, problems-based learning theories and flow theory. We will also develop a model course based on the designing principle for elementary school students, discuss how they can help students to use learning resources actively to solving problems, include basic kinematics and NXT's programming and to encourage them become independent thinkers and learners.

THEORY

In this study we adopt the idea of anchored instruction to our Lego robotics' class design as our teaching method to encourage the exploring and independent thinking. The Lego Mindstorms NXT Robot kit which is our study' main content, the web-based learning, the problem-based learning and flow theory which are integrated in our course designing principle will also be introduced as follow.

Lego mindstorms NXT

Lego mindstorms NXT is a programmable robotics kit, released by Lego Group in 2006. It is designed specifically for teachers for educational purpose and for adults and children who are aged 8 and up, to create varied robotics toys, by using the various components and programming software.

The kit contains more than 600 elements for creating robots, including the most important programmable brick also called micro-computer; servo motors for driving robots; and several kinds of sensors as ways to detect and measure signals like light level, volume level and distance etc. from environment. Other components such as gears, levers, pegs, axles, wheels, tracks and tires etc. are providing for constructing the mechanical structures of the creations.

The Lego Mindstorms NXT education software called NXT-G is a very simple graphic program that comes bundled with the NXT. It is adequate for NXT's basic programming such as dealing sensor's inputs, driving motors, calculating etc.

Lego robotics has been successfully used in many engineering educations and programming courses (Elmore and Seiler, 2008; Williams, 2003; Kim and Jeon, 2009).

These educational robots are designed to be low cost robotic tools. And the elements provided are basic and have enough ability to use for many educational purposes (Mitnik et al., 2008).

Since Lego Mindstorms NXT kit is considered some features like relatively inexpensive, robust, reconfigurable, and are familiar to students (Kim and Jeon, 2009), it became popular in educational studies in the decade (Klassner, 2002; Klassner and Anderson, 2003; Ryu et al., 2008). It has facilitated novices to learn simplified kinematics, programming structures and flow control. Therefore, numerous resources especially videos are spread on the internet by people all over the world, to display and demonstrate what and how Lego Mindstorms NXT can work (Elmore & Seiler, 2008; Kim et al., 2009). It is very helpful to introduce learners to using this information on self-directed exploring and learning part.

Anchored instruction

As situated cognition researches had indicated that learning always takes place in certain enabling situation all the time (Fenwick, 2003), it is inseparable from humans' cognition. Anchored instruction uses the video-based problems (called anchors), which each problem contains various sub-problems as series of visual examples embedded in authentic contexts to make students to be immersed in the problem contexts (Hickey et al., 2001). Its main purpose is to manage to create various interesting contexts which are rich in content to provide opportunities to encourage students in constructing their own knowledge actively and promoting their higher-order thinking while they attempt to explore and examine the content's multiple perspectives, which are embedded through the complex problem space, called macro-contexts.

Anchored instruction is different from the traditional lecture instruction approaches. In the latter knowledge are transmitted from the teacher to the student, however the former emphasizes an understanding of the overall problem, to enhance student in integrating information into a solution by themselves, and finally, to develop their knowledge and confidence to become independent thinkers and learners (Shyu, 1999; Mary, 2005).

According to McLarty et al., (1989) there are seven design principles for guiding the development and implementation of an anchored instruction, which are: (1) Choosing an appropriate anchor; (2) Developing shared expertise around the anchor; (3) Expanding the anchor; (4) Using knowledge as tools for problem solving; (5) Teaching with the anchor; (6) Merging the anchor with literacy experiences; and (7) Allowing student exploration.

Web-based learning

As Wright's (2008) opinion, the education of 20th century

stress on the reciting, but the education and learning of 21st century will focus on the searching for information and accumulating the knowledge actively by students themselves. The internet is the students' favorite manner to acquire many useful information, because the "search engine" is thus universal and convenient (Madden, 2006).

Lou and MacGregor (2004) had indicated that students do not have problems in searching data on the internet today, but they still need effective strategies to acquire the useful information and preventing to get lost on the vast database of the net.

Furthermore, Lim (2001) had stressed that "inquiry-based learning" can be implemented by the teaching methods which are basis on Constructivism, such as goal-based learning, problem-based learning and Web-Quest. The inquiry-based learning doesn't emphasize on the "most correct answer", on the contrary it emphasize on finding the "most appropriate solution", just like the Constructivism.

WebQuest is an inquiry-oriented lesson format, which had be studied and considered that it can support students in thinking skills such as analysis, integration and assessment (Swindell, 2006). It can also improve the quality of students tasks, promotes their motivation and enthusiastic (McGlinn and McGlinn, 2003). Dodge (2004) proposed six items for designed a WebQuest, which are:

(1) Introduce the scenarios, to attract students; (2) Task, which be present by slides, for example: PowerPoint; (3) Process, to separate the task to small parts; (4) Resources, to provide list of on-line related resources; (5) Evaluation, to set the goal of the work or task; and (6) Conclusion, to end a task and remind students what they have learned. Dodge believed "task" is the most important part in the WebQuest; teachers can use the items to develop appropriate for their own instructions.

After review the researches from 1960 to 1980, Mayer (2004) had found that guided discovery of the instruction was effective than the pure discovery in helping students' learning. Because this guided and structured inquiry is necessary, WebQuest's references will be helpful on our course designing principle for students' active exploring.

Problem-based learning

In the beginning, the problem-based learning (PBL) was originated in the medical school program at McMaster University in Canada about the late 1960s by Howard Barrows and his colleagues. Later it was widely used in adult learning and schools' learning (Neville, 2009). Many researchers had proposed the problem-based learning has various aspect of positive impact, for example: PBL approach can enhance the effectiveness of teaching, encourage students become spontaneous and more active on their learning (Caroly et al., 2004); promoting students' self-directed learning, motivation (LeJeune, 2002); helping students to transfer their knowledge from theories to applications and upgrade their adaptability for the future (Pang et al., 2002); Dunlap and Grabinger (2003) found that PBL had positive impact on the C++ computer language programming learning; and the study of Thomas and Chan (2002) showed that 70% of students agreed that PBL helped them to discovery new knowledge. In Bjorck's research (2002), the students who are after the PBL instruction had better performance on the hypothesis-deductive than the students who are after the traditional teaching methods.

The definitions of problem-based learning by each researcher are almost similar except slight differences. Barrett (2005) proposed the operational definition of problem-based learning (PBL) are: (1) Guiding students to be interested in the problem; (2) Students define the content of the problem and what they don't know, what their need to learn; (3) Students search the information which they need in the library or on the internet by themselves; (4) Students share their found information;

(5) Students discuss, choose the solution of the problems and implement together; (6) Students review their problem and implementation to and think what they have learned. On the other hand, Berger et al. (2003) divided the PBL to: (1) Problem finding; (2) Requirement identification; (3) Information search; (4) Self-learning; (5) Knowledge application; (6) Information assessment. Sheella and Kevin (2004) had advised teachers give students' appropriate questions on the right time will guide students' discussion to be deeper, and teachers shouldn't modify the idea of students too often to give them having more free on creative thinking when using PBL instruction.

Flow theory

Motivation is one of the important aspects in the educational researches (Jenkins, 2001; Lynch, 2006). It is used to promote efficiency and achievement of learning (Linnenbrink and Pintrich, 2002).

Flow, as a psychological state and a way of understanding motivation was originally defined by Csikszentmihalyi (1990), which constructs into eight dimensions: (1) clear goals and immediate feedback; (2) equilibrium between the level of challenge and personal skill; (3) merging of action and awareness; (4) focused concentration; (5) sense of potential control; (6) loss of self-consciousness; (7) time distortion, and (8) autotelic or self-rewarding experience (Csikszentmihalyi, 1997).

This opinion has been applying on various human activities such as games and sports etc. (Csikszentmihalyi, 1997). Various researches had proposed that there is a positive association between person's flow state and their learning activities, intrinsic motivation and perceived ability (Skadberg and Kimmel, 2004; Jackson et al., 1998; Jackson et al., 2001).

Nakamura and Csikszentmihalyi (2005) found that

when students encounter a new challenge they raise their skills to overcome it. After that, they tend to deal more complex challenges which are correspond to their skills' level. It's because when people's perceived challenges are higher than their perceived skills, they will feel anxiety; otherwise, when their perceived skills are greater than the perceived challenges, they will experience bored; if both the skills and challenges are low, people will be apathetic. The flow state requires a balance between the level of perceived skills and perceived challenges (Csikszentmihalyi, 1990). Besides, some other core characteristics like feeling in control, focusing attention on activity, feeling curiosity, and having intrinsic interest (Trevino and Webster, 1992); and seamless-sequence of responses, intrinsically enjoyable, accompanied by a loss of self-consciousness, and self-reinforcing (Hoffman and Novak, 1997); and enjoyment and time distortion (Wu and Chang, 2005) also had been adopted in measurements.

Since flow state has great influence in the motivation, the characteristics of flow will be considered in our course designing principle.

RESULTS

In this section we will discuss the main factors in our course designing principle development. And we will integrate the reference of web-based learning, problem-based learning, flow theory and anchored instruction which had be mentioned in the previous section, to integrate them to our principle of Lego Mindstorms NXT course design of promoting students in active exploring and problem solving skill.

Main factors of the principle

There are two main improving factors in our course principles development which are found by interview. After the practical teaching experience of author and interviewing teachers who had taught NXT classes, we had come at the fact that usually students (especially fresh students) are always interesting in particular functions, such as using Bluetooth to control their NXT caterpillar cars by computers as remote control cars; waving the stick installed on the robot to hit other students' robots or anything. They have no idea to explore and search the possibility of what the NXT can do or achieve, even in the thematic activities in the classes, also they seems have not interest to build something the teachers required.

Besides, the students in the classes usually cannot find out the key concept to solve problems about basic programming or mechanics by themselves. They even have no interest, motivation and intention to manage an attempt by teachers' suggestions or cluing, and are used to leave the problems away to teacher, then back to enjoy the functions of the NXT which they are always interested in.

Therefore the two main factors in our Lego Mindstorms NXT course developing principle are: (1) Promoting students' interest in exploring the widely functions of Lego Mindstorms NXT when different kinds of motors and sensors combine with different programming and mechanics. And (2) Encouraging students' motivation in problems solving of basic Lego Mindstorms NXT programming and mechanics.

Situation's aspect

The most important element in our robotic course development is the influence of learning situation. We will discuss many theories which base on situated cognition and especially anchored instruction.

The anchored instruction is ground in a story or a fictional situation which called "anchor" to present to learners the learning topic (McLarty et al., 1989). In the anchor several problems which are related to the learning topic will be contain. The anchor engages learners with the series of related problems and encourages them to develop skills to correspond with the solutions. In Prensky's (2001) opinion the situation or context must be meaningful for learners. For example: to identify which is the appropriate anchor for students' age is important (McLarty et al., 1989), and also it had to fit the teaching goal. As the suggestion of flow theory, the dynamic balance between challenge and skill can also make learners to immerse on the present activity (Csikszentmihalyi, 1990; Jackson and Eklund, 2002).

From the side of multimedia, Marchionini's (2003) study had indicated that using multimedia to assist teaching will promote the interest, concentration, imagination and the learning effectiveness of the students. In addition, the digital video which rich in images, sounds and story contents also can attract students and promote their imagination (Hein, 2001). Hence the style and the interest of the anchor video's content is another important side for consideration. Although this represents the instructors or teachers have to put in more effort, time and resources in design a better quality of "anchor" problem condition at the same time.

In anchored instruction, the educational activity and all learning begin from the problems (Antonietti, 2001; Schroeder and Zarinnia, 2001). Educators create the appropriate conditions for students in continuing motivation and interest, afterwards the condition guides the educational activities and encourages students keeping explore the problems around the anchor (Levin, 2001; Trop and Sage, 2002; Gentry and Springer, 2002; Barrett, 2005).

After these discussions of anchored instruction, the situation's aspect of our robotic course design principle

should be: Creating a rich condition with multimedia that contains problems related to learning objectives and are meaningful for learners.

Knowledge's aspect

The other aspect which is highlighted in the anchored instruction is using knowledge as tools (McLarty et al., 1989). According to Cognition and Technology Croup at Vanderbilt (1990) anchored instruction is intended to enable learners to have opportunities to act the "experts" who encounter in practicing problems or be immersed in a situation, and are familiar and thinking about these. In the study of science education by Pantidos et al. (2001) had shown that the role playing activities helped students to have more comprehension and understanding to get easier to reach the instructional goals.

Kain's (2003) view gives us a better understanding of using knowledge as a tool. He stated that the un-successful problem solvers are wasting time in "doing something" blindly, but the successful problem solvers spend time to think "what should we do" and to unearth the "truth" in the problem. The former is what most people do in their unfamiliar field, and the latter is how the experts deal with their professional fields. The important is the manner of using the information (Dodge, 2004). Students have to use their concept and knowledge to a new condition and solve the problem (Stonewater, 2005).

On the base of these studies, the second principle of our robotic course design should be: Students play roles to immersive in the condition and work to solve the problems as protagonists.

Student's aspect

The most important element in student's aspect in the anchored instruction is "hands-on projects", which in the process of students working by themselves and trying to find out the solutions, it will train them and develop their higher-order thinking (Milson and Downey, 2001). Thus students can transfer the resources and information which they gather to their own knowledge (Wright, 2008). In the view of flow theory, flow is an intrinsic motivation, it's different from extrinsic motivation, and the hands-on activities will be closer to this psychological state. As Ghani and Deshpande (1994) said, the self-motivated learning is believed the best way of learning. And when students are intrinsically motivated in learning, they will want to learn more, and also can achieve more tasks (Chan and Ahern, 1999). Being in intrinsic interest alone, students will seize opportunities to learn and work, to keep gaining feedback to satisfy their curiosity and furthermore, to challenge more complex tasks (Deci and Ryan, 1987).

The guide of anchored instruction also emphasize that the condition of the video must provide ways and opportunities enables students to have sense of the anchor and explore, generate to their own information (McLarty et al., 1989). Students have to integrate various kinds of information and their knowledge; finally they will be able to solve the problem (Bottge et al., 2004). The learning condition only provides the necessary resources and direction, and encourage students to gather information actively, check the problems' subject and design their research method to find the solution, and the result of their attempt are unknown before (Prensky, 2001; Chang, 2002; Dipasquale et al., 2003; Stonewater, 2005). In this way it helps students to construct their own knowledge.

In Barrett's (2005) view of problem-based learning, students learn independently in their learning issue, they do not rely on teacher but use the library, internet, database and other people to acquire information they need.

The third principle of our robotic course design in the student's aspect should be: Providing students only necessary resources, direction and opportunities for them to learn independently in the hand-on project.

Cooperation's aspect

Sharing ideas and opinions are also paying attention in the anchored instruction since this approach is base on student-centered pedagogy. When students explore and solve problems independently, teamwork will enhance the quality of their thinking and accelerate the accomplishing of their tasks.

In the point of McLarty et al. (1989), anchored instruction must increase the possibility for learners to share the information. And almost all of the researchers in the field of problem-based learning agree that cooperative learning is indivisible from the PBL. Savin-Baden (2000) especially stressed on the communication and personal interaction in the problem-solving. In PBL there is a need to create a free and open ambience for discussion and encourage the members of teams to discuss and share their opinions (Gentry and Springer, 2002; Sheella and Kevin, 2004). With the peer guidance and working together, students test and verify the problems, then they establish assumptions, verify and modify the assumptions, to outcome a conclusion (Dipasquale et al., 2003; Barrett, 2005).

Some researchers suggest that the small group learning approach is helpful in the problem-based learning; the dialogue should be the core of PBL and group work (Antonietti, 2001; Schroeder and Zarinnia, 2001). Co-operative learning helps students not only learn the problem solving, but also the skills of communication and leadership (Maxwell et al., 2001). Even the study of WebQuest had shown that the students of participating in cooperative learning received more positive reinforcement

and less criticism in their task, and were more efficient than the students without cooperative learning (Dobson, 2003). So the principle of our Lego Mindstorms NXT course design in this aspect is: Providing opportunity for students' collaboration, dialogue and discussion in the educational tasks.

CONCLUSIONS

After integrating the references above about anchored instruction, web-based learning, problem-based learning and flow theory, we classify these into 7 categories, they are: (1) Situation's Aspect; (2) Knowledge's Aspect; (3) Student's Aspect; (4) Cooperation's Aspect; (5) Web's Aspect; (6) Teacher's Aspect; and (7) Solution's Aspect.

Then we discuss into each references related to these 7 aspects and develop the corresponding 7 principles of designing our Lego Mindstorms NXT robotic course point to the 2 main factors of our course development, which are:

(1) Situation: Creating a rich condition with multimedia that contains problems related to learning objectives and are meaningful for learners.

(2) Knowledge: Students play roles to immersive in the condition and work to solve the problems as protagonists.

(3) Student: Providing students only necessary resources, direction and opportunities for them to learn independently in the hand-on project.

(4) Cooperation: Providing opportunity for students' collaboration, dialogue and discussion in the educational tasks.

(5) Web: Leading students to develop the efficient strategy of seeking on-line resources in the teaching activities.

(6) Teacher: Teachers act as the promoters to guide students' knowledge constructing, listen to their discussions then ask right questions at the right moments.

(7) Solution: The problems in the educational condition should be open and without one correct answer.

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