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Can Computer Programming Enhance Problem Solving Skills ?

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프로그래밍언어가 문제해결학습에 미치는 영향 고찰

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Abstract

Computers can be used in providing new ways to promote intellectual skills. A computer programming enironment can create conditions under which an intellectual mode takes root. Especially problem solving skills can be promoted through programming. To investigate whether and, if so, how computer programming enhances problem solving skills, the nature of programming and problem solving skills are examined. Then, issues on the programming learning context in relation to problem solving are presented.

요 약

본 연구는 프로그래밍이 문제해결학습에 미치는 효과를 문헌을 통해 조사하고 있다. 컴퓨터는 이제껏 타매체가 실현하지 못했던 분석적인 사고를 함양하는 것으로 알려져 있다. 특히 프로그래밍을 하면서 자신의 사고과정에 주목하게 됨으로서 문제해결수업에 가장 적절한 매체로 주목받고 있다. 그러나 실제로 이를 뒷받침할 현장 검증 자료가 산출되지 않은 상황에서 이 가정을 검토하기 위해 프로그래밍의 특성과 문제해결학습의 공통분모를 검토하고 학교 현장에서 위의 전제를 실현시키기 위한 교육과정의 개선을 제시하고 있다.

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Ⅰ. Introduction

It is said that computers can be used in solving existing educational problems as well as in providing new ways to promote new intellectual skills [1, 2, 3]. For example, it is claimed that a computer programming environment can create conditions under which an intellectual mode takes root. Computers can make the abstract both concrete and personal because they help improve children's learning by making their thinking process conscious [1]. Mostly because of the above reasons, it is believed that problem solving skills can be enhanced through programming.

There is little evidence, however, that programming actually promotes problem solving skills. In this context, it is necessary to examine the nature of programming and problem solving skills in order to determine the reasons why programming does or does not promote problem solving skills.

To do this, the nature of computer programming and problem solving skills will be examined at first. Next, an attempt will be made to answer whether programming enhances problem solving skills. Third, issues on the programming learning context in relation to problem solving learning will be presented. Finally the summary will be presented.

Ⅱ. Computer programming

It is said that programming is "a set of activities involved in developing a reasonable product consisting of a series of written instructions that make a computer accomplish some task" [4]. In order to understand the underlying meaning of this statement, lets look at computers themselves because programming is considered as an activity which comes from a computer, a new tool, in the human environment.

Computers, like other tools, transform human activity. This transformation affects the human psychological process; that is, human cognition is mediated through the role of computers. Using computers, humans alter the external environment; but these alterations influence their internal cognitive processes. As the development of gasoline engines provided a tool for human physical activity, the development of the computers provides a new tool for human mental activity [3].

In this context, programming should be understood as a new cultural element and it should be used for developing human mental activities. Therefore, the most desirable ways to use computer programming is to solve problems which otherwise would be impossible to solve and to enhance intellectual abilities such as creativity.

One of the human mental activities in which creativity plays an important role is problem solving. In order to know whether programming can be used in a unique way to promote problem solving ability, it is necessary to examine the nature of problem solving.

Ⅲ. Problem solving ability

Problem solving is an important aspect of knowledge. When knowledge is defined scientifically, it can be said that having knowledge means having answers about problems [3].

There are many kinds of problems in the human environment which cannot be defined in one sentence. In order to try to examine this

notion, the structure of problems and those elements will be examined. Also, desirable school climate to teach problem solving will be examined.

1. Structure of problems

Problems can be divided into two categories: well-structured problems and ill-structured problems. Well structured problems are those which have explicit goal and steps to go on.

Most of school's problem solving is focused here and it is integrated within the subject matters [5]. On the other hand, learners mostly meet ill-structured problems in and outside schools. Ill-structured problems have no explicit goals and often need information from outside sources or (and) from the learner's mind (e.g. long term memory). Schools rarely can teach ill-structured problem solving because it requires a great deal of experience and there is no short cut to teach ill structured problem solving skills whereas well-structured problem solving skills can be promoted through practice [6].

However, there is no clear cut way to divide problems solving skills in the real world. Whether they are well or ill structured problems depends on the problem solver [5, 6, 7]. A problem may be well-structured for the problem solver who possesses the requisite knowledge and has practiced the relevant problem solving procedures or it may fall in the other category for one who has had insufficient experience or training in solving problems of that type.

In addition, ill-structured problems also can be decomposed into well-structured problems and be solved on the basis of well-structured problem solutions [7]. Despite the differences between well-structured problems and ill-structured problems, there are some general elements in problem solving skills: problem representation, problem solving procedures and pattern recognition [5].

2. Elements of problem solving skills

2.1. Problem representation

Problems are represented through "task environment" and "problem space" [5]. Task environment is the structure of the facts, concepts, and their interrelationships that make up the problem. Problem space is the problem solver's mental representation of the task environment. The quality of solution to the problem will be determined by the adequacy of this representation of the problem. For example, while the experts categorize problems on the basis of fundamental principles during problem solving, the novices tend to sort problems according to surface features [5]. That is, experts can use chunking in order to contain enough knowledge which is needed in solving problems.

2.2. Problem solving procedures

It is said that a problem solving procedures is a planning activity devised to accomplish goals. In this sense, planning means more than a group of tasks; it depends on problem solver's subjective values as well as knowledge. The plan structure often depends on the values the problem solver gives to the success or the failure of his position [3]. Expecially when the problem is not explicitly presented, the emotional states appearing in the course of problem solving are an essential part of the problem solving process.

In addition, Greeno(1980) believes that since planning depends on knowledge, it probably occurs in different way depending on the problem

solver's knowledge of the domain. That is, for the person experienced in the domain planning may be automatic while the novice must generate and try out various strategies.

2.3. Pattern recognition

Experts have learned to recognize patterns and use such patterns in processing information. Through using patterns, problem solvers can chunk the problem in order to use existing schemata usefully in receiving new knowledge and to transform it to their knowledge [5]. This example is explicitly shown in expert chess players. Pattern recognition requires a great deal of practice and training in a specific area [5, 7].

3. How can we teach problem solving skills?

How these general elements of problem solving skills can be taught is the biggest issue in this area. Some insist that problem solving skills should be taught in relation with specific knowledge because the most important thing in problem solving is the acquisition of well organized procedural networks for specific domains rather than general planning procedures [7, 8, 9]. Also, when trying to teach a generalized problem solving procedure which is separated from specific subject knowledge, it may be disintellectualized and carried out in a rote fashion [8]. Greeno(1980) questions the wisdom of teaching strategic knowledge explicitly because this is mingled with subject matter and often cannot depart form its specific domains of knowledge.

On the other hand, problem solving can be taught in a general way because evidence from artificial intelligence and from human transfer experiments indicates that powerful general methods of problem solving do exist and that they can be taught in such a way that they can be used in a new domain when they are relevant.

Whether problem solving should be taught as a part of subject matter or as independent knowledge appears to be dependent on the situations. Because there are many kinds of problems in and outside schools, explicit learning as well as discovery learning should be used to enhance student's specific knowledge and to generalize the acquired procedures to problems. That is, a variety of problem solving settings should be prepared in order to maximize transfer and to try to involve students in problem solving activities. Also, to foster creative problem solving activity, the school should create a climate that encourages idea seeking rather than one that promotes rote learning.

IV. Can computer programming enhance problem solving skills?

The computer's impact on human cognition has been hot issue in education. Some people believe that programming affects people's thinking mode logically and analytically at the expense of intuitive, empathetic and holistic thinking whereas some think computers do not change anything in human cognition [10]. Although not based on empirical evidence, it is said that computer programming will make students good problem solvers [1, 9, 10]. Having no empirical basis does not mean that some belief is falsified. Human discourse is as important as empirical evidence. Computer programming can enhance problem solving skills and that is should primarily be used to amplify students new intellectual skills. This belief is due to following reasons.

First, the computer's immediacy can allow students more control over their problem solving process than any other problem solving context. That is, the computer's immediate feedback to a course of action will permit students to have control over their activities.

Secondly, through the computer's enormous capability of storing information and its searching function, students can be more involved in creative aspects of problem solving [3]. Like written language, as an artificial memory of mankind, gives an immense advantage of humans over animals, computers can provide students with knowledge which is necessary for solving problems. For example, in the hypothesis and testing procedure, students can concentrate on establishing the right hypothesis and save their energy by relying on computers to test hypotheses.

Third, computer programming can provide a personal atmosphere and make students conscious of their thinking process [11]. A problem solving activity often requires creativity of problem solvers. Problem solvers often need to connect ideas in a new way and usually this is risk-taking activity. In order to encourage students to take part in this activity, the environment should be playful and personal rather than evaluative and revealing. If there is enough computer accessability, the computer programming surely can provide a more personal and safe environment for problem solving.

Fourth, procedural characteristics of programming will enhance the student's chunking (clustering) ability so that they can efficiently use their mind. Also, through debugging, students will be more actively involved in their problem solving.

Finally, computer programming's provision of diverse ways of solving problems will affect student's emotional aspect and will make them feel confident in a problem solving context.

Problem solver's personal sense and the subjective values are not just added in a neutral way to the problem solving procedure; they can take a direct part in the control of the processes of a problem solving activity [3]. In this aspect, the empirical evidence of "transfer of feeling" in Logo environment must not be ignored in problem solving learning [10,12].

Like in any other learning, "the right environment of programming" is critical. Programming is not an exception in that it also can be taught in a mechanical way just like other notions of symbols [10, 13, 14, 15]. In addition, right environment is a practical issue that school personnel should be aware of. In order to lend support to the above conditions, practical issues in integrating programming into curriculum will be examined.

V. Issues for the right environment for programming

In order to define the right environment for computer programming, the following will be examined; dependency (independency) of subject matter, choice of language, and learning environment.

1. Dependency of subject matter

There is an argument as to whether programming should be taught with mathematics or science or as a subject matter in and of itself. Soloway(1982) insists that programming should be taught with mathematics because transfer between programming and mathematics will occur.

However, evidence for this assertion has yet to be found. In the Brookline Project, Papert(1996) tried to teach Logo in geometry and physics. There was some transfer of feelings to other subjects even though transfer in the cognitive aspect was not statistically significant.

Likewise, evidence of transfer across subject matters has not yet been found. This may results from insufficient learning and/or from the learning context which simply cannot enhance the generalizable transfer effect. For example, the common "black-box approach" to programming is another way of rote learning and generalizable transfer cannot occur in such a mechanical learning environment. This issue needs more reliable empirical research.

2. The choice of language

A question arises when programming is discussed as a promoter of problem solving skills in general. Are there any differences among the effects that programming language have on learners? Pea(1984) claims that there is no difference among programming languages and only the level of mastery produces difference in promoting high level intellectual skills through a programming activity [16]. It is said, on the other hand, that a programming language which presents powerful ideas of Computer Science should be chosen as an introductory programming language [4, 10]. Also, every programming language has its background; that is, language designers decide what kinds off problems their language can deal with best [17]. For example, Basic was originally invented for undergraduate students in an Art department.

It seems that Logo is a proper language to introduce programming ideas to children. Logo presents fundamental ideas of programming and it has its root in Piagetian learning and Artificial Intelligence; that is, Logo programming can be learned through a transferable, natural way and learners will be aware of their thinking process.

3. Right environment for programming

Besides the above aspects, there are many other issues that must be solved, e.g. the prerequisites for and some constraints of programming skills [18]. In order to solve all the above problem, it is first answered how much exposure to computers is necessary for producing generalizable changes in intellectual growth. Transfer problems in examples of particular can be answered after there are enough computer programming occurring in the school context. In order to maximize the effect of computer programming, the right programming environment should be researched.

VI. Summary

In order to know whether computer programming enhances problem solving skills, the nature of programming and problem solving skills have been examined. Because problem solving skills can be enhanced when enough knowledge is available and students are actively involved in problem solving activities with good strategies, computer programming can activate these skills in a number of ways. First, it provides a large storage capacity as well as searching skills. Secondly, it provides immediate feedback in order to give students control over their own activities. Thirdly, computer programming's atmosphere is so personal and reflective that students can concentrate on their own thinking. Fourth, its

procedural and emotionally confident provisions can help student's problem solving activities.

However, in order to use computer programming for promoting new intellectual skills, it should be understood as a new element in cultural context. When programming is integrated into an existing curriculum this understanding becomes important. Because computer programming simply can not be added into a traditional curriculum; the curriculum itself should be changed in order to maximize the computer programming effect. Through this way it can give school system a chance to change their roles form notorious inactive institutions to educational systems which can lead to social change. Therefore, in order to determine desirable directions of change, generalizable research from many directions is badly needed.

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