Natural Learning in a Lego-Logo Learning Environment

Jyrki Suomala
Department of Teacher Education, University of Jyväskylä
Seminaarinkatu 15 40351 Jyväskylä, Finland
e-mail: suomala@jyu.fi

Abstract

The concept of natural learning is a central concept in the conception of learning of Seymour Papert, who developed the Logo programming language. In this paper, Papert’s view of learning is compared with L. S. Vygotsky’s description of the development of the child’s modes of thinking. On the basis of this comparison, an attempt is made to show that natural learning is an important intermediary stage in the process whose final goal is the genuine understanding of scientific concepts.

In the paper, the concept of natural learning is elucidated by means of describing situations in which primary school pupils act in a Lego-Logo learning environment according to the idea of natural learning. The description is based on a teaching experiment with 104 eight-year-old pupils in the municipality of Laukka, Central Finland, during Spring 1992. The material for the paper was gathered by means of the method of participatory observation during the lessons that were part of the teaching experiment.

Keywords: Lego-Logo, learning environment, learning, thought

Jyrki Suomala was born in 1959. He is Lecturer of Pedagogics at the Department of Teacher Education, University of Jyväskylä. He received Master of Education (Primary School Teacher, University of Oulu 1983) and Licentiate of Education (University of Jyväskylä) degrees. His research interest is Logo learning environment and its influence on pupils’ thinking skills. Doctoral thesis on the subjects is underway at the University of Jyväskylä. He has worked as class teacher in 1983-1988, but for the past five years he has been working at the University of Jyväskylä as Lecturer and Researcher.
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Seymour Papert’s view on learning

Logo is a programming language developed by Seymour Papert expressly for children [3]. The central concept in Papert’s views on learning is that of natural learning. The concept of natural learning refers to a learning process in which an individual acquires knowledge of phenomena in his surroundings without conscious effort and without conscious teaching. Papert aims at showing that people learn an enormous amount of things according to the principle of natural learning [3]. It is typical of such learning that it is intertwined with emotional experiences and is of very personal nature. Although the effects of natural learning are very profound, it is hard to observe them e.g. by means of psychological tests.

Papert elucidates the significance of culture in learning by means of the concept of “Mathland” [3,4,5]. In the Mathland, mathematics is learned as easily as the French language is learned in France [3,5]. The Logo environment is one example of a Mathland in which children learn the models of systematic thinking in a natural way.

Papert’s view of learning converges at several points with other approaches that emphasize the significance of culture in the learning process. For instance Cole and Cole take it that the child’s development has as its prerequisite the acquisition of models that are in force within a culture [1]. According to Wartofsky, an individual constructs his own cognitive models of cultural artifacts [10]. Those artifacts include linguistic models, objects, tools, rules of behaviour, and models of thinking. The Logo environment developed by Papert is an instance of an environment in which pupils can learn thinking skills according to the principle of natural learning. In a LEGO/Logo environment the object of programming can be any device built by a child with LEGO components [6,7,8]. In such a situation, Logo serves as a new cultural artifact produced by information society - an artifact by means of which children can learn cognitive models according to the principle of natural learning. Perhaps the most fruitful theory of human development to have dealt with natural learning is that of L. S. Vygotsky.

In the following, an attempt will be made to specify the concept of natural learning by means of Vygotsky’s theory of human development. In his theory, Vygotsky describes the evolution of forms of thinking through the understanding of everyday concepts to the understanding of genuine and scientific concepts. According to Vygotsky’s theory, concepts are cultural entities which the child gradually adopts during his/her development.

The Development of the Basic Forms of Thinking

A word, according to Vygotsky, has always two basic functions: 1. referential function and 2. meaning function [9]. In Vygotsky’s theory, this is not just a linguistic distinction; instead, the question is of the functional relationship between thought and word, which relationship changes all the time as the child grows up. The development of thinking means the evolution of the meaning function from the understanding of an everyday concept to the use and understanding of the concept as a part of a scientific conceptual system.

When the child first uses words, his/her use of them is closely connected to the interactive situations in which the words serve as tools for mutual understanding. They have a very pragmatic function, but at the same time a lot of rational experimentation and play is involved in their use. The word “mother”, for instance, refers to the child’s own mother, some of whose concrete properties the child associates with the word. At this stage the word’s referential function and meaning function coincide.

Vygotsky [8] uses the term everyday concepts of words that are adopted in such concrete situations. An everyday concept refers to some concrete object. The child adopts this kind of concepts, whose meaning function and referential function coincide, as separate entities. They are given a diffuse, subjective meaning. Meaning production, thus, is based on some directly observable property of the object [9]. Vygotsky’s central insight was that such a concept is not static, but that its meaning changes as the child’s thinking.
evolves; meaning function becomes separated from the original referential function.

By genuine and scientific concepts Vygotsky refers to words that have a generalized and hierarchical meaning in the child's mind [9]. Everyday concepts evolve towards genuine concepts so that their functional relationship with reality changes. The sign stays the same, but the meaning associated with it changes. Meaning is no longer connected to immediate perception, and the child becomes able to incorporate the word into a conceptual system, thus making it a genuine tool [9]. The child understands that the meaning of the word "mother" is not in his/her subjective use of it, but that the word has a wider conceptual meaning.

Vygotsky showed that the child does not learn the word's genuine-conceptual meaning until about at the age of twelve [9]. This stage corresponds to Piaget's period of formal thinking [2].

Everyday concepts, thus, develop in natural interactional situations from concrete reference towards genuine conceptual meaning, "bottom up", while scientific concepts develop "top down". The conscious control of phenomena that is characteristic of genuine and scientific concepts presupposes that the phenomena are related to each other as parts of a general conceptual system [9].

Thinking evolves, thus, in two dimensions. On the one hand, it goes from the unconscious to the conscious, on the other hand its sphere extends from the concrete to the conceptual. The thinking process never emerges as separate of the child's prior experiences [9].

Natural learning, as described by Papert, resembles the acquisition of everyday concepts as described by Vygotsky. It is only gradually that the concept that emerged as a product of natural learning in a Logo environment can evolve into a concept that the child can use consciously as part of a conceptual system and as a tool for planning. In the case of Logo, that conceptual system consists of the hierarchical programme structure with its subprogrammes. In view of learning, it is necessary that the child can play with concepts and use them in their own ways.

The central problem with school teaching has traditionally been to link scientific concepts to pupils' prior experiences. At school, it is only seldom that pupils can experiment and play with scientific concepts. The following chapter focuses on situations in a LEGO/Logo learning environment in which the principle of natural learning is at work.

Instances of the occurrence of natural learning in a LEGO/Logo learning environment

General

The following examples were gathered in connection of a teaching experiment carried out in the municipality of Laukaa, Central Finland, during Spring 1992. A total of 104 fifth-grade pupils from two primary schools participated in the experiment. The pupils were divided into two groups, each of which was given 20 hours of teaching. The pupils worked on LEGO/Logo in pairs.

During the experiment, the pupils carried out both the merry-go-round project and the robot project. In both projects, the pupils were taught the Logo commands controlling the engines, the lights, and music. In addition, the "repeat" command and the writing of the program were introduced. The following five examples are taken from the field diary in which the descriptions of the instances of natural learning were recorded immediately after the lessons.

Adding lights

The merry-go-round project was designed so as to include the possibility of adding new lights to the device. When one light had been installed, one of the pupils came to ask if more lights could be added. Permission
granted, all the pupils started adding lights of different colours. They found it very important to have a lot of lights of different colours in their merry-go-rounds.

Installing extra lights seemed to have a positive effect in that it made the programmes written by the pupils more complicated. The pupils were faced with the demanding task of making the lights work at the right moment. And when pupils built a fine light system, they naturally also wanted to test if it worked. All this sets their thinking skills on trial.

The tournament

The pupils had just studied LEGO/Logo for 12 hours. They had completed the LEGO robot and connected it to the computer. They were now supposed to use their skills learned during the merry-go-round project for moving the robot. This time the task was more difficult, however, because the robot had two engines instead of one.

Two of the pairs of pupils started to test whose robot would be stronger. The robots were placed so that they faced each other, and the engines were started. Interested spectators gathered around the table. Finally one of the robots won. After this, the rest of the pupils wanted to try the same. They started building their robots for that purpose.

The pupils started discussing eagerly how the robot should be tuned to be make it stronger. Some of the students made the bumper longer, some set long sticks in front of the robot. To increase friction, one of the students decided to put more weight on the robot.

After taking up a new idea, it was tested in a tournament. In case of defeat, the pupils who lost thought of what was better in the other robot, and tried to build one’s own robot accordingly. The idea spread at once through the group, and everybody wanted to test it.

The tournament was such an exciting and inspiring experience for the pupils that they wanted to take it up during the next lesson as well. The other groups heard about the tournament, and it was then arranged in their lessons, too. In the tournaments, pupils obtained experience of such basic concepts of physics as friction, power, and velocity. The concepts were given a meaning through practical operations, not as part of a system of physical concepts. Such an experience is a good starting point of later studies in physics.

Jerky movement with the command REPEAT

The pupils were taught, as a new topic, the “REPEAT” command. Now they were to write a programme applying the new command. Two boys wrote the following programme (Fig.1):

<table>
<thead>
<tr>
<th>COMMANDS</th>
<th>EXPLANATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>TO PETER</td>
<td>Name of the programme</td>
</tr>
<tr>
<td>SETPOWER 7</td>
<td>Full speed</td>
</tr>
<tr>
<td>ONFOR 100</td>
<td>Rotation for 10 sec.</td>
</tr>
<tr>
<td>RD</td>
<td>Change of direction</td>
</tr>
<tr>
<td>ONFOR 110</td>
<td>Rotation for 11 sec.</td>
</tr>
<tr>
<td>SETPOWER 5</td>
<td>Decrease speed</td>
</tr>
<tr>
<td>REPEAT 5[ONFOR 1 RD]</td>
<td>Rotation for 0,1 sec and</td>
</tr>
<tr>
<td></td>
<td>change direction 55 times</td>
</tr>
<tr>
<td>SETPOWER 7</td>
<td>Full speed</td>
</tr>
<tr>
<td>ONFOR 107</td>
<td>Rotation for 10,7 sec.</td>
</tr>
<tr>
<td>END</td>
<td>End of programme</td>
</tr>
</tbody>
</table>

Figure 1. Programme “Peter” written by two boys

When the boys ran the programme, it aroused amazement and joy in the group. The “REPEAT” command
made the merry-go-round rotate in a jerky fashion. When seeing this, the other pupils asked how it was done, and the boys told them how they had done it. The others soon started to apply the command with the intention to bring about the jerky movement.

This incident shows the kind of activities that occur in a LEGO/Logo learning environment. The main principle of the action there is not to achieve a specific goal but to encourage pupils to exploit their own ideas and experiences. In view of programming, the pupil’s goal may be quite peripheric. However, such action gives him/her new experiences and is significant for later learning. At first the commands are used as everyday concepts, but later they turn into genuine and scientific concepts.

Connotations of the programme name

When carrying out the merry-go-round project, the pupils to went on practice linking subprogrammes into the entire programme structure. For an eleven-year-old pupil, this process is still difficult to grasp. Although the pupils learned the principle of the subprogramme, they did not use subprogrammes very much on their own initiative.

The following example describes how two pupils killed two birds with one stone. The boys’ intention was to test the “REPEAT” command and use it to bring about a jerky movement. However, they also wanted to use a sentence of their own invention to control the merry-go-round. Since more than one words can not appear in the programme name, the boys went to the command center and wrote the words LITTLE BOY WENT on the same command line. They wrote three subprogrammes and gave them the names “BOY”, “WENT”, and “LITTLE”, so that the programme could be launched from the command center with the sentence “LITTLE BOY WENT”.

The programme worked, and the boys managed to carry out their own idea in the LEGO/Logo learning environment. Naming a programme seems to be a very personal process. The pupils give their programmes their own names or those of their friends or idols. The name does not need to have anything to do with the contents of the programme. However, by giving the programmes the names they want, the pupils retain a personal touch with the programming tasks.

Systematic experimentation

Logo programming gives opportunities to many kinds of activities. A popular way to write a programme seems to be to test a specific command systematically in a certain order. The following example illustrates this tendency in more detail.

Two girls were testing the “TONE” command by making the following programme (Fig.2):

<table>
<thead>
<tr>
<th>COMMANDS</th>
<th>EXPLANATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>TO MUSIC</td>
<td>Name of the programme</td>
</tr>
<tr>
<td>TONE 262 1</td>
<td>Note C, duration 0.1 sec.</td>
</tr>
<tr>
<td>TONE 294 2</td>
<td>Note D, duration 0.2 sec.</td>
</tr>
<tr>
<td>TONE 330 3</td>
<td>Note E, duration 0.3 sec.</td>
</tr>
<tr>
<td>TONE 349 4</td>
<td>Note F, duration 0.4 sec.</td>
</tr>
<tr>
<td>TONE 392 5</td>
<td>Note G, duration 0.5 sec.</td>
</tr>
<tr>
<td>TONE 440 6</td>
<td>Note A, duration 0.6 sec.</td>
</tr>
<tr>
<td>TONE 494 7</td>
<td>Note H, duration 0.7 sec.</td>
</tr>
<tr>
<td>TONE 523 8</td>
<td>Note C, duration 0.8 sec.</td>
</tr>
<tr>
<td>TONE 494 7</td>
<td>Note H, duration 0.7 sec.</td>
</tr>
<tr>
<td>TONE 440 6</td>
<td>Note A, duration 0.6 sec.</td>
</tr>
<tr>
<td>TONE 392 5</td>
<td>Note G, duration 0.5 sec.</td>
</tr>
<tr>
<td>TONE 349 4</td>
<td>Note F, duration 0.4 sec.</td>
</tr>
<tr>
<td>TONE 330 3</td>
<td>Note E, duration 0.3 sec.</td>
</tr>
<tr>
<td>TONE 294 2</td>
<td>Note D, duration 0.2 sec.</td>
</tr>
</tbody>
</table>

Figure 2. Programme “Music” written by two girls
Increasing the duration of the notes is a typical instance of systematic experimentation that follows the principle of “add one”. The same kind of systematic experimentation occurred in connection with the commands “SETPOWER” and “ONFOR” as well.

Conclusions

This paper has focused on natural learning. Papert has designed the Logo programming language so as to enable pupils to learn systematic thinking naturally by means of it. Vygotsky’s description of the development of everyday concepts towards genuine and scientific concepts seems to support Papert’s idea concerning natural learning. Teaching situations should, however, be arranged so that pupils could get acquainted with new concepts by giving them personal meanings. It is only after this stage that they can be expected to use concepts consciously as tools for planning and as part of a conceptual framework. In a LEGO/Logo learning environment, natural learning means that pupils may, in projects, use Logo commands to control objects they themselves find significant.

In the situations described in this paper, the pupils built the LEGO device according to their own purposes. These purposes were very personal: winning a tournament, or building light systems, or increasing the rotation speed of the merry-go-round. It was especially important for the pupils to make the merry-go-round to jerk. They also found it important to give the programme an amusing name or to try different values with the commands.

These are instances of natural learning. In this kind of learning, a Logo command is learned as an everyday concept in which referential function and meaning function coincide. This means that the meaning of a Logo command is in the action that is produced in using its concept. It is only later that Logo concepts acquire, in pupils’ minds, a genuine or scientific meaning as part of the hierarchic system of all Logo commands.

Note

The development of genuine and scientific concepts of the pupil’s participating in the teaching experiment has also been studied after the teaching period, in an open problem solving situation. The pupils’ problem solving situation was video taped. This material, however, is not dealt with in this paper.

REFERENCES