

EFFECTS OF COGNITIVE LOAD IN COMPUTER-BASED LEARNING ENVIRONMENTS

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ABSTRACT

Recently, computers have been widely used in educational settings. Many researchers have proposed to construct computer-based learning environments based on the Cognitive Load Theory. The purpose of this study is to clarify the effect of cognitive load in computer-based learning environments. We constructed a video-based learning support system. This system can control the speed of the video by the background process. We assume that the speed of the video can control cognitive load; we examine the effects of cognitive load through experiments using this system.

1. INTRODUCTION

Recently, instructional videos have been widely used in educational settings. Many researchers have proposed to construct video-based learning environments based on the Cognitive Load Theory [1] [2]. The purpose of this study is to clarify the effect of cognitive load in computer-based learning environments.

2. OVERVIEW OF A LEARNING SUPPORT SYSTEM

In this study, we constructed a learning support system that replays videos of the process of creating the MindStorms's product from creator's perspective [3]. Figure1 shows an overview of our learning support system. A user creates the MindStorms's product while viewing videos replayed on the display. The video is replayed controlled by a mouse and a foot controller.



Fig 1 Overview of a learning support system

To examine the effects of cognitive load, we designed a system that can control the speed of the video by the background process. We assume that the speed of the video can control cognitive load; we examine the effects of cognitive load through experiments using this system.

3. EXPERIMENT

3.1. Subjects

Fifty-one undergraduate students participated in the experiment. We set up three experimental conditions: (1) Gear condition: high cognitive load during making a gear mechanism and low cognitive load during making a pulley mechanism; (2) Pulley condition: low cognitive load during making a gear mechanism and high cognitive load during making a pulley mechanism; and (3) Control condition: cognitive load is not controlled. Seventeen subjects were randomly assigned to each of the three conditions.

3.2. Procedure

Experimental procedure was (1) pretest (10 min.), (2) learning phase (40 min.), (3) posttest (10 min.), and (4) performance test (10 min.).

3.2.1. Pretest and Posttest

The pretest and posttest were conducted to examine to what degree the subjects acquired the basic knowledge of the Mindstorms. Each test consisted of sixteen problems categorized into two types. The blocks, as test items used in the eight problems in one category, were related to a gear mechanism that is part of the products in the learning phase. The blocks in the other category were related to a pulley mechanism.

3.2.2. Learning Phase

In the learning phase, subjects produced the relatively complex creature [4] while using our learning support system. We controlled cognitive load by accelerating or decreasing the speed of the video.

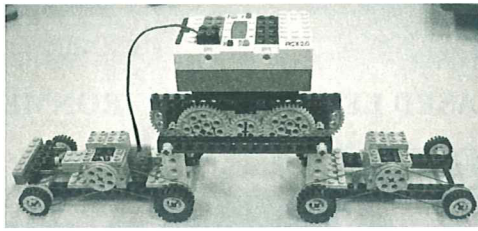


Fig 2 Creature produced in learning phase

3.2.3. Performance Test

Performance tests evaluated the subjects' knowledge and skills for constructing a mechanism to achieve a specific goal, which is considered a fundamental skill of the Mindstorms.

In this test, one motor and two beams on which obstruction parts were connected were prepared. The test's requirement was to fix the two beams on the motor and transmit the motor power to both ends of the two beams while avoiding obstructions.

4. RESULTS

4.1. Pre/Post test

In the pre/post test, errors within one segment in shaft length were ignored because it was difficult to identify the differences on the parts list used in the pre/post tests. Figure 3 shows a comparison of the pre/post tests.

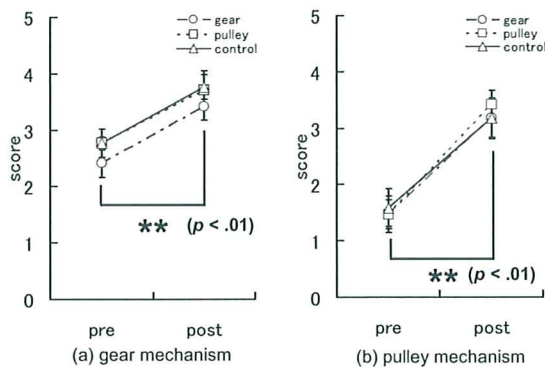


Fig 3 Comparisons of pre/post test

In both gear and pulley tests, a 3 (condition: gear, pulley, control) x 2 (tests: pretest/posttest) ANOVA showed a main effect of tests (gear mechanism test: $F(2,48)=30.58, p < .01$, pulley mechanism test: $F(2,48)=57.98, p < .01$), no main effects of condition (gear mechanism test: $F(2,48)=1.11, ns$, pulley mechanism test: $F(2,48)=0.06, ns$), and no interaction (gear mechanism test: $F(1,18)=0.06, ns$, pulley mechanism test: $F(1,18)=0.20, ns$).

These results indicate that the subjects successfully acquired knowledge of parts and combinations of the parts. In addition, the learning effect did not differ between the three conditions.

4.2. Performance test

We defined the subjects who produced a work fulfilling the requirements of the performance test as successful subjects. Table 1 shows the performance test results. The number in each cell indicates the number of successful and unsuccessful subjects in each condition.

Table1. Performance test results

	successful	unsuccessful
gear	10	7
pulley	10	7
control	13	4

Chi-square test did not reach significant differences ($p > .10$). Hence, performance test scores also did not differ across the three conditions.

5. CONCLUSION

In this study, we constructed a video-based learning support system that can control cognitive load. We examined the effects of cognitive load through experiments using this system. Experimental results show that there were no significant differences in the learning effect.

Future works include a detailed analysis of learning process such as learning time, the number of errors, and the interactive behaviors in the learning phase.

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