Preliminary Design of a Network Protocol Learning Tool Based on the Comprehension of High School Students: Design by an Empirical Study Using a Simple Mind Map

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Abstract. The purpose of this study is to develop a learning tool for high school students studying the scientific aspects of information and communication networks. More specifically, we focus on the basic principles of network protocols as the aim to develop our learning tool. Our tool gives students hands-on experience to help understand the basic principles of network protocols.

Keywords: Learning Tool, High School Student, Empirical Comprehension, Mind Map, Network Protocol.

1 Introduction

In her proposal statement on Computational Thinking (CT), Wing pointed out the importance of educational opportunities for college/university freshmen and pre-college students [1,2]. Based on her paper, Phillips described the CT concepts as follows [3] : Algorithms, Data (variables, data bases, queue), Abstraction (conceptualizing, modularizing), Queries (search, conditionals, boolean), Sensing & Feedback(robotics), Iterations (loops, recursion) and Systems. CATA and ISTE have discussed bringing CT to K-12 [4]. Some schools / universities also have started new lectures on CT education [5].

In Japan, CT related education starts in elementary school [6-8]. Especially at high school, "information study" has been one of the compulsory subjects for all students from 2003. The core curricula for information study can be divided into three parts, "using information in practice", "scientific understanding of information study", and "proper attitudes for participating in an information society". To design an appropriate learning tool related to these topics, we examined the comprehension of high school students and university freshmen about information and communication

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networks through a simple mind map. A Simple mind map consists of nothing but nodes with a word and edges between nodes. These objects do not have any colors or graphical parts like the original mind map [9].

2 Comprehension of High School Students for Informatics

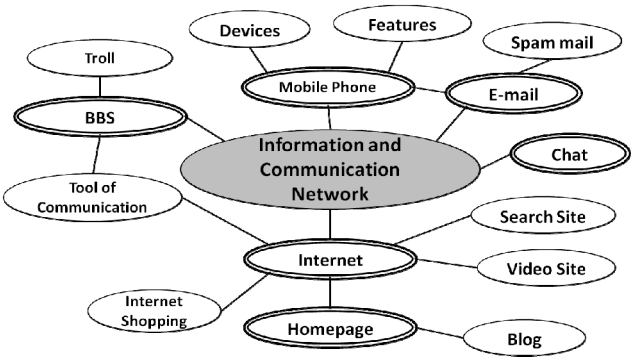
2.1 Methods

The subjects were 270 high school students (1st, 2nd and 3rd grade students) and 96 university freshmen. We asked them to draw a simple mind map about "information and communication network" from three aspects of core topics in information study. These maps were called student maps. On the other hand, we made a "text map" based on some textbooks authorized by the Japanese government for information study at high school. This text map had 91 words. From all student maps, we (1) counted the number of words in each map, (2) separated all words in two groups: formal (in the text map) and informal (not in the text map), and (3) counted the use frequency of all words.

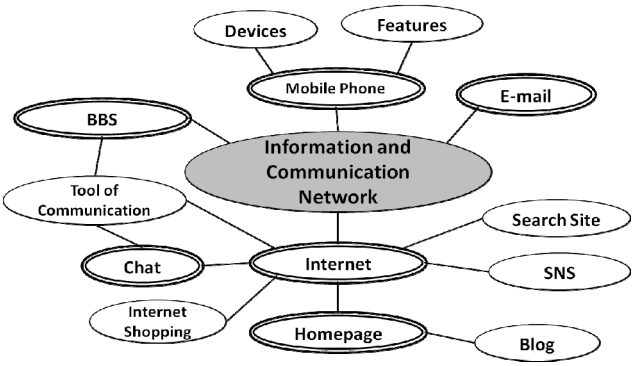
2.2 Results

Based on (1) and (2), there was no significant change in number of formal words for only "the scientific understanding of information" related to the school grades of the subjects. Therefore, the comprehension level of this domain does not change or avoids increasing at those developmental stages (from 1st grade in high school to freshmen in university). Based on (2) and (3), the number of formal words which 10% or more of the subjects used was 6 for high school students and 7 for university freshmen. We called these words typical words. Of these words, 50% or more students used only 3 words: e-mail, mobile phone and internet. Two typical student maps were made based on these frequently used words (see Fig. 1 (a) and (b)). The words in double circles are typical words. The words in single circles are "related words", which are connected by edges with each typical word in all student maps. From these maps, the concept hierarchy of our subjects is unarranged and unsuitable. Any words related to scientific fundamental rule, architecture or mechanism do not appear in those maps.

Meanwhile, based on the text map, (2) and (3), we showed comprehension maps of our subjects (see Fig2 (a) and (b)). The text map had 8 divisions: internet, packet switching, network protocol, file transfer, security, e-mail, data transmission speed and network services. In those divisions, whole words of 10% or more of the high school students described in their maps are matched to only 3 divisions. In the case of university freshmen, 5 divisions were matched to our subjects' words. The number of divisions which were not matched was 3. They were protocol, file transfer and data transmission speed.



(a) high school student



(b) university freshman

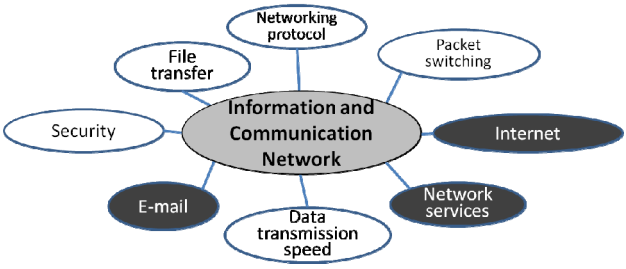
Fig. 1. Typical maps

More specifically, we focused on the basic principles of network protocols as the aim to develop our learning tool. Our tool gives students hands-on experience to help understand the basic principles of network protocols.

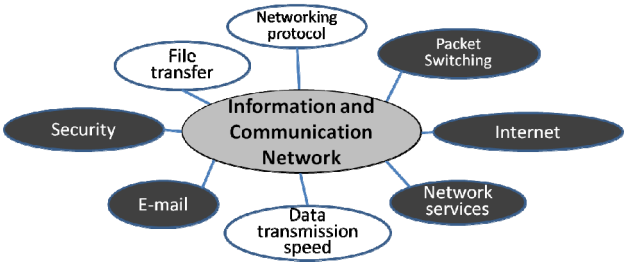
3 Preliminary Design of a Network Protocol Learning Tool

Referring to previous research, we ordered the basic principles of network protocols and summarized them into the four following points:

1. the start of the data to be communicated,
2. the end of the data to be communicated,
3. the format of the data to be communicated,
4. how to recover when a communication error occurs.



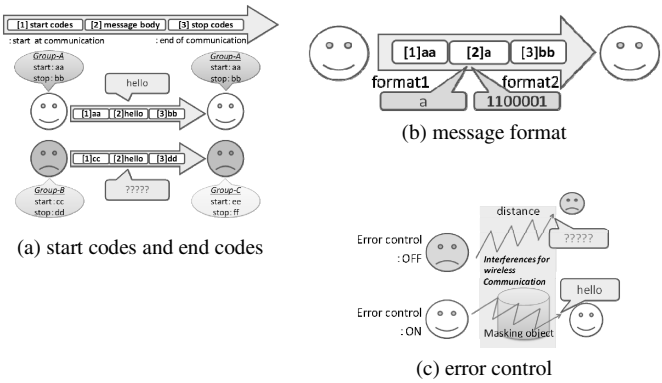
(a) high school student



(b) university freshman

Fig. 2. Matching divisions for student maps

We embodied these points into the specifications of the learning tool. Also, we made our hands-on size learning tool experimentally on an electronic circuit using Arduino [10]. We defined the data to be sent and received as the start code, message, and stop code. This learning tool allows learners to set up the start code and stop code, and assemble outgoing messages. These functions correspond to points 1. and 2. above (see Fig.3 (a)). To show the message body, the user can make a choice between two formats: ASCII code(8 bits / 1 ASCII character) or ASCII character. This function corresponds to point 3. above (see Fig.3 (b)). Daily objects such as "distance" and "fall" are easily presented credible threats to wireless communication. By using IT technology, we can recover from these communication errors. Our tool helps the user to be aware of the existence of these technologies. This function corresponds to point 4. above (see Fig.3 (c)).



(a) start codes and end codes

(b) message format

(c) error control

Fig. 3. Features of our proposed tool

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