論文 / 著書情報
Article / Book Information

題目(和文)	高校の専門教科向けアルゴリズム学習ツールの設計と評価：使用性，教育効果，動機づけの考察
Title(English)	Design and Assessment of an Algorithm Learning Tool for High School Computer Science: Usability, Pedagogical and Motivational Considerations
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出典(和文)	学位:博士（学術）, 学位授与機関:東京工業大学, 報告番号:甲第10044号, 授与年月日:2015年12月31日, 学位の種別:課程博士, 審査員:西原 明法,中川 正宣,前川 眞一,中山 実,室田 真男
Citation(English)	Degree:, Conferring organization: Tokyo Institute of Technology, Report number:甲第10044号, Conferred date:2015/12/31, Degree Type:Course doctor, Examiner:,,,,
学位種別(和文)	博士論文
Category(English)	Doctoral Thesis
種別(和文)	要約
Type(English)	Outline

論 文 要 約

THESIS OUTLINE

Design and Assessment of an Algorithm Learning Tool for High School Computer Science: Usability, Pedagogical and Motivational Considerations

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Chapter I Introduction

An Algorithm Learning Tool with Algorithm Visualization was created for the students of the Information Systems Course of a science and technology high school in Japan. Several issues on the importance of designing such a tool for introductory computer science for high school, particularly, in the area **usability, pedagogical and motivational assessments** were addressed by this research. The main research question is: "*What are the design and evaluation properties of an algorithm learning tool with algorithm visualization which can help enhance the learning performance and motivation of high school students in an introductory computer science course?*".

Chapter II Review of Related Literature

This research may be classified under computer science education (CSEd) and belongs to the research category on **"teaching/learning theories and models"** (Sheard et al., 2009). Four algorithms, namely, Linear Search, Binary Search, Selection Sort and Bubble Sort are considered because they are included in the curriculum of the student participants and are usually tackled in introductory programming and algorithm classes.

The main feature of the algorithm learning tool is Algorithm Visualization (AV), a technology that incorporates graphics and animation of algorithms. Research experiments that aim to verify the effectiveness of AV as an instructional material in computer science had been carried out and one of the factors considered is student **"engagement".** With the role AV plays in computer science education comes the need for its proper evaluation so properties such as Symbol System, Interactivity, and Didactic Structure and the Categories of Algorithm Learning Objectives (CALO) (Lee and Rößling, 2010) were incorporated in the design of the tool's evaluation instruments. In order to assess the effects of the learning tool on the motivation of the students, MSLQ or the Motivated Strategies for Learning Questionnaire (Pintrich & DeGroot, 1990) and the ARCS (Attention, Relevance, Confidence, and Satisfaction) model (Keller, 2008) were used in designing the questionnaires on motivation

Chapter III Research Methodology

The learning tool offers lecture notes and visualizations of four fundamental algorithms which are included in the curriculum of the students. The tool offers two types of visualization, one with more input menu options and control (AlgoVis1) and another with less (AlgoVis2). Along with the learning tool, a written pretest and posttest on algorithms and a questionnaire on the usability and pedagogical effectiveness of the tool were designed based on previously proposed AV evaluation properties. Two motivation questionnaires, one based on the MLSQ and the other on the ARCS model, were designed and were later combined to form one questionnaire on motivation. These evaluation instruments were employed along with the algorithm learning tool both in the pilot implementation and in the validation phase of this study. The students of were divided into two groups, the treatment group (A) students used AlgoVis1 while the control group (B) used AlgoVis2. To find out if there is a general increase in the learning performance and motivation of the students after using the learning

tool, *paired-samples t-test* was conducted. In order to determine the differences in the learning and motivation effects between the visualization with more input options and control and the one with limited options, *independent-samples t-test* was used between Group A and Group B. The two initial versions of the questionnaires on motivation and the tool's evaluation questionnaire used in the implementation of the learning tool have undergone revisions after the initial implementation with the pilot class. The two-step model building proposed by Byrne (2001) was conducted in the revision process using both SPSS and AMOS (Analysis of Moment Structures).

Chapter IV Results and Discussions

The results of the pretest and posttest on algorithms show an increase in the performance of most of the participants. In the absolute scale, the students who used the AV type that provide more input options and control have better improvement in the posttest. However, the differences in the scores between the control group and the treatment group are not big enough to produce statistically significant results. After using the learning tool, the students have proven to be capable of performing certain tasks based on CALO.

Following the two-step model building by Byrne (2001), factors that correspond to the three properties for evaluating AV tools were obtained: (1) Interface Assessment ("Interactivity"), (2) Algorithm Learning Objectives ("Didactic Structure") and (3) AV Characteristics ("Symbol System"). These factors were used in building a structural model that relates the factors and the posttest scores of the students. The structural model indicates that the AV features integrated in the design of the learning tool are effective in meeting the targets set by the Algorithm Learning Objectives. This further implies that the algorithm learning tool developed for this study is successful in meeting some of the learning goals set by the learning objectives normally used in CS education.

The two initial motivation questionnaires also underwent revision and validation to come up with one motivation questionnaire. Applying the two-step model building, motivation components (intrinsic motivation, self-efficacy, self-determination and learning preferences) were derived. Confirmatory factor analysis result shows that the questionnaire items measure well their corresponding factor while the structural model indicates that among the motivation components, self-efficacy and learning preferences were found to correlate with the students' posttest performance in algorithms. Analysis of the responses to the motivation questionnaires (both the initial and the revised) signify that there is a general increase in the learning motivation of the students after using the algorithm learning tool.

Chapter V Summary and Conclusions

In summary, the results of this study may be used to address the poor-performance and low motivation problems among high school students of computer science. As computer science is now being offered in the secondary school curriculum with the aim of helping students prepare for CS-related degrees in the university, the need to improve performance and to sustain student interest and motivation in learning CS has become a crucial issue in computer science education. The models proposed in this study, which relate Algorithm Visualization features, learning objectives, motivation, learning strategies and performance may be considered in the design and assessment of algorithm learning tools. The tool developed for this research may be extended to include other fundamental algorithms taught in introductory computer science. The tool may also be implemented and examined among a bigger sample size of participants for better analysis results.