Students' Science Process Skills Diagnosis

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Abstract. A virtual experiment environment was developed to provide students a virtual space to engage students learning science and practicing science process skills. To provide teachers information of their students' science process skills according to the actions and decisions students taken within the virtual experiment environment, a graph edit distance based diagnosis methodology was proposed. A small pilot in which 31 grade-10 students participated had been conducted. This short research study aims to verify whether or not the proposed method can correctly diagnose students' science process skills.

Keywords: Test of Integrated Science Process Skills (TIPS), Physics, Virtual Experiment Environment, Science Process Skills

1 Introduction

The research team designed a Virtual Experiment Environment which combines both of the gaming factors and the virtual experiment to engage students in science learning [1]. In the system, a graph edit distance method was proposed and developed to diagnose students' science process skills according to their actions and decisions taken in the virtual laboratory [2]. To verify if students perceived the virtual experiment environment is useful, a pilot had conducted [3]. In the pilot, thirty-one grade-10 students who had learnt basic Dynamics in Physics were recruited. All of them were asked to take the Test of Integrated Science Process Skills (TIPS) [4] which has 30 items developed to assess students' science process skills, before they started to use the system. Also, their actions and decision making within in the virtual environment were collected.

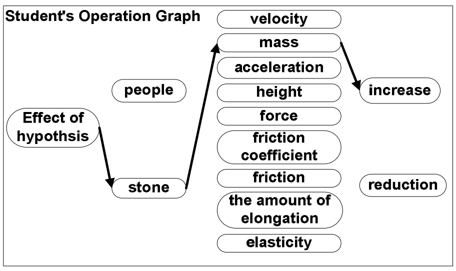
This short research study aims to use ANOVA to verify whether or not the scores of particular science process skills diagnosed by the proposed method are in line with the scores of correspondent TIPS items that students received. This paper is organized into three main sections. Section 2 introduces the virtual experiment environment and the graph edit distance based diagnosis method. Section 3 talks the hypotheses this research has and reveals the analysis results. At the end, Section 4 discusses the future works of this research.

2 Virtual Experiment Environment and Diagnosis Method

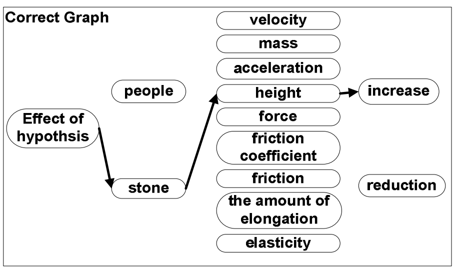
This research integrates story element into the virtual experiment environment proposed by Kuo et al. (2000) [5]. When students use the system, the system first prompts a story (include animation and text-based narration) and asks students to solve the problem involved in the story. For example, students role play an adventurer in a scene of the story, where they arrive at a valley and have to find a way to cross the valley by using a vine to swing to the other side where is higher than the cliff at this side.

Students then may make a hypothesis to solve this problem. For example, students can assume that when the adventurer runs faster, he or she may swing higher and reach the higher cliff at the other side of the valley. To verify the correctness of the hypothesis, students can choose one of the Java simulations [6] to preview the correspondent follow-up story scene when their assumption is applied. They have to find out which object in the story animation (such as the adventurer) is the corresponding object in the Java simulations (such as the bullet in a shooting simulation). They also need to consider which physical quantities (such as mass or speed) they may need to operate and to observe in the simulation.

Students need to consider what are independent, dependent, and control variables. In the above-mentioned story, students may think the running speed of the adventurer is an independent variable and the height that the rock can reach when it swings to the other side is the dependent variable. Next, students run the simulation by adjusting the values of the independent variables and record the values of the dependent variables via observation. After the experiment data is collected, students can examine the data and interpret the relations between the independent and dependent variables. At the end of the experiment, students need to assess the experiment results and to determine whether or not the results confirm the hypothesis they made earlier. If the hypothesis is not supported by the results, students can go back to previous stages to refine their experiment design.



(a)



(b)

Fig. 1. Graphs of choosing physical quantities.

The research team uses graph edit distance [7] to diagnose students' science process skills by converting actions taken by the students (as Figure 1a shows) and actions that students supposed to do (as Figure 1b shows) into two graphs and using the graph edit distance to calculate the difference in-between the two graphs [2]. Currently the method can diagnose students' integrated skills of identifying variables, constructing hypotheses, defining variables operationally, describing relationships between variables, constructing graphs, and interpreting data.

Three operations in graph edit distance are insertion, deletion, and relabeling for both nodes and edges. Different from the error-correcting graph matching algorithm [8], the proposed method doesn't take node costs into consideration due to the two graphs in this research have identical node sets. Also, the cost of substituting an edge does not take into consideration either due to the graphs are undirected graph and there is no different meaning attached on the edges. More details of the proposed diagnosis method can be found in [2].

In order to verify the diagnosis results' correctness, this research wants to find the relation between the diagnostic score and TIPS score of three science process skills: choosing physical quantities, identifying variables and graphing and interpreting data. Three hypotheses are then made:

- H1. There is a relationship between students' diagnostic scores and TIPS scores of choosing physical quantities.
- H2. There is a relationship between students' diagnostic scores and TIPS scores of identifying variables.
- H3. There is a relationship between students' diagnostic scores and TIPS scores of graphing and interpreting data.

3 Results

This research uses ANOVA to verify the three hypotheses. For hypothesis H1, at very beginning, the researchers find that there is no significant relationship (i.e., $p > 0.05$). When the researchers examine the data further, a special case (i.e., student #18), is found – the student's TIPS score is high but his/her diagnostic score is low. After review the actions he/she took for choosing physical quantities, we find him/her chose many quantities that the object doesn't even have. When we temporarily remove his/her data, the ANOVA result shows there is relationship existed (i.e., $p < 0.05$); therefore, hypothesis H1 is supported.

For hypothesis H2, similarly, at first round, the ANOVA result shows no significant relationship. When we examine the data further, we find four students have either high TIPS score with low diagnostic score (i.e., student #9, #16, and #31) or low TIPS score with high diagnostic score (i.e., student #6). By reviewing their learning log, we find that these students were either confused the meanings of independent and dependent variables or failed to choose exactly amount of variables. On the other hand, from student #6's responses toward TIPS items, we find that he/she jumped to next item immediately by choosing the first option he/she thought it is correct without reading all options completely.

For hypothesis H3, as too many students didn't finish graphing and interpreting data and received zero for the diagnostic score of this particular skill, the ANOVA result also shows no significant relationship. The reason that students didn't practice this skill probably is because they had only 50 minutes in the pilot and before they could start graphing they need to collect data first – phenomena observation and data recording are time consuming tasks no matter in real or virtual experiments.

4 Future Works

Although not all diagnostic scores of three science process skills have relationships found with the TIPS scores, the proposed diagnosis method is capable of grading students' science process skills properly when the special cases are ignore. Before we can confidently say the proposed diagnosis method is effective and has acceptable accuracy rate, two tasks need to be done: (1) new TIPS should be re-designed and in line with the concepts that virtual experiments cover – currently the TIPS the pilot uses is adopted directly from [4][9]; (2) a bigger and longer pilot is needed – so students can have enough time in practicing all science process skills.

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