Process Mining and Interaction Data Analytics in a Web-Based Multi-Tabletop Collaborative Learning and Teaching Environment

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ABSTRACT

This article builds on the intersection of educational process mining and the automatic analysis of student’s collaborative interaction data previously collected from a web-based multi-tabletop learning environment. The main focus of the article was to analyze and interpret the data using several process mining techniques in order to increase the instructor’s awareness (knowledge) about the students’ collaboration process and group progress in terms of specific quantitative indicators as follows: participation (consisting of participation density, participation rate and participation dynamics metrics), interaction (consisting of interaction density and interaction dynamics metrics), time performance (including the number of time intervals between the activities as well as the duration of idle/inactive periods), similarity of tasks (or symmetry of actions) and division of labor (or symmetry of roles). The empirical findings showed that there are substantial differences between the high and low performance groups.

KEYWORDS

Apriori Algorithm, Association Rule Mining, Computer-Supported Collaborative Learning (CSCL), Educational Process Mining, Frequent Itemsets Mining, Fuzzy Miner, Role Hierarchy Miner, Social Network Analysis

INTRODUCTION

In this research the Multi-Interactive Table Computer Lab (MITCL) environment was composed of two interactive tabletops (Table Computers) which were equipped with an online concept mapping application (OCMA), an Instructor Dashboard (ID), small groups of students and an instructor (see Figure 1). Students were able to enter their e-mails in order to log in to the system. The designed OCMA allowed the students to draw a concept map that corresponded to their collective understanding about the assigned task. The developed ID also allowed the instructor to generate real-time reports of the on-task progress of the small groups of students. The MITCL system was capable of automatically and unobtrusively capturing, collecting and formatting the students’ collaborative interaction data based on specific quantitative collaboration indicators (i.e., contexts). The collected data were initially

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converted into MXML-formatted event logs in order to be used and analyzed by the ID which was equipped with several process mining tools and techniques. Accordingly, the resulting quantitative information of group work could increase the instructor’s awareness about the students’ collaboration activities as well as the flow of knowledge building during the assigned task.

Being aware of the fact that the term collaboration process in computer-supported collaborative learning (CSCL) situations is too general and can depend on countless variables and factors, and after reviewing the secondary data related to the “Theories of Groups” (McGrath, 1991), “Theories of Groups Performance and Interaction” (McGrath, 1984), “Theory of Group Cognition” (Stahl, 2006), and based on definitions of collaboration in CSCL environments described in several works conducted by Roschelle’s and Teasley (1995), Dillenbourg (1999a,b), Morgan and Buttler (2009), Dillenbourg and Jermann (2010), Dillenbourg et al. (2011), Dillenbourg and Evans (2011), Martinez-Maldonado (2014), Martinez-Maldonado et al. (2013), and Premchaiswadi and Porouhan (2015a); eight independent indicators and one dependent variable were chosen for the initial Conceptual Framework of the study as shown in Table 1. The reliability analysis of the proposed Conceptual Framework with regard to the Cronbach’s Alpha (α) indicated a fair reliability for every single indicator as well as a total reliability of 85% for all of the indicators. In order to measure the linear correlation or the level of dependency between the indicators; the Pearson Product-Moment Correlation coefficient (2-tailed approach) was used. Considering the results of the correlation analysis; four indicators of “Task Difficulty”, “Prior Experience”, “Gender” and “Group Size” were not supported. As a result, the total number of independent indicators was reduced from 8 to 4.

Using the Ridge Regression Analysis technique, the most significant indicators of collaboration in a CSCL environment (see Table 2) were identified as the following, respectively: Extent of Participation (with significance level of 0.000 < 0.05 and t-value of 5.197 > 2.0), Extent of Interaction (with significance level of 0.000 < 0.05 and t-value of 4.466 > 2.0), Similarity of Tasks and Division of Labor (with significance level of 0.000 < 0.05 and t-value of 3.569 > 2.0), and Time Performance (with significance level of 0.003 < 0.05 and t-value of 2.998 > 2.0). The resulting coefficient of determination (R Square) indicated that 71.3% of the variance in the dependent variable is predictable from the four independent variables as shown in Table 3.
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