# Analytics of Time Management Strategies in a Flipped Classroom

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**ABSTRACT**: This study aims to explore time management strategies followed by students in a flipped classroom through the analysis of trace data. The study was conducted on the dataset collected in three consecutive offerings of an undergraduate computer engineering course (N=1,134). Trace data about activities were initially coded for the timeliness of activity completion. Such data were then analyzed using agglomerative hierarchical clustering based on the Ward's algorithm, first order Markov chains, and inferential statistics to detect time management tactics and strategies from students' learning activities. The results indicate that meaningful and theoretically relevant time management patterns can be detected from trace data as manifestations of students' tactics and strategies. In addition, this study also showed that time management tactics had significant associations with academic performance.

**Keywords**: Learning Analytics, Time Management, Flipped Learning, Self-Regulated Learning

## 1 BACKGROUND

Learning analytics allow for comprehensive data capture, however, connecting this data with higher level constructs such as learning strategies still remains a challenge. This study is an initiative to explore the capacity of data analytics methods to uncover patterns and trends in students' time management practices based on the trace data captured by a learning management system. It makes use of trace data to reveal individual differences in time management tactics and strategies and how these relate to the students' learning achievements (Broadbent & Poon, 2015), especially in flipped classroom setting. Time management was analyzed by looking at times when the students completed pre-class activities, as evidenced in the trace data and validated against the course schedule provided by the course instructor. Each week students were required to study one topic. Modes of study were assigned to each learning action based on its timing with respect to the week's topic: i) preparing - if students were on the topic that they were supposed to study for the given week, ii) ahead - if they were advance of the schedule, iii) revisiting - if students had visited the required activities for the behind-the-schedule topic at some earlier point in time, and iv) catching-up - if students had never before accessed activities related to the behind-the-schedule topic. By examining the students' modes of study, we expected to obtain insights that could inform the provision of feedback. In line with this objective, we defined our research questions as follows: i) Can we detect theoretically meaningful tactics and strategies of student time management from trace data about students' interactions with online preparatory learning activities in a flipped classroom? ii) What is the association between the students' time management strategies in the online component of a flipped course and their achievement? In particular, this study focuses on online learning activities that were designed to prepare students for face-to-face sessions. Trace data were collected

from three consecutive student cohorts enrolled, in years 2014, 2015, and 2016, in a computer engineering undergrad course ($N_{2014}$ = 290, $N_{2015}$ = 368, and, $N_{2016}$ = 476) that followed a flipped classroom design. Meanwhile, the second data source was derived from midterm and final exam scores. These data were used to examine time management practices of high performing and low performing students, and if / how the two differed. In terms of analysis, first, each learning session was encoded as a sequence of learning modes indicative of student time management tactics. This was done using the TraMineR R library (Gabadinho, Ritschard, Mueller, & Studer, 2011). Second, agglomerative hierarchical clustering based on Ward's method was used to identify: i) time management tactics by grouping similar learning mode sequences and ii) time management strategies by grouping students with similar time management tactics. For both cluster analyses (i.e. tactics and strategies), the optimal number of clusters was determined by inspecting dendrograms. Finally, First Order Markov Model (FOMM) was generated for each time management tactic to further explain the tactics identified through clustering. FOMM allows for modeling the changing of states based on the probability theory and the assumption that the next state depends only on the current state. The pMineR R package was used to compute and visualize process models (B et al., 2017).

The clustering of the learning mode sequences produced four clusters that could be considered as manifestations of the time management tactics adopted by the students, namely: i) Tactic 1 (*Mixed and Short*) typically started their learning in the *preparing mode*; that is, by engaging with the activities required for the week's face-to-face session, or by revisiting the learning activities they have previously done as a part of preparation tasks, ii) Tactic 2 (*Revisiting*) shows high probability of revisiting events performed by the students for the entire course, iii) Tactic 3 (*Short Preparing*) is distinguished by high probability of preparing events throughout the course iv) Tactic 4 (*Long Preparing*) is strongly focused on preparation events throughout the duration of the course, but unlike Tactic 3, preparation events tended to form long learning sessions. Subsequently, three time management strategies were identified by grouping students with similar time management tactics, as follow: i) *Comprehensive and Active* strategy group mostly used the *Mixed and Short* tactic. They also demonstrated how to use effectively spaced practice (Tactic 2 – *Revisiting*) and combined that with tactics focused on preparation only (Tactics 3-4), ii) *Selective and Active* strategy group showed a low use of Tactic 1 (*Mixed and Short*) and almost no use of Tactic 4 (*Long Preparing*), iii) *Limited Activity* strategy group included students who focused mainly on Tactic 1 (*Mixed and Short*) for the entire duration of the course but not as intensively as in the previous two groups, while, all other tactics were very rarely used. Our analysis also suggests that students with higher academic performance were characterized by consistent efforts and diverse time management tactics throughout the entire course (*Comprehensive and Active*) compared to mid-performing (*Selective and Active*) and poorly performing students (*Limited Activity*).

In conclusion, the methodology proposed in this work allows for identifying patterns in students' time management behavior on the basis of study session data. Our findings indicated that time management patterns can be detected from student learning session as manifestation of students' time management tactics. Such observable patterns in learning behavior led to the detection of several strategy-based student groups. In addition, consistent with previous research, we found that more active and directive time management strategies promoted effective self-regulation and positive association with academic performance.

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