Chronotypes and Online Learning: 
A Study on Learners’ Choice, Participation and Performance

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Keywords: chronotype, factors for choosing online learning, participation, performance

Abstract
Introducing a new theoretical framework of chronobiology, this paper presents a survey study examining learners’ choices, participation and performance in two discussion-heavy online history courses. The study comprises two major parts: a repetition study and an exploratory study. Adopting the research methodology developed by the same researchers in a previous study, the repetition study confirms the statistically significant relationship among the three factors for choosing online learning: perceived level of control, independence and satisfaction; as well as between learners’ chronotypes and their preferred online learning time. The second part of the research explored the level of participation and performance of learners having different chronotypes in two discussion-heavy online courses. The results indicate there was a statistically significant relationship between students’ chronotypes and the time of their activity in online courses. The overall level of student participation affected student performance in online course—students who were more active in LMS were likely to have higher final course grades. Besides, students who were more active in group-wiki were likely to have higher group wiki grades. Implications and limitations of the study are discussed.

Introduction
Online learning is becoming more and more affordable, accessible and suitable for today’s learners who can enjoy the convenience and efficiency of learning while staying connected all the time. While “the world is flat”, classrooms are becoming flat and borderless thanks to the development of online learning technology. “Online enrollments have continued to grow at rates far in excess of the total higher education student population, with the most recent data demonstrating continued substantial growth (Allen & Seaman, 2010, p. 1). Previous studies have identified some personal factors affecting online learner participation and patterns of participation such as learners’ background knowledge (Ross, 1996) and content area experience (Vonderwell & Zachariah, 2005) as well as instructional factors such as instructional tasks (Vonderwell & Zachariah, 2005) and instructor interventions (Vrasidas & McIsaac, 1999). Learners’ individual differences, such as mental abilities, cognitive controls, cognitive styles, learning style, study habits, personality, communication skills, and prior knowledge and experience would affect online learners’ learning outcomes (Picciano, 2002).

Therefore, educators need to give careful consideration to individual differences to provide online learners a more effective learning environment (Halim, Ali & Yahaya, 2011). This research hopes to examine online students’ choice, participation and performance in online learning from the perspective of one particular personal factor of learners—chronotypes. Human beings with different chronotypes would function differently at different times of a day, which is determined by their inner biological clock. Morning-types or “larks” prefer to wake up early in the morning while can hardly stay up beyond their usual bedtime; however, evening-types or “owls” show a preference for sleeping at late hours at night and often have difficulty in getting up in the early morning (Giannotti, Cortesi, Sebastiani, & Ottaviano, 2002). With regard to online learning, Luo, Pan, Choi, Mellish & Strobel (2012)’s research studied the effect of chronotypes on university students’ choice of online learning and found out that there is a correlation between chronotypes and students’ preferred time to do online learning. The study pointed out that online learning offers students a viable option to choose a time to attend or work on course in terms of their circadian preferences.

This research thus hopes to make a contribution and to add to what is already known about online learning from the perspective of chronotypes, one of learners’ most indispensable biological functions, by examining the learners’ choice, participation and performance in two online discussion-heavy courses. The purpose of this research is to shed light on the understanding of learners’ participation level and performance in online learning taking into consideration students’ chronotypes, and ultimately benefit the design and implementation of online instruction.

The research comprised two major parts: a repetition study and an exploratory study. Using the research
methodology developed by the same researchers in a previous study, the repetition study aimed to investigate the relationship among the three factors for choosing online learning: perceived level of control, independence and satisfaction; as well as the relationship between learners’ chronotypes and their preferred online learning time. The second part of research explored the patterns of learners’ participation in two discussion-heavy online courses using the log-in data in Black Board Learn, the learning management system (LMS) in use at the institution of the study. In this study, we used the log-in data of students’ hits on the online courses as a whole as well as their hits on two important asynchronous instructional components in Blackboard Learn: discussion boards and group wiki. We tied the log-in data then to learners’ chronotypes and performance in the online courses for further analyses.

The research questions were:
1. Are there any variations in students’ level of activity in LMS at different time period of the day and final course grade by chronotype? In addition, is there any correlation between students’ level of activity in LMS and final course grade?
2. Are there any variations in students’ level of activity in discussion board by chronotype? In addition, is there any correlation between students’ level of activity in discussion board and final discussion board grade?
3. Are there any variations in students’ level of activity in group wiki by chronotype? In addition, is there any correlation between students’ level of activity in group wiki and final group wiki grade?

Literature Review

Time Issues in Online Learning
In terms of the time issue in online learning, students perceive that online learning has several advantages over traditional methodologies: saving them commuting time; fitting in better with their schedules; and enabling them to take more courses (Dutton, Dutton & Perry, 2002). Instructional activities emphasizing convenience and time management are preferred by online students (Butler & Pinto-Zipp, 2006). Poole (2000) studied students’ participation in an online discussion-oriented course and found out that students participated in online discussions at times most convenient to them: there were more posts made on Saturdays than any other day of the week. The study also indicated that as most of the participants were teaching during daytime hours on weekdays, fewer posts were made during daytime than evening hours throughout the week. Indeed chronotypes (inner biological clock) is relevant to education. The circadian system cannot adapt to changes in sleep/wake schedules fast so that it has consequence on education: adolescent students who have vastly different sleep/wake schedules between school nights and non-school nights such as weekends or holidays would find it hard to reconcile these schedules and therefore experience fatigue, difficulty in falling asleep at night and awakening in the morning when school days resume (Carskadon, Acebo & Jenni, 2004; Battro, Fischer & Léna, 2008).

From late 1970’s, there has been a number of the research on the relationship between the instructional conditions in the classrooms and the effect of time preferences on students. In these studies the significant relationship(s) between learning style, time preference, assigned instructional schedule, and achievement in certain student population have been identified (Dunn, Dunn, Primavera, Sinatra & Virostko, 1987). In terms of online learning, Luo et al. (2012) studied the effect of students’ circadian preferences on online learning and demonstrated that it is very likely that learners would choose a time to engage in online learning according to their circadian preferences as a way to minimize their “social jetlag” (Jovanovski & Bassili, 2007), which refers to the misalignment of the biological and social clocks, which cause people to function daily.

Discussion Boards and Group Wiki in Learning Management System
Online discussions form a constructivist learning environment for participants to interact and collaborate (Rovai, 2007; Cheung, Hew & Ng, 2008). The constructivist approach of online discussions encourages learners to investigate multiple perspectives on problems or ideas (McLoughlin & Mynard, 2009).

Discussion boards are often text-based and are integrated with an online learning management system such as Blackboard or WebCT. In contrast to synchronous online discussions which require real-time access and interaction among instructors and learners, discussion boards are asynchronous so that it enables users to communicate through it at different times (Weisskirch & Milburn, 2003). Instructors or learners may start new threaded discussion topics and then others can respond to the topics by posting messages, which are displayed in a threaded format with fields such as authors, topics and posting time (Tu, Blocher & Gallagher, 2010). According to Vonderwell, Liang & Alderman, (2007), asynchronous discussion boards could provide learners with independence.
in learning regardless of time constraints and enable them to monitor their own learning process through instructor and fellow learners’ feedback.

Chao (2007) defined wiki as “a website containing a collection of web pages that can be edited by visitors to the site (p.2)”. Wiki allows people to collaboratively create and edit the web contents (Chao, 2007). With the ability of communication and knowledge building feature, wiki is commonly used as a tool for collaborative learning in education (Boulos, Maramba, & Wheeler, 2006; Engstrom & Jewett, 2005; Parker & Chao, 2007; Wagner, 2004). Researchers suggested several ways to use wiki in the classroom and effectiveness of the tool was studied (Parker & Chao, 2007; Elgort, Smith, & Toland, 2008; Witney & Smallbone, 2011). The study of Elgort et al. (2008) showed that wiki encouraged students to participate better. Students mentioned that wiki was a good tool for collecting and organizing information. Furthermore, instructors expressed that wiki made the management and student tracking easier (Elgort et al., 2008). Witney and Smallbone (2011) also mentioned that wikis do help the student experience of collaborative learning, but emphasized that adequate support and scaffolding is recommended as well. Overall, researchers introduced wiki as a common tool for collaborative learning in online courses.

Online Learners’ Participation and Performance

A literature review study done by Hrastinski (2008) indicated six levels to conceptualize learner participation in previous study: 1) online participation equals to the number of times a learner access an online course; 2) online participation equals to the messages or words a learner write in an online course writing; 3) online participation equals to writing contributions that are of high quality; 4) online participation equals to the number of writings written and messages read by a learner in an online course; 5) online participation equals to the number of messages that are perceived as important written by a learner in an online course; 6) online participation is related to learners’ taking part in a rewarding dialogue.

Mason (1994) categorized online learners into three groups based on their online participation: active participants, lurkers who read messages but do not post, and those who do not take part. Similarly Taylor (2002) used three distinct groups to show participation patterns in online discussions: workers, proactive participation group; lurkers, peripheral participation group; and shirkers, parsimonious participation group. Workers actively participate in the discussions and visit the class website regularly. Lurkers participate occasionally and often in a “read-only mode.” Shirkers perform the minimum required tasks with fewer postings and visits to the class website.

Student performance outcomes do not have a definite measurement as it relies on the course content and the nature of students. Successful completion of a course, course withdrawals, grades, knowledge and skills gained are some indicators of students’ performance, which can be measured through multiple ways such as testing, written assignments, individual projects, group projects and so on (Picciano, 2002). In terms of the previous studies on predicting the success of distance learning, they largely focus on the demographic (age, gender, marital status, occupation, etc.) and personality traits of the learners (Navarro & Shoemaker, 2000).

Research Methodology

Acting as both a repetition and an exploratory research, this research adopts the survey in a previous research conducted by the same authors, and adds 5 additional questions asking participants’ preference for online learning. The validated survey contains three sections: a demographic section, an online learning section and a chronobiology section. The online learning section contains questions such as participants’ preferred time of conducting online learning; participants’ preferences of different kinds of online instructional activities and why do participants choose online learning. The chronobiology component is based on the Munich ChronoType Questionnaire (MCTQ) (Roenneberg, Wirz-Justice & Merrow, 2003), which is a validated instrument to assess the chronotypes of participants. The research procedure is demonstrated in Figure 1 below.
**Part 1: A repetition study**
--Calculating MSFSC to determine learners’ chronotypes
--Correlation analyses between three factors for choosing online learning: perceived level of control, independence and satisfaction, learners’ chronotypes and their preferred online learning time

**Part 2: An exploratory study**
--Kruskal-Wallis test/ANOVA analyses on student participation level in online courses, taking into consideration the chronotypes
--Correlation analyses between chronotypes and student performance
--Correlation analyses between student participation level and performance

*Figure 1.* The research procedure of this research.

**Data Collection and Analysis**

In the repetition study, the survey was distributed online to full-time residential undergraduate students registered in two core curriculum online courses at a Midwestern university: HIST104 and HIST152. These two online courses were delivered through Blackboard Learn in the 2012 fall semester. 153 students in total received the online link to the survey, with a return of 88 valid responses. Among these responses, 28 were from male participants and 60 were from female participants.

In the exploratory study, the students’ participation data in the 2012 fall semester collected were as follows: the timestamps recording each participant’s hits on the Blackboard Learn courses as a whole; each participant’s hits on the specific instructional components of discussion board and group wiki; and the sum of hits in the Blackboard Learn tracking database for each student that took place during the listed hour of the listed day. The participation data were obtained with the help from the Office of the Vice President for Information Technology at the Midwestern University. The performance data were students’ final discussion board and group wiki grades, which were downloaded from the Blackboard Learn gradebook with the help of the instructor.

The survey data and participation data were analyzed with the help of Microsoft Excel ® and SAS ®. In terms of the survey data which needed additional coding, such as category of the participants’ preferred online learning time, two researchers first did the coding separately and then compared each other’s coding to reach an agreement, in order to ensure reliability of data analysis.

**Validation of Chronotype Instrument**

As there are two means of obtaining participants’ chronotypes: research participants’ self-assessment (7-point scale) and a calculated chronotype (MSFSC) based on the participants’ responses to the standardized questionnaire, we validated the chronobiological instrument again according to the same approach as in previous studies – MSFSC is the mid-sleep on free days corrected for differences between sleep duration on free days and sleep duration on work days (Roenneberg, Kuehnle, Pramstaller, Ricken, Havel, Guth & Merrow, 2004) and is used for determining chronotype (Kühnle, 2006). Similar to the previous study, Table 1 below indicates participants’ self-assessment and MSFSC were highly correlated (Pearson correlation coefficient was 0.51 with P value < .0001). Thus MSFSC was adopted for further analysis.
Table 1
Correlation analysis between MSFSC and the self-evaluated chronotype Correlations

<table>
<thead>
<tr>
<th></th>
<th>MSFSC calculated by MCTQ questionnaire</th>
<th>Self-assessed chronotype</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSFSC calculated by MCTQ questionnaire</td>
<td>1</td>
<td>0.50662</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;.0001 *</td>
</tr>
<tr>
<td>Self-assessed chronotype</td>
<td>0.50662</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;.0001 *</td>
</tr>
</tbody>
</table>

Note. *p<.01

Results

Results of the Repetition Study.
In terms of the distribution of learners’ chronotypes, which are calculated by MSFSC—the mid-sleep on free days corrected for differences between sleep duration on free days and sleep duration on work days (Kühne, 2006), this research confirmed the findings of the authors’ previous research. As Figure 2 demonstrates, the MSFSC distribution of the participants was close to a normal distribution ($\mu=6.93$, $\sigma=1.56$). Figure 3 exhibits the distribution of participants’ time preferences for doing online learning (morning=1, morning-afternoon=2, afternoon=3, afternoon-evening=4, evening=5, evening-morning=6, split=7 and all=8). Similar to the previous study, the distribution was right-skewed ($\mu=4.92$, $\sigma=1.91$), implying most of the participants prefer to do online learning at a later time of a day.

![Distribution of Chronotype as Measured by MSFSC](image)

Figure 2. Raw MSFSC distribution of the participants.
Figure 3. The distribution of participants’ time preferences for doing online learning.

Results in Table 2 exhibit that the three existing factors of learners’ choice of online learning—perceived level of control, independence and satisfaction were highly correlated with each other (with all p-values <.01), which was in accordance with the previous study as well.

Table 2

Correlation analysis between three factors of choice of online learning

<table>
<thead>
<tr>
<th></th>
<th>Level of control</th>
<th>Level of independence</th>
<th>Level of satisfaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level of control</td>
<td>1</td>
<td>0.39087</td>
<td>0.69408</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.0002*</td>
<td>&lt;.0001*</td>
</tr>
<tr>
<td>Level of independence</td>
<td>0.39087</td>
<td>1</td>
<td>0.57606</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.0002*</td>
<td>&lt;.0001*</td>
</tr>
<tr>
<td>Level of satisfaction</td>
<td>0.69408</td>
<td>0.57606</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>&lt;.0001*</td>
<td>&lt;.0001*</td>
</tr>
</tbody>
</table>

Note. *p<.01
In addition, the results further confirmed the statistical significance between online students’ chronotypes and their preferred online learning time. Table 3 shows the correlation between MSFSC and participant’s time preference was quite strong (P value=0.01), which indicates an early-type online learner might prefer studying online in the morning while a late-type might prefer studying at a later time of the day.

### Table 3

**Correlation analysis between chronotype and choice of online learning time**

<table>
<thead>
<tr>
<th></th>
<th>MSFSC calculated by MCTQ questionnaire</th>
<th>Students’ preferred online learning time</th>
</tr>
</thead>
<tbody>
<tr>
<td>MSFSC calculated by MCTQ questionnaire</td>
<td>1</td>
<td>0.27107</td>
</tr>
<tr>
<td>Students’ preferred online learning time</td>
<td>0.27107</td>
<td>1</td>
</tr>
</tbody>
</table>

Note. *p<.01

#### Results of the Exploratory Study

In order to explore if there are any variations in students’ level of activity in LMS at different time of the day by chronotype, we first calculated each student’s total number of hits in LMS at different time period of the day during the semester: morning (7am-12pm), afternoon (1pm-6pm), evening (7pm-12am), and midnight (1am-6am). We then performed Kruskal-Wallis test/ANOVA test on the number of hits in each time period as well as the total number of hits, using chronotype as the categorical predictor. The selection of test depends on the normality of the dataset. We used Kruskal-Wallis test when the normality assumption was violated. Otherwise we used ANOVA test.

### Table 4 Test on LMS activity

<table>
<thead>
<tr>
<th>Test</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morning</td>
<td>0.0178*</td>
</tr>
<tr>
<td>Afternoon</td>
<td>0.7318</td>
</tr>
<tr>
<td>Evening</td>
<td>0.0315*</td>
</tr>
<tr>
<td>Midnight</td>
<td>0.1418</td>
</tr>
<tr>
<td>Total number of hits</td>
<td>0.4139</td>
</tr>
</tbody>
</table>

The result in table 4 indicates there was a significant difference in students’ level of activity in the morning and evening by chronotype as the p values for both tests were less than 0.05. Therefore we further examined the Wilcoxon mean scores obtained from the tests on morning and evening data (table 5 and table 6). From the tables we can see that the morning-afternoon (type 2) and the morning (type 1) had more hits and therefore were more active in LMS in the morning, while in the evening, the all (type 8) and the evening (type 5) were the most active groups. It was also noticed there was no significant difference in the total number of hits among the participants’ of different chronotypes.
Table 5 Wilcoxon mean scores from analysis of morning data classified by chronotype

<table>
<thead>
<tr>
<th>Chronotype</th>
<th>Wilcoxon mean scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>67.7</td>
</tr>
<tr>
<td>1</td>
<td>65.8</td>
</tr>
<tr>
<td>8</td>
<td>54.0</td>
</tr>
<tr>
<td>3</td>
<td>49.2</td>
</tr>
<tr>
<td>7</td>
<td>47.4</td>
</tr>
<tr>
<td>5</td>
<td>44.5</td>
</tr>
<tr>
<td>4</td>
<td>41.4</td>
</tr>
<tr>
<td>6</td>
<td>26.7</td>
</tr>
</tbody>
</table>

Table 6 Wilcoxon mean scores from analysis of evening data classified by chronotype

<table>
<thead>
<tr>
<th>Chronotype</th>
<th>Wilcoxon mean scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>59.7</td>
</tr>
<tr>
<td>5</td>
<td>59.4</td>
</tr>
<tr>
<td>7</td>
<td>46.0</td>
</tr>
<tr>
<td>4</td>
<td>45.7</td>
</tr>
<tr>
<td>6</td>
<td>45.4</td>
</tr>
<tr>
<td>3</td>
<td>31.6</td>
</tr>
<tr>
<td>1</td>
<td>29.4</td>
</tr>
<tr>
<td>2</td>
<td>8.3</td>
</tr>
</tbody>
</table>

In order to determine if there are any variations in students’ final course grade by chronotype, we performed Kruskal-Wallis test on the final course grade using chronotype as the predictor. The result indicates there was no significant difference in students’ final course grade by chronotype (p=0.0752). We then further explored whether there was any correlation between students’ level of activity in LMS and final course grade using the Spearman’s rank correlation analysis (due to the non-normality distribution of the data) and the result showed they were positively correlated (correlation coefficient= 0.340, p=0.0012), meaning students who are more active in LMS are likely to have higher final course grades.

To determine whether there are any variations in students’ level of activity in discussion board by chronotype, we performed Kruskal-Wallis test on the total number of hits in discussion board, using chronotype as the predictor. The result showed no significant difference (p=0.5042). Next, we explored whether there was any correlation between students’ level of activity in discussion board and final discussion board grade using Spearman’s rank correlation analysis and the result showed no significant correlation (correlation coefficient= 0.209, p=0.0509).

To determine whether there are any variations in students’ level of activity in group wiki by chronotype, we performed ANOVA test on the total number of hits in wiki, using chronotype as the predictor. The result showed no significant difference (p=0.6119). Next, we explored whether there was any correlation between students’ level of activity in group wiki and final group wiki grade using Spearman’s rank correlation analysis and the result showed a positive correlation (correlation coefficient= 0.470, p<0.0001), meaning students who are more active in group wiki are likely to have higher group wiki grades.
Discussion and Conclusion

Kühnle (2006) defined 2.5% at each end of the MSFSC distribution as extreme chronotypes, with extreme late types (MSFSC > 7.25) and extreme early types (MSFSC ≤ 2.17). When comparing the distribution of MSFSC in this research to that in Kühnle, it is noticed in Figure 4 that there tend to be many more extreme late types (37.5%) and fewer extreme early types (1.14%) among online learners as compared to the extreme types among the general population.

Furthermore, undergraduate online learners with different chronotypes would have their different preferred online learning time. More specifically, their self-reported preferences were corroborated by the Blackboard Learn log-in data. The early-bird students, which include the morning-afternoon and the morning types, are more active in the Blackboard Learn in the morning. On the other hand, the all type and evening type students are shown to have the most activity in Blackboard Learn in the evening. This results show that students are experiencing learning benefit from the advantage of online course, which is ‘the flexibility of time’.

However, in spite of their preferences and different level of activity in the morning and in the evening, the undergraduate students’ overall performances in the online courses are not significantly different. Such finding is in contradiction to the previous research indicating the effects of time effects on student achievement in traditional classrooms, for instance, Randler & Frech (2006)’s research implying that morning-type college students would perform better than their evening-type counterparts. To this end, online learning may outperform traditional face-to-face learning in terms of its convenience to learners and especially the learners who experience time issues or conflicting schedules in real life. In other words, that we didn’t find significant difficulties in students overall performance based on chronotype, let’s us cautiously argue that the offering of online courses mitigated any effect of chronobiology previously reported for face-to-face classes.

This research also found that students with different chronotypes access the asynchronous instructional components in Blackboard Learn, the discussion boards and the group wiki with a similar frequency and that chronotype was not a significant variable. It is the overall level of activity that affects the students’ final grades. This finding confirms Davies & Graff (2005)’s research, which argued the level of interaction in Blackboard would have effect on the grades of undergraduate students. Overall, our research showed the benefit of online learning by showing the correlation among students’ chronotype, their preferred time to study in LMS, and participation level.
Although the study showed no significance between different chronotypes and performance level, the research furthermore leaves the room for deeper investigation; will the same student have lower performance level if she/he does not follow their own chronotype – say in a face-to-face course that is misaligned with the preferred time? Research could also be done on the relationship among chronotypes, student participation level in synchronous online instructional components (such as synchronous online discussion, virtual office hours), and student performance. In addition, researchers could investigate the satisfaction level among the students of different chronotypes. Since most traditional schools are scheduled for morning/afternoon person, evening chronotype or very early morning chronotype may have more satisfaction level to the online course. These potential research areas could support the reason to choose online over face-to-face classroom.

Limitation for this research is that sample size is confined to two history classrooms with certain activities. A course with other subject and grades distribution, and more students could possibly show more variance for participation level and performance level.

This research is significant to researchers, instructors, and instructional designers who are curious about the effectiveness of online course. With the other researchers of online learning, this research could be a good reference for pursuing why online learning should be delivered.

References


