

Design of a Learning Dashboard to Enhance Reading Outcomes and Self-directed Learning Behaviors in Out-of-class Extensive Reading

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ABSTRACT

Self-directed learning (SDL) requires students to take initiative to learn and control their own learning process. Literature highlights the importance of SDL for lifelong learning. Yet, little understanding is known regarding how to support SDL at the school level, specifically for out-of-class learning context. To fill up this gap, this research developed a learning dashboard and integrated SDL process management in GOAL system. It was implemented to provide support for out-of-class online self-directed extensive reading (SDER) at a high school level. A two- group study conducted during a three-week spring vacation found the experimental group (N=35, with SDL support) achieved significantly more reading outcomes than the control group (N=12, without SDL support). Detailed GOAL interaction behavior analysis of the experimental group showed that viewing learning dashboard was significantly correlated with reading outcomes as well as interactions related to SDL process management. These findings highlights positive effect of SDL support in GOAL on students' out-of-class SDER outcomes as well as their SDL behaviors. The study provided implications for research related to extensive reading and SDL support for out-of-class learning.

KEYWORDS

learning analytics; self-directed learning; self-direction; learning dashboard; extensive reading; out-of-class learning

1. Background and Introduction

Self-directed learning (SDL) is vital in 21st-century learning, according to P21-Framework (2009). In 21st-century, people have access to a massive of information from anywhere at any time. It brings great challenges to educational institutions to prepare students for surviving in today's information society. The importance attached to memorization of content knowledge faded as conceiving the nature of knowledge (Tekkol & Demirel, 2018). The demands extend gaining content knowledge to skill-based competencies such as SDL, problem-solving, critical thinking, etc. SDL represents a learning process that is individual, purposeful, and developmental (Morris, 2019b). Skills associated with SDL relate to competencies to implement such learning process, such as setting and executing plans, monitoring and reflecting learning

progress. SDL enables individuals to improve their self-confidence, autonomy, motivation and lifelong learning skills (O’Shea, 2003). However, students experience anxiety and fear when they engage in SDL initially and need effective SDL instructions (Williamson, 2007). Therefore, educational institutions must take responsibility to instruct students to engage in SDL and improve SDL skills.

In the past few decades, many scale development studies have emerged for measuring SDL skills (Fisher, King, & Tague, 2001; Stockdale & Brockett, 2011; Williamson, 2007). These studies contribute to a measurable and feasible method for helping students improve SDL skills. Educators typically employ questionnaire-based assessments with various meta-cognitive aspects of SDL in the classroom for informing instruction and complementing evidence. Several limitations exist in previous studies. Firstly, the results from those questionnaires rely mainly on the students’ self perception and might have its own biases. Understanding on students’ performance in a real self-directed activity was still unknown. Secondly, most of them were conducted with university students and adults, while limited study has taken secondary and high school students as the focus (Tekkol & Demirel, 2018). Thirdly, beyond classroom learning is barely supported even though it requires more substantial self-direction than classroom learning. Bentley (2012) pointed out that to be truly effective, education must give young people exposure to a wide range of contexts and role models for learning, along with experience of genuine responsibility. Hence, instead of the conventional classroom setting, we focus on beyond the classroom learning as the training scenario for improving students’ SDL skills.

The information age brings not only challenges but also opportunities to facilitate the promotion of innovative learning strategies (Hwang, Yin, & Chu, 2019). Many education systems have been developed for different purposes, such as a web-based product called Moodle (Rice & William, 2006) for organization and management of student and course information, an e-Book reading system called BookRoll (Ogata et al., 2015) for browsing textbooks. These systems enable automatically tracking and observing learning behaviors of students. Chen, Yin, Isaias, and Psotka (2020) pointed out that such large amounts of unstructured data can potentially generate novel and useful information to help teachers and students improve their teaching/learning strategies by employing learning analytics approaches. Students learning behaviors were analyzed in previous research used for reviewing learning patterns (J. Li, Majumdar, & Ogata, 2021; Stauffer & Grimson, 2000; Yin et al., 2019; Zhao, Hwang, & Yin, 2021), investigating the self-regulation of students (H. Li, Flanagan, Konomi, & Ogata, 2018; Yamada, Oi, & Konomi, 2017), providing learning support (Changhao, Toyokawa, Nakanishi, Majumdar, & Ogata, 2021; Wang & Han, 2021). Little understanding is known regarding utilizing technology to develop SDL skills. Our research fills this gap by conducting a technology-based SDL support in the actual school setting.

The previous work has adopted an online environment with an e-book reading system and an SDL process management tool integrated to support self-directed extensive reading (SDER) (H. Li, Majumdar, Chen, Yang, & Ogata, 2021). Students were asked to do online reading and to execute SDL skill under teachers’ instruction step by step in the class. The findings suggested that the learning behaviors and outcomes facilitated by the online environment were affected to varying degrees by the levels of students’ SDL ability, and the SDL process management tool was established the validated factors of conducting planning and monitoring the plan and its behavior had a positive correlation to the reading outcomes. In this study, we additionally assembled a learning dashboard into the online SDL support environment. The learning dashboard provides two features: i) highlighting various reading outcomes to help students

understand the context and their status. ii) providing navigation aid to the different SDL phases to help students independently use the SDL process management tool without instruction from their teachers. We aim to investigate the effect of the on-line SDL support on reading outcomes, motivation and autonomy when students are not intervened by teacher's instruction. Hence, we address the following two research questions:

RQ1: How does the online self-directed learning support affect students' reading outcomes in out-of-class extensive reading?

RQ2: How does the online self-directed learning support affect students' motivation and autonomy in out-of-class extensive reading?

Moreover, we investigate the relations of interactions on the learning dashboard to reading outcomes and SDL behaviors with the following two research questions:

RQ3: What is the correlation between the use of the learning dashboard and reading outcomes in out-of-class extensive reading?

RQ4: What is the correlation between the use of the learning dashboard and self-directed learning behaviors in out-of-class extensive reading?

Overall, this study aims at helping students to enhance reading outcomes and SDL behaviors by importing an online environment in the context of out-of-class ER.

The rest of the paper is organized as follows: in the literature review section, we review the previous study on notions of SDER. Eight characteristics of a successful reader in the SDER program are defined based on that. Related technologies to support SDER are given after that. In the next section, we illustrate the detail of the proposed online SDER support environment and the learning dashboard, and define SDER outcome measures. In the research methods section, we describe our data collection platform, experiment procedure, and data analysis processes. In the result section, we demonstrate the results obtained. Then in the discussion section, we further explain the results regarding our research questions. In the last section, we summarize our conclusions, highlight our contributions and point out the possible directions of our future work.

2. Literature Review

2.1. Self-directed learning

Knowles (1975) defines SDL as *a process in which individuals take the initiative, with or without help from others, in diagnosing their learning needs, formulating goals, identifying human and material resources, choosing and implementing appropriate learning strategies, and evaluating learning outcomes*. SDL skill is considered one of the important skills for lifelong learning (Candy, Crebert, & O'leary, 1994; Greveson & Spencer, 2005; Spencer & Jordan, 1999) to achieve success in the 21st century. As mentioned before, this article extends SDL study to the context of beyond the classroom learning in the school setting. In such a context, students define the preparedness to engage in learning activities by themselves, rather than by a teacher (Schmidt, 2000). This nature makes SDL closely related to two kinds of students' personal attributes: motivation and learner autonomy.

Motivation in learning refers to driving influences from internal (intrinsic) or external (extrinsic) forces that give students the power to learn effectively (Makewa & Ngussa, 2015), which reflects the perceived value and anticipated success of learning goals (Garrison, 1997). Compared with teacher-directed learning where the learning

goals tend to be uniform (Morris, 2019a), SDL gives students freedom in formulating learning goals. Furthermore, Rigby and Ryan (2018) state that volitional, high-quality motivation is energized directly by the employees' needs, values, and interests (p. 136), and it is evident when one pursues goals and values that are personally meaningful (p. 137). Hence, the development of motivation for learning can be considered one potential consequence of SDL.

Learner autonomy also has a deep link with SDL. Gharti (2019) states that learner autonomy is the ability of a learner to understand and manage learning processes responsibly and effectively. Benson (2013) points out that the concept of autonomy is grounded in a natural tendency for learners to take control over their learning. The point of taking responsibility and control of own learning is consistent with the requirement of SDL. Many scholars also emphasize the importance of learner autonomy to accomplish SDL (Candy, 1991; Holec, 1988). Moreover, learner autonomy becomes more crucial while moving the context to out-of-class learning because of the disappeared teacher supervision. As Brandt (2020) mentioned, engaging in activities that require autonomy and experimenting with autonomous behaviors can help individuals to develop autonomy. Thus, improvement of learner autonomy is expected as another valuable effect of encouraging students to engage in out-of-class SDL.

Except for students' personal attributes of motivation and autonomy, scholars emphasize the important role of the learning process in SDL. Knowles (1975)' definition has five phases to describe the process. Garrison (1997)'s model contains self-monitoring in the process. Loyens, Magda, and Rikers (2008) extract goal setting and task analysis, planning, and self-evaluation as the process. Although phases in those process models differ from each other, it is commonly approved by scholars that learner control and active engagement in the learning process are crucial in SDL (Boyer & Usinger, 2015; Brockett & Hiemstra, 2018; Grover, 2015).

The existing research into SDL commonly adopts structured interview schedules, questionnaires, prompt sheets, and measurement scales as the methodology. Various scales were developed based on their theoretical understanding of SDL. For example, Cheng, Kuo, Lin, and Lee-Hsieh (2010) proposed SDLI (Self-Directed Learning Instrument) to access students' readiness for SDL from the dimensions of learning motivation, planning and implementing, self-monitoring, and interpersonal communication. Stockdale and Brockett (2011) designed PRO-SDLS with items from the dimensions of Initiative, Control, and Motivation. These assessments investigate students' perceptions from different dimensions, which is beneficial to collecting evidence of SDL effects and informing instruction. However, such a method may fail to capture the variation in students' performance during the learning process (Hsiao et al., 2019). Therefore, while we utilize questionnaires to investigate students' personal attributes, we also collect students' behavioral data during the learning process to bridge this knowledge gap.

2.2. Extensive reading and self-directed extensive reading

Extensive reading (ER) refers to the independent reading of a large quantity of material for information or pleasure (R. R. Day, Bamford, Renandya, Jacobs, & Yu, 1998). The characteristic of ER, that students are free to read self-selected books at their own pace, makes it to be a suitable context for importing SDL strategy. The primary aim of an ER program is to get students to read in the second language and help students to enjoy reading. Some scholars examined the positive influence of ER on students'

motivation (Takase, 2009; Tanaka, 2017; Wu, 2012). And some scholars revealed that ER is possible to affect students' readiness of becoming autonomous learners (Enisa, İnceçay, & Inceçay, 2013; Ningsih, 2019; Takahashi & Umino, 2020). Consequently, ER is as closely related to personal attributes of motivation and autonomy as SDL.

On the other hand, scholars devote the ER study to defining and collecting reading outcomes as measures to assess the effectiveness of ER. Most of them tested vocabulary acquisition as the main focus in ER program (Horst, 2005; Pigada & Schmitt, 2006; Suk, 2017), because it is believed that ER can help students to develop an awareness of common word partnerships that are not taught in textbooks. Some scholars demonstrated the effect of ER program on improving students' reading speed (Huffman, 2014; McLean & Rouault, 2017; Mo, 2021; Suk, 2017). Developing reading comprehension is another reading outcome considered to benefit from ER (Suk, 2017). These studies enlighten us on the method of extracting related measures for examining the effectiveness of SDER. Next, we summarize the characteristics of SDER by combining SDL theory and ER theory.

SDER is one kind of ER activity, sharing the same characteristics: read a large quantity of material, read at a faster rate, read self-select material at own pace. Additionally, it encourages students to engage in the reading by using the SDL strategy. Based on literature about SDL and ER, motivation and autonomy are also important dimensions valued in SDER. In SDER, students are required to control the reading process by themselves, rather than by a teacher. When students are given freedom of choice without teachers' instruction, whether they can persist for a long time becomes a problem. Lucy and Guglielmino (2004) states that the habit of persistence is one of the most important habits of a successful learner in SDL. A reader with a high level of SDL skills is more likely to persist in a longer-term reading. Based on the above, the following eight characteristics of a successful reader in the SDER program were listed:

- 1) Have self-motivation (Garrison, 1997)
- 2) Be autonomous (Candy, 1991)
- 3) Read a large quantity of material (R. Day & Bamford, 2002; R. R. Day et al., 1998)
- 4) Read at a faster rate (R. Day & Bamford, 2002; R. R. Day et al., 1998)
- 5) Read self-select material at own pace (R. Day & Bamford, 2002; R. R. Day et al., 1998)
- 6) Persist a long term reading (Lucy & Guglielmino, 2004)
- 7) Control reading process on their own (Boyer & Usinger, 2015; Brockett & Hiemstra, 2018; Candy, 1991; Garrison, 1997; Grover, 2015)
- 8) Active engagement (Boyer & Usinger, 2015; Brockett & Hiemstra, 2018; Grover, 2015)

In our research, we conduct the experiment based on the above theoretical summary. On one hand, we import questionnaires to investigate students' ER motivation and autonomy regarding characteristic 1 and 2. On the other hand, we define SDER outcomes and extract measures based on students' actual behavioral logs following characteristic 3–8. The detailed definition and extraction is given in the next section.

2.3. Related technologies to support SDER

In SDER, we are concerned with both students' reading logs and behavioral logs in managing the reading process. The current development of technologies has made a foundation for collecting such learning logs. First, we look into the existing systems to support ER and the learning process.

At present, many e-book reading systems have been developed and used by scholars for supporting online ER, such as BookRoll (Ogata et al., 2015), XReading (Wilkins, 2019), M-Reader (McBride & Milliner, 2014). As students read digitized reading materials on the system, their click events are recorded automatically as an essential data source for learning analytics research into students' reading behavior. Meanwhile, various systems have been developed to provide learning process support in the online learning environment. Scholars recognized a great value in recording and analyzing data related to learners' behaviors and interactions during the learning process (Hwang, Chu, & Yin, 2017; H. Li et al., 2018; Yamada et al., 2017). For example, Pérez-Álvarez, Maldonado-Mahauad, and Pérez-Sanagustín (2018) designed a web-based tool called NoteMyProgress to support the learners' self-regulated learning process in MOOCs. Mejia et al. (2016) presented the PADA system to facilitate reflection and self-regulation in the learning process. Majumdar et al. (2018) proposed a GOAL system to facilitate the execution of SDL based on a five-phase process model, DAPER (Data Collection – Data Analyze – Setting Goal and Plan – Execution and Monitoring - Reflect). Such systems contribute to assisting students in using recommended learning strategies to improve learning. H. Li et al. (2021) combined BookRoll and GOAL systems to support in-class SDER for the first time. In such in-class SDER support, students receive instructions from teachers who guide them to use the e-book reading system for reading and the SDL process management tool for managing the reading process. Yet, limited work has done for supporting out-of-class SDER. While changing to the out-of-class context, there is no role in informing students of the learning context and their learning status. A technical solution is required to solve this problem.

A learning dashboard is a single display that aggregates different indicators about learner(s), learning process(es), and/or learning context(s) into one or multiple visualizations (Schwendimann et al., 2016). It can output data reports to inform students of their learning progress and behaviors in real-time (Bodily, Ikahihifo, Mackley, & Graham, 2018). The effectiveness of the learning dashboard has been admitted by a number of previous studies. Wang and Han (2021) found that students' learning effectiveness becomes better by using the learning dashboard based on process-oriented feedback. Sedrakyan, Malmberg, Verbert, Järvelä, and Kirschner (2020) also agree that the learning process can be positively influenced by dashboard feedback.

To this end, we construct an online environment by assembling an e-book reading system, an SDL process management tool and a learning dashboard for supporting out-of-class SDER. The next section elaborates the design and the interface of the proposed online SDER support environment.

3. Facilitating self-directed extensive reading in an online environment

3.1. Structure of the online environment and required sources

In the SDER program, students are required to read self-selected ER books and manage the reading process by using SDL strategies. An online environment with multiple educational systems integrated (see Figure. 1) is adopted in this study. The

Moodle system (Rice & William, 2006) maintains students' personal information (student id, name, password, etc.) and course information, as well as integrates entrances to the BookRoll and the GOAL system.

(Figure 1. Structure of online SDL support environment)

The e-Book reading system, BookRoll, provides students with over 500 books for extensive reading. Figure. 2 shows the screenshot of the BookRoll system. The BookRoll system records students' click events such as flipping to the next or previous page, jumping to different pages, memos, bookmarks, and markers.

(Figure 2. Screenshot of BookRoll system)

The process management tool based on DAPER model in the GOAL system possesses features to support the execution of the SDL strategy shown in Figure. 3. Page for "Data collection" provides buttons for students to choose to synchronize one-week reading data and shows daily reading data synchronized from BookRoll. The actions on checking the "Data collection" page and clicking synchronize button are tracked as students' SDL behavior of executing collection skill. Page for "Analysis" provides students a bar chart visualized own reading data and related data (such as maximum/minimum/average value of a group) and a self-report panel. The actions on viewing the trend of own reading data, comparing with related data, submitting an analysis report are considered as students' SDL behavior of executing analysis skill. Action on setting a plan in the "Planning" page reflects students' execution of planning skill. Actions on checking and reporting the progress of the plan in the "Execution and monitoring" page are tracked for measuring execution and monitoring skill. Actions on submitting a reflection report of the plan in the "Reflection" page are observed for measuring reflection skill.

(Figure 3. GOAL system interfaces to support SDER process management)

The learning dashboard presents an overview of current reading outcomes and SDL skill status for connecting SDL skills and the context it occurs. The next sub-section gives a detailed introduction to the interface design of the learning dashboard.

3.2. Learning dashboard design and user interface

While designing a learning dashboard for a certain context, we emphasize that the relevant information should be given clearly at a glance for the purpose of helping students understand the context and their own state. According to eight characteristics of SDER, three modules are designed in the learning dashboard for displaying related information: a. overview of reading outcomes; b. overview of SDL skills; c. Skill detail information. The screenshot is shown in Figure. 4. The overview of reading outcomes is given in the form of numbers calculated from reading data in the past week. The overview of SDL skills is illustrated in a radar chart, that may help students compare five sub-skills. The skill level is computed based on an SDL skill scoring rubric proposed by Majumdar et al. (2019). The skill detail information offers students skill level information and feedback to varying skill levels for helping them improve SDL skills.

(Figure 4. Screenshot of the learning dashboard in GOAL system)

3.3. Outcome measures in SDER context

The objective of SDER is to improve students reading outcomes as well as to foster their SDL skills. SDER outcome measures concerns both reading outcomes and SDL behaviors. In the literature review section, we summarized eight characteristics of SDER. We defined SDER outcome measures based on that. Table. 1 reveals SDER outcome measures from those characteristics. The characteristic of "Read as much as possible" focuses on the amount which students read. The number of books, pages, words students read were processed from raw data recorded in the BookRoll system. Students' average reading speed was processed to respond to the characteristic of "read at a faster rate". The characteristic of "Control reading process on their own" requires students to engage in five DAPER phases of SDL. The number of phases students engaged in reflects students' how deeply they execute SDL skills. The fourth characteristic is "Active engagement in reading with SDL strategy". Based on Ma, Han, Yang, and Cheng (2015), in the online setting, student engagement is concerned with the time and energy paid by the students in the process of online learning. Hence, in this study, we observe the time students read books, and clicks generated on the e-book reading system (e.g. click "Next page" to turn page, click "Marker" to add a marker, etc.) and the process management tool (e.g. click button to submit a self-analysis report or set a plan, etc.) as outcome measures of student engagement. Those students who actively used the e-book reading system to read generate more clicks on the system, and may spend more time on the reading system. Similarly, those students who actively engaged in the SDL strategy for reading by using the process management tool generate more clicks on the tool.

Lastly, for the characteristic "Keep a reading habit", we treat the number of unique days students read as the measure because students with good habits will persist in reading for a longer term.

(Table 1. SDER Outcome measures and interpretation)

4. Research Methods

Within the scope of the research process from the creation of the learning dashboard to the evaluation procedures, qualitative and quantitative data was collected with an integrated approach. So, the embedded research method design was utilized in a complementary way to assess the effectiveness of the proposed dashboard in the SDER program (Creswell & Clark, 2017).

4.1. Participants and contexts

The quasi-experimental was conducted in a high school 1st year with seven classes in Japan with a total of 286 students (age is around 16 years).

All seven classes were introduced the BookRoll system for ER activity and were

allowed to read self-select books during their three-week spring vacation. The levels of e-books were from level pre-A1 for beginners to level B2 for upper intermediates of the Common European Framework of Reference for Languages (CEFR) (Council of Europe, 2001).

Then, four classes with 164 students were additionally introduced the GOAL system for reviewing SDER dashboard and managing the reading process, while the other three classes with 122 students were not.

Eventually, 47 students participated in the experiment, with 35 students in the SDER program (who used the BookRoll system and the GOAL system) as the experimental group and 12 students in the ER program (who used only the BookRoll system) as the control group.

4.2. Procedure

The procedure of the experiment displays in Figure. 5. At the beginning of the experiment, a questionnaire-based pre-survey was given to investigate students' perception of their SDL skill level. Next, all students were introduced ER on the BookRoll system, and the experimental group was additionally introduced SDL support on the GOAL system.

During spring vacation (22 days), both the control group and the experimental group used BookRoll to read at their own choice and pace. The experimental group checked the SDER dashboard and managed the reading process on the GOAL system, while the control group was not.

Lastly, a questionnaire-based post-survey was given to two groups to assess their motivation and autonomy on ER as a supplement for understanding students from the affect and cognitive aspect.

(Figure 5. Procedure of experiment)

4.3. Instruments and data Collected

In the pre-survey, we imported a scale called Self-Directed Learning Instrument (SDLI) proposed by Cheng et al. (2010) to assess students' SDL skills from three dimensions: Learning motivation (6 items), Planning and implementing (6 items), Self-monitoring (4 items) at the first beginning. In the post-survey, the questionnaire was employed to investigate ER motivation (5 items) and autonomy (5 items).

Forty-seven results were received from all participants in the pre-survey and the post-survey. Each answer for pre-survey and post-survey was scored on a Likert-type 5-point scale, where 5, 4, 3, 2, and 1 represented "strongly agree", "agree", "neutral", "disagree", and "strongly disagree". The Cronbach's alpha values were calculated based on that, which are 0.846 for learning motivation, 0.772 for planning and implementing, 0.748 for self-monitoring, implying acceptable reliability of the scales in pre-survey. The Cronbach's alpha value of samples on ER motivation is 0.878, implying acceptable reliability of the scales. However, the Cronbach's alpha value of samples on autonomy is 0.554, implying relatively low reliability of the scales.

During the spring vacation, based on the reading logs recorded on the BookRoll system, 9339 click events were generated and 191 books, 4068 pages were visited by all participants. Logs saved in the GOAL system show that the SDER dashboard was

visited 300 times, and 615 click events in the process management tool were generated by 35 participants.

4.4. Data analysis

In this study, the number of times students viewed the learning dashboard and SDER outcome measures (defined in Table. 1) were processed based on reading logs saved in the BookRoll system and SDL logs saved in the GOAL system. Descriptive statistics were calculated for all survey scores and measures, including SDLI score from pre-survey, motivation and autonomy score from post-survey, dashboard viewed times, book count, page count, word count, reading speed, reading clicks, time read, unique days, phase count, daper clicks and dashboard clicks of each student (see Table. 2).

(Table 2. Descriptive statistics of survey scores and SDER outcome measures)

To investigate the effect of the proposed SDL support, the difference of two groups on reading outcomes and perception results were analyzed. We did a Shapiro–Wilk test to test the data normality for reading outcomes and perception results. The data for SDLI score and ER motivation is normal ($p > .05$) and with equal variances based on the Levene’s test so that the student’s t-test was chosen to analyze the difference of two groups on SDLI score and ER motivation. However, data for reading outcomes and autonomy significantly deviate from a normal distribution ($p < .05$). Hence, the Mann–Whitney u-test is used for analyzing the difference of two groups on reading outcomes and autonomy.

Furthermore, to investigate the relationship of the learning dashboard use to reading outcomes and SDL behaviors, a correlation was calculated between the number of times students viewed the learning dashboard and SDER outcome measures based on the data from the experimental group.

5. Results

5.1. Difference between two groups in reading outcomes and perception results

Table. 3 presents the comparison results of the reading outcome and perception result of the two groups. Firstly, we look into actual reading data generated by students and analyze the difference between two groups in reading outcomes. It shows that the experimental group demonstrates significantly more reading outcomes than the control group on the measures of book count ($p < .05$), page count ($p < .05$), word count ($p < .01$), reading clicks ($p < .05$) and time read (minute) ($p < .05$) with a small effect size (Cureton, 1956). And the experimental group read more unique days ($p < .001$) than the control group with a moderate effect size (Cureton, 1956). However, the reading speed of two groups shows not much difference.

Next, we compare perception results of two groups. The pre-survey results shows that SDLI scores from three dimensions (Learning motivation, Planning and implementing, Self-monitoring) shows that no significant difference exists between two groups. The mean values of two groups on Learning motivation (> 18), Planning and implementing(> 18), Self-monitoring (> 12) suggest that students in both

groups generally believe that they have a relatively adequate level of SDL skills. The post-survey results indicate that there is not much difference between two groups in students' perception of ER motivation and autonomy after they engaged in the assigned program. And both two groups show a relatively sufficient ER motivation (> 15) and autonomy (> 15).

(Table 3. Reading outcomes, perception results of two groups)

5.2. Correlation between dashboard viewing behavior and SDER outcome measures

Figure. 6 illuminates the matrix of the correlation between the number of times students viewed the learning dashboard and SDER outcome measures. While looking into the relations with reading outcomes, the number of times students viewed the learning dashboard was found to have significant positive correlations with book count, page count, word count, reading clicks, and unique days. However, it has a limited correlation with reading speed and total time in minutes students read. As to correlations with SDL behaviors, a significant positive correlation was found with the number of clicks generated in the process management tool and the number of SDL phases students engaged in. Additionally, a limited correlation is found between SDL behaviors and reading outcomes.

(Figure 6. Correlation between dashboard viewing behavior and SDER outcome measures)

6. Discussion

In this study, we evaluated the effect of the proposed online SDL support for out-of-class ER by addressing two research questions, RQ1: *How does the online self-directed learning support affect students' reading outcomes in out-of-class extensive reading?* and RQ2: *How does the online self-directed learning support affect students' motivation and autonomy in out-of-class extensive reading?* Two groups were assigned to different programs, one with online SDL support (experimental group) and another without such support (control group).

First, we look into the comparison result of the two groups. Based on the pre-survey results, students in both two groups showed a relatively adequate level of SDL skills and a similar skill level. However, the experimental group more actively engaged in reading, read more numbers of materials, and more days than the control group during the three-week vacation. The difference in those partial reading outcomes indicates that the proposed online SDL support has a relatively positive effect on their ER activity. This is consistent with previous research findings which say SDL support positively affects students learning achievements (Avdal, 2013; Cazan & Schiopca, 2014). Based on the empirical evidence of the effectiveness of ER on improving reading speed (Huffman, 2014; Sakurai, 2015), students who read more seem should lead to faster reading. Yet, even students in the experimental group read more, they did not read faster than the control group. One reason we consider is that improvement of reading speed is difficult to observe in a short term. The second reason is that reading

speed can be affected by many factors, such as the book level, personal preferences and students' goals. To further understand these factors more longer-term observations can be conducted in the future.

After engaging in two different programs for extensive reading, in the post-survey, both the groups perceived to have positive ER motivation and autonomy, and no significant difference was found. It indicates current online SDL support does not have any negative effect on students' ER motivation and autonomy. Wachob (2006) also pointed out that motivation and learner autonomy depend on various factors, such as how students perceive their own achievement, how autonomous students feel, and how important it is to be autonomous. Further study is required to consider such factors in a longer duration of the reading activities.

In addition, this article reported the design of a learning dashboard for connecting SDL skills and the context it occurs. We further examined the relations between the use of the learning dashboard, reading outcomes, and SDL behaviors by addressing two research questions, RQ3: *What is the correlation between the use of the learning dashboard and reading outcomes in out-of-class extensive reading?* and RQ4: *What is the correlation between the use of the learning dashboard and self-directed learning behaviors in out-of-class extensive reading?* According to the result of quantitative analysis, the number of times students viewed the learning dashboard was found to have positive correlations with book count, page count, word count, unique days and the number of SDL phases students engaged in, which corresponding to the characteristics of "Read a large quantity of material", "Persist a long term reading", "Control reading process on their own". The students who viewed the learning dashboard more times were also generated more clicks in reading and the process management tool, which expressed their active engagement in SDER, although they were not necessarily read longer time in minutes. These findings meet the point of view which states that the learning dashboard gives learners the opportunity for greater awareness and reflection on their learning, using the insights gained to modify their perceptions or behaviors (Verbert, Duval, Klerkx, Govaerts, & Santos, 2013). However, a limited correlation was found with reading speed, which means the use of the current dashboard can barely help students in reading speed development in the short term. Above all, our findings advanced empirical understandings of student experience with the learning dashboard in the out-of-class extensive reading context.

7. Conclusion

We advocated an online self-directed extensive reading (SDER) environment, which consists of BookRoll, an e-book reading system, and GOAL, an SDL support system for the purpose of enhancing students' reading outcomes as well as SDL behaviors in the context of extensive reading. In this research, we extended our study to the context of out-of-class extensive reading. Eight characteristics of a successful reader in the SDER program were summarized based on previous literature. We demonstrated the design of the online SDER environment. Considering the data affordances of the systems, a list of SDER outcome measures (see Table. 1) were extracted linking to several characteristics. An evaluation was done based on the analysis result from a control experiment conducted with an experimental group that engaged in extensive reading with the SDL support and a control group that engaged in extensive reading without the SDL support in a three-week spring vacation. The findings suggest that the online SDL support has, i) a positive effect on multiple reading outcomes (book

count, page count, word count, reading clicks, time read in minutes, unique days in Table. 1); ii) no negative effect on students' ER motivation and autonomy.

On the other hand, we demonstrated a newly assembled learning dashboard on the basis of the previous version of the GOAL system, which contains an SDL process management tool. The learning dashboard provides two features: i) highlighting various reading outcomes to help students understand the context and their status; ii) providing navigation aid to the different SDL phases to help students independently use the SDL process management tool without instruction from their teachers. The results based on quantitative analysis confirmed that significant correlations exist between the use of the learning dashboard and multiple reading outcomes (book count, page count, word count, reading clicks, unique days) and SDL behaviors (see Table. 1).

The present study contributes to the understanding of SDL from several aspects. Firstly, this study utilized multiple learning systems to support students' SDL instead of teacher guidance. Teachers' instructional load is minimized that they only need to introduce the students to how to use the systems at the beginning. Secondly, this study encourages students to engage in real self-directed activity and observes their real-time SDL behaviors, while previous studies generally applied questionnaire-based reflective practices as the method to help students develop SDL skills. Thirdly, this study filled the gap to support SDL in the high school setting, and extend SDL studies beyond classroom learning. Lastly, a learning dashboard to connect SDL skills and the context it occurs is firstly proposed and evaluated in the context of ER.

This study has limitations that should be recognized. Current short-term experiment still can not confirm the effect of the online SDL support on many perspectives, such as reading speed, ER motivation, and autonomy. Our future work considers taking continuing support and a long-term observation in the school. Additionally, we also consider providing students adaptive feedback in the learning dashboard for helping them to promote reading outcomes and SDL skills in future work.

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Figures

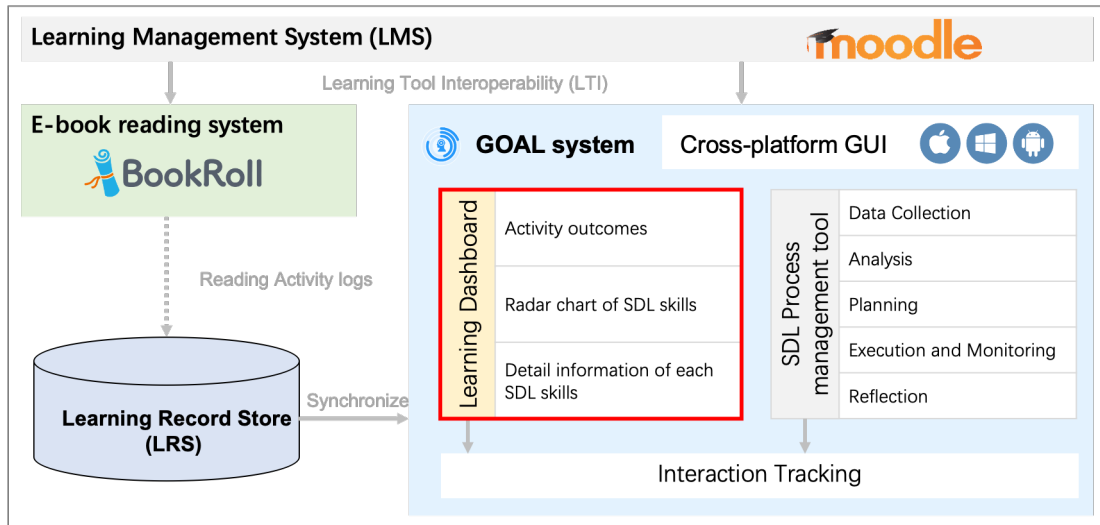


Figure 1. Structure of online SDL support environment

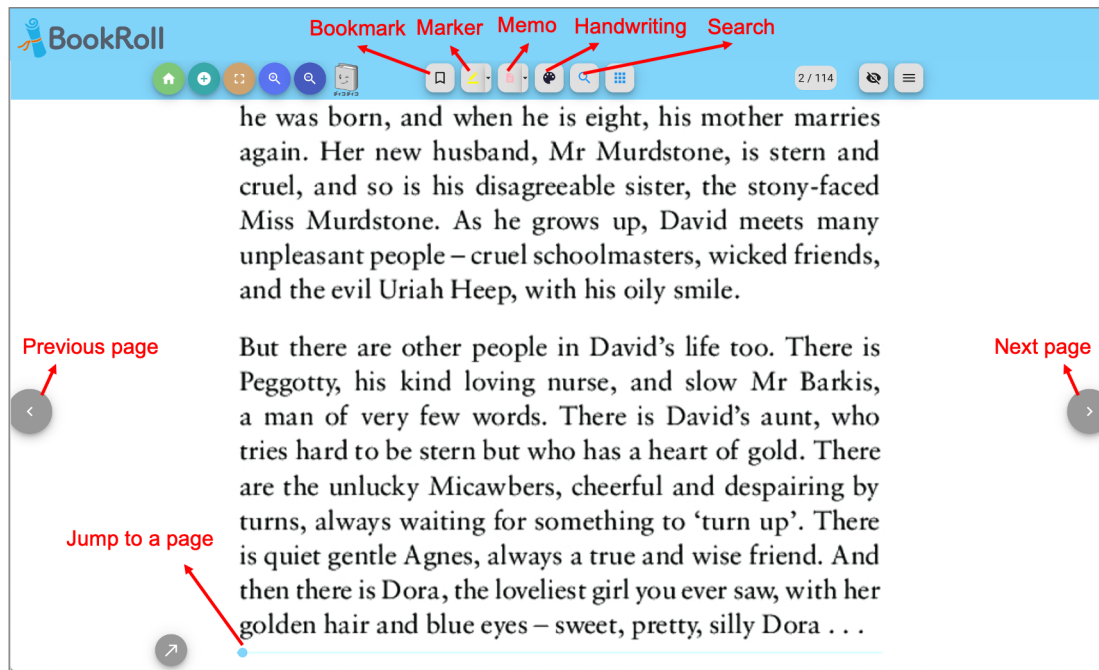


Figure 2. Screenshot of BookRoll system

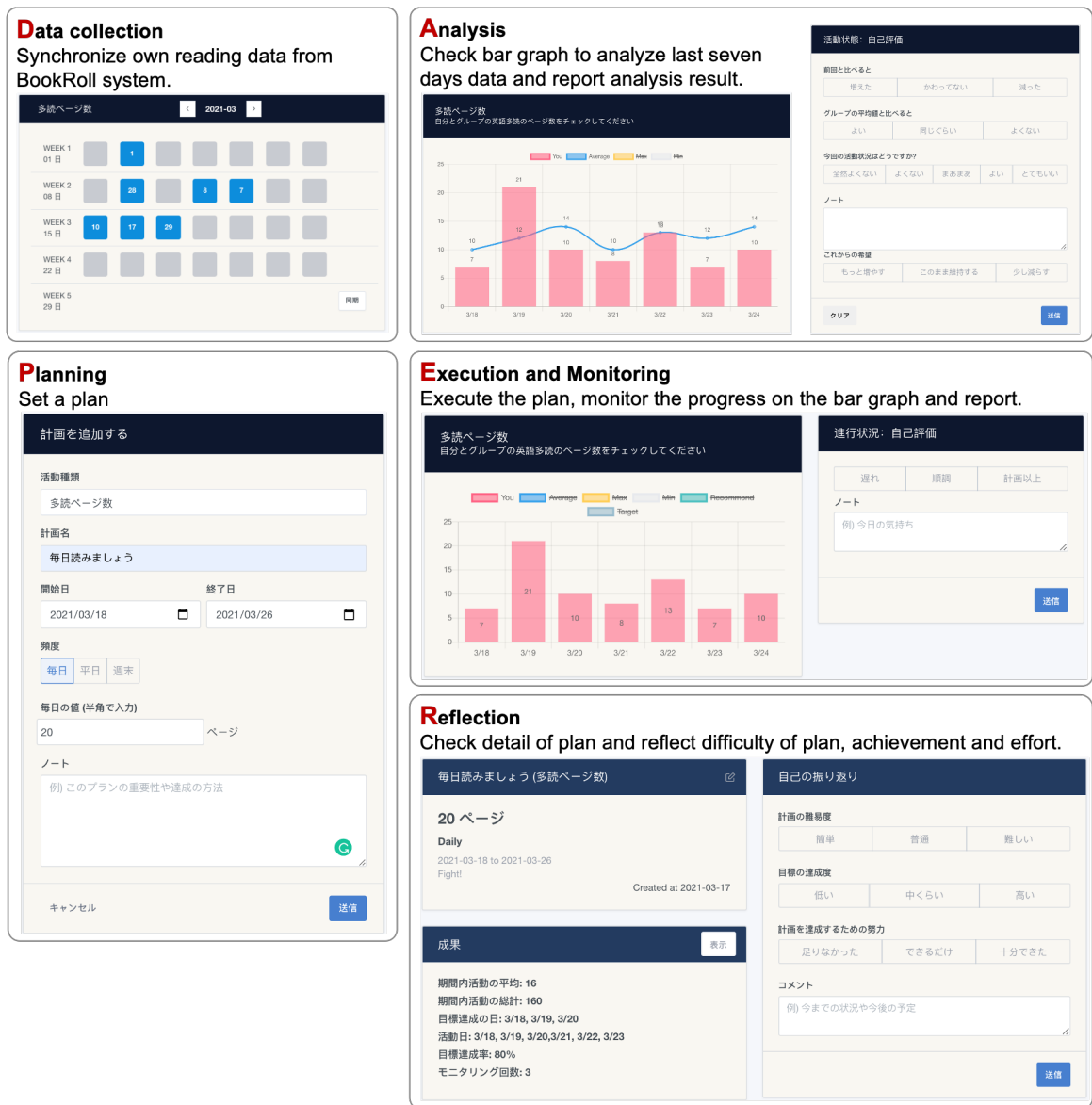


Figure 3. GOAL system interfaces to support SDER process management



Figure 4. Screenshot of the learning dashboard in GOAL system

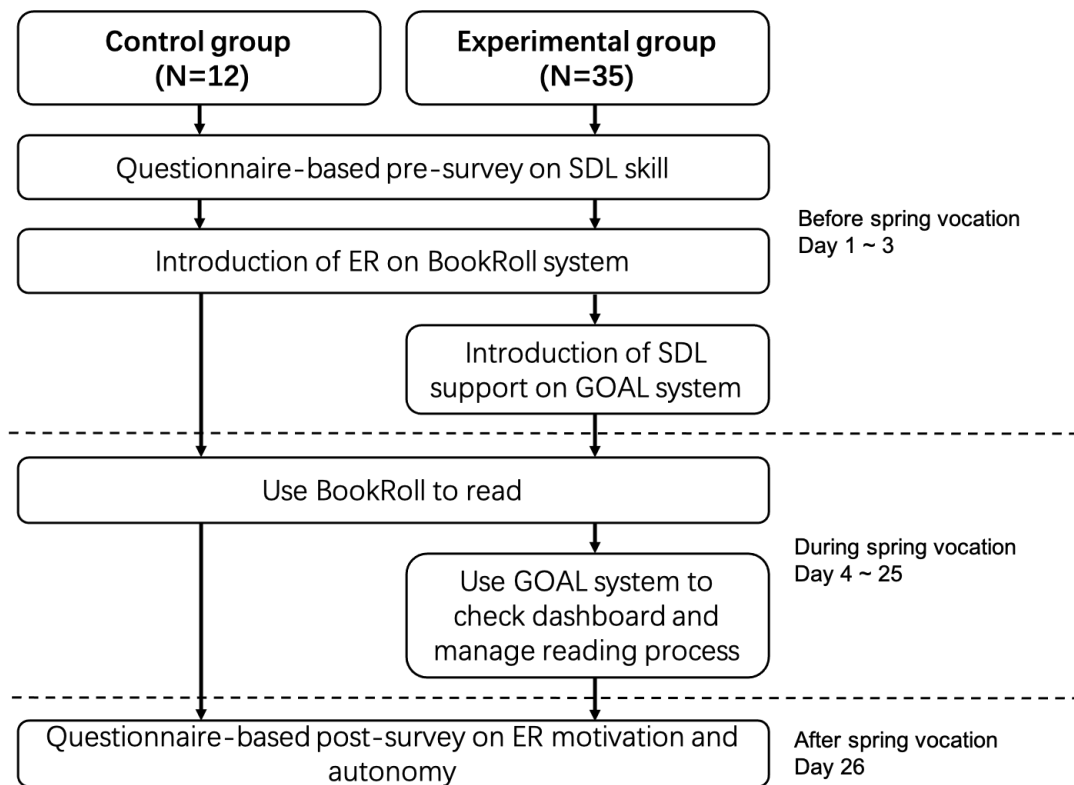


Figure 5. Procedure of experiment

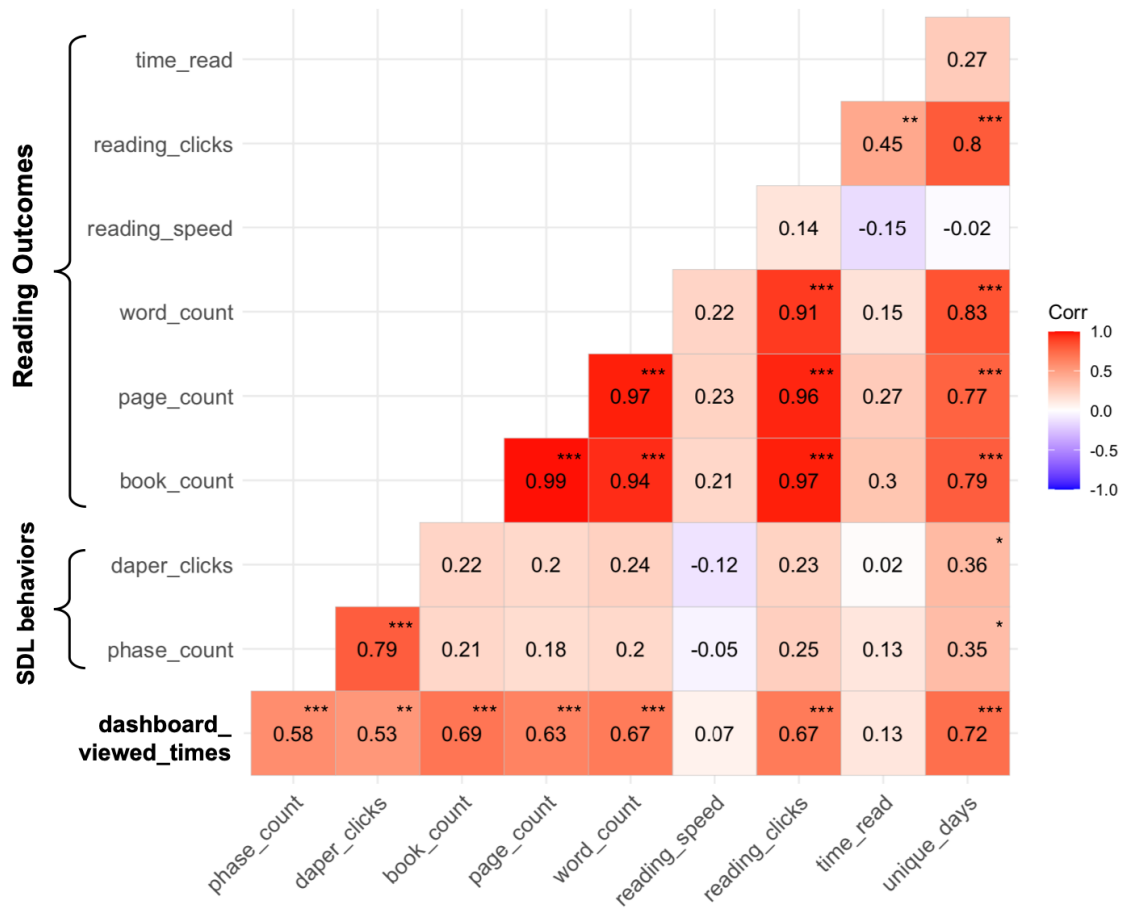


Figure 6. Correlation between dashboard viewing behavior and SDER outcome measures

Tables

Table 1. SDER Outcome measures and interpretation

Characteristics	Measures	Description	Category
Read a large quantity of material	book count	Number of books visited	reading outcome
	page count	Number of pages visited	reading outcome
	word count	Number of words read	reading outcome
Read at a faster rate	reading speed	Average reading speed	reading outcome
Persist a long term reading	unique days	Number of days read	reading outcome
Control reading process on their own	phase count	Number of SDL phases students engaged in	SDL behavior
Active engagement	reading clicks	Number of clicks in reading	reading outcome
	time read	Number of minutes spend on reading system	reading outcome
	daper clicks	Number of clicks while students engage in five DAPER phases	SDL behavior

Table 2. Descriptive statistics of survey scores and SDER outcome measures

Category	Measures	N	Mean	SD	Min.-max.
Reading outcome	book count	47	6.04	8.98	1-43
	page count	47	122.3	216.26	1-1086
	word count	47	5635.45	10178.11	0-51786
	reading speed	47	119.59	83.78	0-472
	reading clicks	47	182.64	262.25	2-1192
	time read (min)	47	130.8	289.33	0.07-1506.23
	unique days	47	2.94	3.38	1-20
SDL behavior	phase count	35	1.51	1.4	0-5
	daper clicks	35	17.57	30.04	0-131
Dashboard use	dashboard viewed times	35	8.54	8.92	1-38
Perception result	Learning motivation (SDLI)	47	22.38	4.07	14-30
	Planning and implementing (SDLI)	47	20.28	3.93	12-30
	Self-monitoring (SDLI)	47	14.49	2.70	8-20
	ER motivation	47	17.69	3.90	5-25
	Autonomy	47	16.29	3.20	9-25

Table 3. Difference of two groups on reading outcomes, perception results

Category	Measures	Group	N	Mean	SD	Statistics	Effect size
Reading outcome	book count	Experimental	35	7.26	10.10	135.00*	0.36
		Control	12	2.50	1.93		
	page count	Experimental	35	150.37	244.13	131.50*	0.37
		Control	12	40.42	39.17		
	word count	Experimental	35	6952.60	11470.70	114.00**	0.46
		Control	12	1793.75	2213.21		
	reading speed	Experimental	35	119.44	64.52	174.00	0.17
		Control	12	120.03	128.41		
	reading clicks	Experimental	35	223.37	291.63	125.50*	0.40
		Control	12	63.83	63.75		
	time read (min)	Experimental	35	169.23	327.36	116.00*	0.45
		Control	12	18.73	20.75		
	unique days	Experimental	35	3.54	3.72	97.00***	0.54
		Control	12	1.17	0.58		
Perception result	Learning motivation (SDLI)	Experimental	35	22.37	3.83	0.033	-0.01
		Control	12	22.42	4.89		
	Planning and implementing (SDLI)	Experimental	35	20.37	4.06	-0.279	0.09
		Control	12	20.00	3.69		
	Self-monitoring (SDLI)	Experimental	35	14.66	2.69	-0.726	0.24
		Control	12	14.00	2.76		
	ER Motivation	Experimental	33	17.42	4.23	0.751	-0.25
		Control	12	18.42	2.84		
	Autonomy	Experimental	33	16.15	3.19	201.50	-0.02
		Control	12	16.67	3.31		

* $p < .05$, ** $p < .01$, *** $p < .001$.