How the Habits of Self-regulated Academic Writers are Behaviorally Facilitated?

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Abstract: In this paper, the authors demonstrated online academic writing behaviors as an example to illustrate a habit loop in Interest-driven Creator (IDC) theory. A habit loop describes that the habitual routine of creation should be triggered by a cueing environment, and provide a sense of harmony. Furthermore, instead of using the theory as a design framework, the authors proposed that the IDC theory could also be used as an analysis framework. In this study, the authors aimed to explore how the habits of self-regulated academic writing were behaviorally facilitated. For this purpose, the authors collected behavioral data of graduate students in an online academic writing system for two months. The students were divided into high and low self-regulated learners. Their behavioral patterns were then computed separately with hidden Markov models. The results showed that the model of the high self-regulated learners included a small version of a creation loop and a habit loop, in which the academic writing were triggered by the behaviors of literature reading, self-monitoring, and co-authoring. Besides, after writing, the high self-regulated learners tended to go back to read more literature and monitor their progress. Conversely, in the model of the low self-regulated learners, all behaviors likely transited to writing without any evident loops, implying that the low self-regulated learners might be performance goal oriented.

Keywords: Habits, self-regulated learning, academic writing, hidden Markov models

1. Introduction

When entering graduate schools, students start to conduct individual research for their very first time. Even with the scaffolding of their advisors, the process of research is basically self-regulated. In other words, unlike undergraduate education, graduate education involves more uncertainty and complexity in field knowledge, research direction, and methodology. When graduate students overcome these issues and finish a study somehow, they still have to figure out how to write their own theses. International graduate students reported that their difficulties in academic writing included literature review, methods, and analysis (Singh, 2015). Because academic writing is a big challenge for most graduate students, they are usually encouraged to submit conference papers in advance. As an example of creation, writing academic papers or theses is not a one-time job. Any professors would tell their graduate students to keep writing as a habit in order to improve the writing quality.

Recently, Asian scholars proposed an Interest-Driven Creator (IDC) theory (Chan, *et al.*, 2018), which emphasizes the importance of interest, creation, and habits in a form of loops. In the habit loop, there are three component concepts: a cueing environment, routine, and harmony. A cueing environment is a habit trigger that psychologically and behaviorally prepares students to do the habitual routine, that is, creation in the theory. A cueing environment could be anything or anyone that could trigger one to create works, for example, a certain setting of learning spaces, fixed learning timetables, or important people (e.g. teachers, parents, and/or peers). Some researchers have proposed portfolio visualization as a cueing environment to trigger students to start writing a new composition (Liao, Chang, Cheng, & Chan, 2017). After the habitual routine, students should feel the sense of satisfaction, achievement, or even harmony. These positive feelings may become a motivated cueing (Wood, & Neal, 2007) or a cached motive (Daw, Niv, & Dayan, 2005), so that students would be willing to do the routine again.

Even though the IDC theory is still young, more and more researchers used the theory as a design framework to develop learning systems (*e.g.* Chang, Shih, & Huang, 2017; Chen, Chi, & Ciou, 2017; Liao, Chang, Cheng, & Chan, 2017). In this paper, the authors would like to further use the theory as an analysis framework to examine how the habits of academic writing were triggered. Furthermore, the authors collected graduate students' behavioral data, in which the students used an online academic writing system to prepare their own papers for two months. In the system, the students were allowed to build literature lists, take reading notes, write manuscripts, provide/receive comments from co-authors, and monitor progress. Ideally, students with good writing habits should work like self-regulated learners. In other words, they should set personal goals, devise strategic plans, monitor their own progress, and regulate their behaviors if necessary (see Zimmerman, 2002). Therefore, their behavioral patterns might have not only cognitive but also metacognitive information. More importantly, studying their behavioral patterns may help us understand the habit loop in the theory.

In this study, we aimed to explore the students' habitual behaviors of self-regulated academic writing by hidden Markov models (HMMs), a machine learning technique that describes a statistical model of Markov process with unobservable variables. Many previous researchers have adopted the machine learning technique to understand self-regulated learning behaviors. For example, Biswas et al. (2010) used hidden Markov models to explore how learning modes might affect students' self-regulated learning behaviors. In their study, it was assumed that the unobservable variables in hidden Markov models could be regarded as metacognitive strategies. Their results demonstrated that a hidden Markov model was a promising technique for modeling self-regulated learning behaviors. In our study, hidden Markov models were used to examine the differences in the behavioral patterns of academic writing between high and low self-regulated learners.

2. Method

2.1 Participants

The participants were 92 first-year graduate students, including 38 male and 54 female students. Their ages ranged from 21 to 25 years old in the spring semester of 2019. Their majors included computer sciences, software engineering, and educational technology. They took a course on the academic reading and writing, in which the students were required to prepare their manuscripts with any topics of their choices in the online academic writing system. They were also required to invite several classmates as their coauthors, who had to providing comments for the first authors during the process of writing. The whole process took a semester, but due to the time limitation, the analysis in this paper only included the data in two months, *i.e.*, April and May 2019.

2.2 Instrument

In the end of the semester, the students were asked to fill out a self-regulated learning questionnaire (Kizilcec, Pérez-Sanagustín, & Maldonado, 2017), which contains 24 questions with six dimensions: goal setting, strategic planning, task strategy, elaboration, self-evaluation and help seeking. The questionnaire was a 5-point Likert scale with options from 1 point (strongly disagree) to 5 points (strongly agree) for each statement. The questionnaire was used to group students as high and low self-regulated learners.

2.3 Online Academic Writing System

During the course, the students were required to use the online academic writing system as a platform to submit their weekly assignments, which included writing one note for an academic paper, writing about 10% of their own manuscripts, and give 3 comments to co-authored manuscripts. The teacher would not really check their progresses every week. Instead, he checked them in the end of the semester, so that the students could demonstrate their behaviors of self-regulate learning in their writing behaviors.

The system was designed to scaffold graduate students to prepare their papers. For this reason, the system served for the following functions: surveying literature, reading literature, goal-setting &

planning, writing papers, self-monitoring, and peer commenting (detailed actions are described in Table 1). For example, in the chapter plan page, as shown in Figure 1(a), students were allowed to monitor the status of all chapters in their manuscripts, including the current word numbers, the target word numbers, and the self-evaluated scores. If they would like to write the manuscripts, they may click a chapter name and write the chapter. In the writing page, as shown in Figure 1(b), their own notes taken for literature were displayed on the right, so that they could reorganize the manuscripts.

(a) The chapter plans

(b) The chapter writing with notes

Figure 1. The online academic writing system.

Table 1

Actions in the Online Academic Writing System

Categories	Codes	Descriptions of Actions
Surveying	KW-ADD	Adding keywords in order to build a personal keyword list
	RS-CHK	Checking a personal researcher list
	LT-ADD	Adding literature in a shared literature list
	LT-CHK	Checking the literature list
Reading	NT-WRT	Taking a note after reading literature
	NT-CHK	Reading notes
Goal-setting & Planning	PL-ADD	Adding a chapter plan, including target word numbers and deadline
	PL-RVS	Revising a chapter plan
Self-monitoring	PL-CHK	Checking all chapter plans in a page (see Figure 1(a))
	CH-EVL	Evaluating the perceived quality of a chapter
Writing	CH-WRT	Writing a chapter with the supports of notes (see Figure 1(b))
	CH-RVS	Revising a chapter with the supports of peer comments
Peer commenting	CM-ADD	Adding comments for co-authored papers
	CM-MNG	Managing comments from co-authors, including full accepting, partial accepting, or rejecting

2.4 Data collection

The behavioral data of students' academic writing activities was collected from 2019/4/1 to 2019/5/31. The data was then coded as shown in Table 1. In the end of the semester, according to the self-regulated learning questionnaire (*M*=3.69, *SD*=0.33), the students were divided into a high SRL group (higher than the average, *N*=49) and a low SRL group (lower than the average, *N*=43). After the process of data collection, there were 5,120 actions for high SRL students and 10,709 actions for low SRL students.

2.5 Data analysis

The data was analyzed by hidden Markov models, in which there are several unobservable states generating observable outputs. Each model was consisted of the sets of transition probabilities (the likelihood of students changing states), emission probabilities (the likelihood of students' actions in every state) and initial probabilities (the likelihood of a state as a starting one). In this study, the observable outputs were the students' actions as given variables, while the hidden states were assumed as the students' cognitive and/or metacognitive strategies. In other words, the hidden states of the models were summarized according to the probability distribution of the actions. The models for the high and low SRL groups were computed separately. In order to determine the optimal numbers of states, Bayesian Information Criteria (BIC) was adopted (see Biswas, *et al.*, 2010). The BIC may consider the better fittingness and conciseness of a model. In the end, there were five states for the high SRL group, and four states for the low SRL groups. It was expected that hidden Markov models could help us understand the behavioral patterns in the online academic writing system.

3. Results

3.1 High Self-regulated Learners

In Table 2, the emission probabilities in the hidden Markov model of the high self-regulated learners are shown. For better readability, the probabilities higher than 5% are highlighted. According to the emission probabilities, the five hidden states were named as literature survey & reading, progress planning, progress monitoring, individual paper writing, and paper co-authoring.

- **Literature surveying & reading**: the state was mainly consisted of the actions in getting prepared to explore research status by searching literature, reading papers, and taking notes. This state could be regarded as the component of imitation in creation loops, because the students in this state learnt knowledge from literature and summarize them as reading notes.
- **Progress planning**: the state was consisted of the actions of adding and revising the plans for each chapter. In this state, the students were planning how to compose the article. This state could be regarded as a part of cueing environments in habit loops, because the students in this state prepared how to write their manuscripts before writing.
- **Progress monitoring**: the state was dominated by the actions of checking the plans for chapters. This state could be regarded as another part of cueing environments and harmony in habit loops, because self-monitoring may serve as a behavior facilitator before writing and an achievement accumulator after writing.
- **Individual paper writing**: the state was dominated by the actions of writing papers with self-evaluation. It was noted that this state rarely involved actions related to peers. This state could be regarded as combination in creation loops, because the students in this state composed their own papers by reorganizing or extending their reading notes.
- **Paper co-authoring**: the state was mainly consisted of the actions of providing and receiving comments with minor probabilities of writing papers. This state could be regarded as staging in creation loops, because the students in this state collaboratively composed papers.

Table 2

The Emission Probabilities of the High Self-regulated Learners (%)

States	Surveying				Reading		Goal-setting & Planning		Self-monitoring		Writing		Peer commenting	
	KW-ADD	RS-CHK	LT-ADD	LT-CHK	NT-WRT	NT-CHK	PL-ADD	PL-RVS	PL-CHK	CH-EVL	CH-WRT	CH-RVS	CM-ADD	CM-MNG
Literature surveying & reading	14.38	3.84	10.38	44.26	10.68	10.97	0.00	0.00	2.24	0.42	1.82	0.00	0.30	0.71
Progress planning	0.00	0.00	0.00	1.05	0.00	0.00	21.83	75.04	1.11	0.00	0.00	0.35	0.23	0.38
Progress Monitoring	0.00	0.00	0.19	0.00	0.00	0.00	0.00	0.00	97.85	0.62	0.00	0.39	0.59	0.36
Individual paper writing	0.38	0.04	0.00	0.19	0.00	0.00	0.00	0.00	0.00	8.41	90.11	0.04	0.29	0.54
Paper Co-authoring	0.65	0.00	0.00	0.60	0.00	0.00	0.00	0.00	0.00	0.28	6.72	9.81	59.51	22.43

The hidden Markov model of high self-regulated learners was illustrated in Figure 2. For better readability, only the transitions with probabilities higher than 5% were shown. In this figure, individual writing and monitoring progress were the two centered states, linked with almost all states, suggesting their importance in the context of self-regulated academic writing.

From the perspective of the IDC theory, the three states about reading and writing could be regarded as the three components in a creation loop, which involved imitation (*i.e.* surveying, reading, and note-taking), combination (*i.e.* individual writing by reorganizing notes and developing arguments), and staging (*i.e.* co-authoring by peer commenting). Basically, the three states were self-transition, revealing that the common nature of reading and writing was immersion. In other words, the students were able to keep in the reading and writing states. Besides, there was a small creation loop between reading literature and writing papers, suggesting that academic reading and writing were not phase-based, but closely connected with each other. Furthermore, self-regulated learners more likely continued writing parts of papers just after reviewing literatures. In the same way, they were also likely back to looking for new literatures when they get stuck in writing papers.

However, although the states of co-authoring might also trigger the states of individual writing, the probability of the reverse transition was lower than 5%. The results implied that the students normally did not want to share their works with others until they were ready. Yet, if they were asked to participate in any forms of staging, the experience could invoke higher willingness to do creation. Additionally, the probabilities of transitions between reading and co-authoring were both lower than 5%. Therefore, although a small creation loop between reading and writing was found, there were not sufficient evidences to identify the complete creation loop in this study.
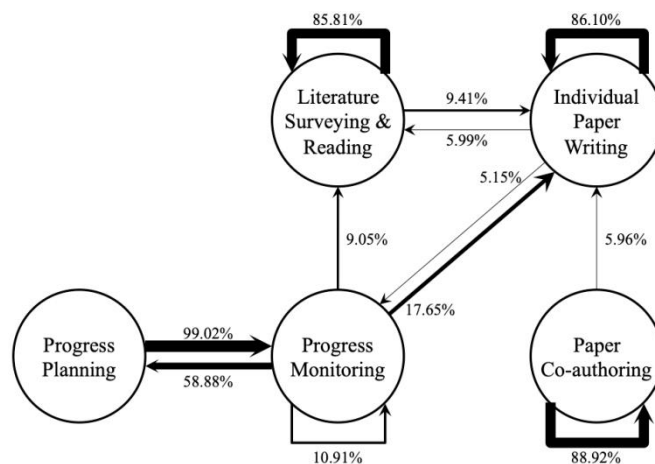

Figure 2. The hidden Markov model of the high self-regulated learners.

On the other hand, if reading and writing were regarded as the routines in a habit loop, then the cueing environment should be self-monitoring evidently in this study. As shown in Figure 2, after monitoring progress, the students had the probability of 17.63% to trigger writing papers, and 9.05% to

trigger surveying and reading more papers. The results could be explained by open learning models (Bull, & Kay, 2007), which explicitly showed learners their working progress and portfolios. In this study, the system displayed their writing progress and self-evaluation in the page of chapter plans (Figure 1(a)). Such an open learner model may not only point out students' efforts and achievements, but also highlight their missing parts, which may further lead them back to reflect themselves and regulate their writing behaviors.

Besides, in the habit loop, after the routine of creation, learners were supposed to feel the sense of harmony or satisfaction. In this study, it was found that the students had probability of 5.15% to go back to the state of progress monitoring after individual writing. The results implied that self-regulated learners tended to reflect how well they just created works in the self-monitoring page. Additionally, the states of monitoring and planning progress were not self-transition, but intertwined. The strong transitions between the two states suggested the dynamics between planning and self-monitoring in self-regulated learning. Furthermore, if self-regulated learners were required to plan their creation, self-monitoring would naturally happen. On the other hand, if self-regulated learners found that their plans were too hard to catch up, they might likely either regulate their learning behaviors or change the plans.

3.2 Low Self-regulated Learners

In Table 3, the emission probabilities in the hidden Markov model of the low self-regulated learners are shown. According to the emission probabilities, the four hidden states were named as literature surveying and reading, progress managing & survey enhancing, paper writing with peers, and peer commenting.

- **Literature surveying & reading**: the state was distributed very similarly with that of high self-regulated learners, so it was named as the same way. The similarity demonstrated that all graduate students, regardless of their self-regulated learning abilities, searched and read papers in the same way.
- **Progress managing & survey enhancing**: the state was mixed of progress planning, progress monitoring and keyword adding. The result implied that the low self-regulated learners might not be able to distinguish their metacognitive strategies in their minds.
- **Paper writing with peers**: the state was consisted of paper writing, evaluation, and receiving comments from co-authors. Unlike those high self-regulated learners' individual writing, the low self-regulated learners tended to modify papers according to co-authors' comments. The reason perhaps was that low self-regulated learners usually had low confidence and thus looked for suggestions when writing.
- **Peer commenting**: the state was majorly consisted of providing comments for and receiving comments from co-authors. This was a state where the learners treated peer commenting as a task, without any connections to writing in their minds.

Table 3

The Emission Probabilities of the Low Self-regulated Learners (%)

States	Surveying				Reading		Goal-setting & Planning		Self-monitoring		Writing		Peer commenting	
	KW-ADD	RS-CHK	LT-ADD	LT-CHK	NT-WRT	NT-CHK	PL-ADD	PL-RVS	PL-CHK	CH-EVL	CH-WRT	CH-RVS	CM-ADD	CM-MNG
Literature surveying & reading	4.24	3.34	10.87	51.01	12.00	14.83	0.00	0.00	1.13	0.07	1.13	0.00	0.90	0.48
Progress managing & survey enhancing	26.73	0.93	0.00	0.91	0.00	0.00	7.82	19.20	42.95	0.14	0.71	0.11	0.50	0.00
Paper writing with peers	0.84	0.00	0.00	0.28	0.00	0.00	0.00	0.00	0.75	12.65	74.21	4.86	1.22	5.18
Peer commenting	0.13	0.00	0.00	0.31	0.00	0.00	0.00	0.00	0.06	0.35	0.94	0.99	91.26	5.96

The hidden Markov model of the low self-regulated learners was illustrated in Figure 2. Despite the fact that the meanings of the states were slightly different from those of high self-regulated learners, the model of low self-regulated learners was basically a subset of that of high self-regulated learners. However, there were no evident loops like those in the model of high self-regulated learners. In Figure 2, it was noticed that the state of paper writing (with peers) was triggered by the other three states. In a sense, these low self-regulated learners might be performance goal oriented instead of mastery goal oriented in terms of achievement goal orientation theory (see Elliot, & McGregor, 2001). Performance goal oriented learners tended to get motivated by the perceived performance and to strive for outperforming others, while mastery goal oriented learners tended to develop their abilities. In other words, in this study, the low self-regulated learners likely read literature, monitor progress and providing comments just for writing papers. The behaviors of self-regulation did not seem evident in the model of the low self-regulated learners.

Figure 3. The hidden Markov model of the low self-regulated learners.

4. Concluding Remarks

In this paper, we built two hidden Markov models of academic writing behaviors for graduate students with high and low self-regulated learning strategies. The two models shared a common hidden state named literature surveying & reading, suggesting that they all gathered information from academic papers in the same way. The two models also demonstrated that the states of literature surveying & reading, paper writing, and peer comments were all self-transition with high probabilities. We believed that the models captured the students' immersions in the three behaviors, which could be regarded as the three components (*i.e.* imitating, combining, staging) in a creation loop from the perspective of the IDC theory. In other words, if students were engaged in these activities of creation, they would naturally keep doing it.

Except these commonalities, the two models had the following dissimilarities, suggesting the characteristics of self-regulated learners in the context of academic writing. First, the high self-regulated learners tended to writing papers alone, while the low self-regulated learners preferred writing papers with others' comments. Second, when doing peer commenting, the high self-regulated learners tended to relate peer commenting with their writing, while the low self-regulated learners preferred treating peer commenting as an independent task. Third, when self-monitoring, the high self-regulated learners had two separate but intertwined mental states, *i.e.* progress monitoring and progress planning, while the low self-regulated learners mixed monitoring, planning, and survey enhancing together in their minds. Fourth, there was a small version of a creation loop between literature reading and writing in the model of the high self-regulated learners, while there was no evident creation loop in the model of the low self-regulated learners. Fifth, there was also a habit loop between progress monitoring and paper writing in the model of the high self-regulated learners, while no habit loop was found in the model of the low self-regulated learners. Therefore, we may conclude that the high self-regulated learners might be mastery goal oriented, while the low self-regulated learners seemed performance goal oriented.

From the perspective of the IDC theory, although we might have identified several behavioral evidences of loops, such as immersing in an interest loop, imitating and combining in a creation loop, as

well as a cueing environment and routine in a habit loop, there were still missing parts in this study. First, about the anchored concept of interest, the current activity of academic writing lacked the explicit design of a whole interest loop. In this study, these graduate students were required to submit their manuscripts with necessary preparation every week. Though, they were allowed to decide the topics of their papers. Second, about the anchored concept of creation, although we found that peer commenting as a component of staging could lead to writing, there were no evident transitions from writing to peer commenting and then from peer commenting to reading like in an ideal creation loop. Therefore, because the loop would not happen itself, educational designers should make the process more visible. For example, students should be required to provide and receive comments after writing, and to go back to survey and read papers after participating in bigger staging. By doing so, a virtuous cycle would naturally happen. Third, about the anchored concept of habit, we found that self-monitoring could facilitate the routines of reading, writing, and planning. We also found that writing could facilitate self-monitoring. Although a habit loop seemed existed, it was still hard to prove the third component of harmony in the habit loop. We did not yet know whether the students had a sense of satisfaction, achievement or even harmony after writing. Perhaps we should operationalize the concept of harmony first, so that we could start to evaluate students' minds when they finished the routine of creation.

Acknowledgements

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