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Progressive Behavior Patterns of Online Discussion at Different Circle of Self-Regulated Learning

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Abstract: This study examines the progressive behavior patterns of learners in online asynchronous discussions during different phases of self-regulated learning, using the Bookroll platform. Learners engaged in self-regulated activities, such as previewing videos at home and participating in online discussions, over a three-month period. The activity logs were divided into three phases, with roles of speakers and respondents coded for analysis. The cyclic behavior analysis revealed significant correlations and differences in discussion behaviors. In the first two phases, responders played a key role in guiding discussions, providing analyses, and asking questions, which promoted critical thinking. In the third phase, positive reinforcement and additional explanations helped redirect discussions when topics deviated. The study highlights the importance of questions and positive reinforcement from instructors to motivate learners, maintain discussion depth, and enhance engagement, thereby promoting effective learning.

Keywords: Progressive behavior analysis, Self-regulated learning, Online discussion, Learning analytics

1. Introduction

Learners' self-regulated learning (SRL) abilities are crucial for sustaining online asynchronous discussions. This study examines how discussion behaviours evolve across SRL phases, providing insights for enhancing online learning strategies. Asynchronous interactions often decline over time; this study uses time-series analysis to explore these patterns across three phases of SRL. To sum up, this study addresses three research questions. It examines the discussion behaviours occurring in the three planned phases of self-regulated learning, focusing on the patterns of deterioration over time as per the time-series analysis. This research serves as a reference for future educators conducting online discussion activities.

1. What is the frequency of online discussion behaviours across the three-phase cycle of self-regulated learning?
2. What are the outcomes of the progressive sequential behaviour analysis of online discussion behaviours in the three-phase cycle of self-regulated learning?
3. What are the observed patterns of decline in online discussion behaviours at various stages within the three-phase cycle of self-regulated learning?

2. Literature Review

2.1 Online Learning Communities

Academic literature offers various perspectives on the impact of asynchronous discussion forums on learning behavior. Asynchronous boards allow flexible participation but also present challenges due to the lack of immediate feedback. Yen et al. (2022) highlight that the quality of social interaction significantly impacts learning outcomes, stressing the need to design online discussions that enhance social presence. Gilmore (2020) emphasizes the importance

of structured instruction and feedback in sustaining learner engagement, focusing on the teacher's role in motivating and guiding learners. Hernández-Sellés et al. (2019) found that combining technical tools with emotional support improves the quality of interactions and learning satisfaction. Kauppi et al. (2020) discuss the balance between learners' social and academic needs in virtual interactions, which is crucial for deeper engagement. Guo et al. (2014) underscore the importance of facilitative feedback in boosting cognitive engagement in asynchronous settings. These studies collectively emphasize the critical role of asynchronous discussion forums in online learning communities and offer insights into optimizing these environments for supporting self-regulated learning and social interaction.

2.2 Format and Layout

Self-regulated learning (SRL) is a self-driven process aimed at achieving goals through systematic and positive actions. It involves setting goals, staying focused, adopting effective strategies, and managing time efficiently (Zimmerman, 2023). Although online learning offers flexibility, it can challenge learning outcomes due to the absence of real-time interactions, which self-regulated learning can help mitigate (Vonderkell, 2003). Research shows that learners who practice self-directed learning improve their academic performance and self-management skills (Lai & Hwang, 2016). SRL allows learners to set flexible learning goals and take responsibility for their learning (Liebendörfer et al., 2022). Schunk and Zimmerman (2023) outline a four-stage cyclical model of SRL:1.Goal Setting: Learners set goals, select strategies, and plan outcomes. 2.Strategy Selection: Learners monitor and adjust their strategies as needed. 3.Monitoring: Learners assess their progress, identify difficulties, and make necessary adjustments.4. Reflection: Learners evaluate their performance and plan for future learning.

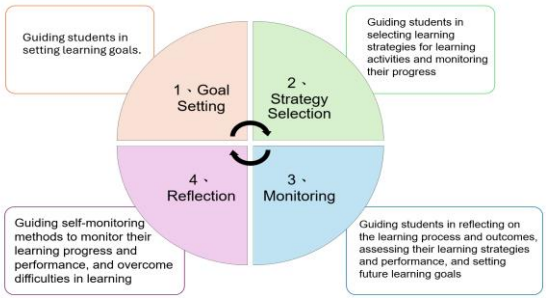

Figure 1. Cycle of self-regulated learning

2.3 Learning Process and Learning Analysis

Online learning platforms can track and analyze learners' behaviors throughout the learning process, providing insights into how they interact with content, environments, and peers to achieve their goals (Yan & Au, 2019). The data collected from these interactions can be used to enhance learning through adaptive processes (Fisher et al., 2014). Lagged Sequence Analysis (LSA) is a method used to detect temporal variations in learning behaviors by systematically comparing learner responses and feedback at different stages (Chen et al., 2018). This analysis helps to understand how learners with different personalities navigate online courses, allowing for the design of personalized instruction models (Tlili et al., 2023). Valiente et al. (2015) note that the advancement of learning analytics research, including the use of machine learning, aids in predicting learning outcomes. Behavioral analysis, as part of LSA, examines the interconnected series of actions during a learner's experience, such as watching videos, answering questions, and participating in discussions. These behaviors are influenced by subjective thinking and environmental factors, which can be explored to improve instructional strategies (Yan & Au, 2019).

3. Method

3.1 Participants

The study involved 15 graduate students from a northern Taiwan university, participating in a three-month asynchronous online discussion program with 13 sessions. The experiment was divided into three phases to analyze the impact of time on discussion behaviours, providing pedagogical insights for future online teaching.

3.2 Learning Platform or Tools

This study employed the Bookroll asynchronous digital learning platform, developed by Kyoto University, for encoding analysis of course content, discussion processes, and feedback. Bookroll, an online electronic book learning system, offers instructors a user-friendly interface for uploading documents and videos, facilitating asynchronous learning. Its E-books feature allows learners to take notes directly on electronic course materials, enhancing flexibility and convenience. The platform's advanced features, such as real-time tracking and visualization, were crucial for analyzing learner interactions and providing feedback. The discussion forum within Bookroll served as a vital space for promoting learner interaction and self-regulated learning. Students watched instructional videos before class, then used the forum to express opinions and respond to peers, deepening their understanding and engagement with the material.

3.3 Experimental Procedure

In this experiment, a three-phase cycle of self-regulated learning will be implemented, with each phase lasting for one month. The total duration of the experiment will be three months. At the beginning of each month, participants will initiate goal-setting and decision-making processes. At the end of each phase, there will be monitoring and reflection, followed by the initiation of goal-setting and decision-making for the next stage. This cycle will be repeated three times throughout the experiment.

3.4 Coding System for Sequential Analysis

Table 1. *Coding schemes for progressive asynchronous online discussion in self-regulated learning*

Code	Example	Describe
RH	There is a quote in the movie: "Learning cannot be designed, it can only be designed for ".	Paraphrase others' words
EB	Adaptive Learning is the use of technological devices (such as computers) to carry out interactive teaching. It provides students with suitable and appropriate teaching materials based on learners' interactive responses and extensive data analysis on the platform. The instructional design also needs to adhere to Mayr's multimedia cognitive theory to reduce learners' cognitive load and align with the learning curve.	Summarise key points and taking refined notes
CT	What types of complex situations should be considered and arranged in scenario-based learning?	Pose questions or doubts about the content observed.
PO	I believe that within course design (e.g., project management), instructional content should emphasize the creation of learning contexts.	Express one's own views
HF	Thus, I found an article titled "Adaptive or Collaborative Learning? https://www.researchgate.net/publication/228516809_Adaptive_or_Collaborative_Learning	Provide reference resources (Google or other online resources from ChatGPT)
OT	Inquiry-based learning, find a typo, please don't mind!"	Engage in unrelated discussions.
RE	Educators can instantly know learners' levels of focus and learning progress through this system, mainly focusing on concentration, as learners tend to get distracted during prolonged classes.	Respond to the questioner.
RF	Really great!	Respondents provide positive (negative) reinforcement information, agree with others, or offer praise and encouragement to others.
CQ	What are the benefits of real-time learning assessment systems for both instructors and learners?	Respondents ask questions or correct the speaker to enhance the accuracy and focus of the discussion.
DF	"Authentic problems" serve as an excellent starting point, regardless of what is being learned, as they allow for the exploration of additional ideas and thoughts through PBL.	Provide detailed explanations, supplementary information, or share experiences.

Code	Example	Describe
SF	I think the company should consider the varying levels of technology acceptance among employees	Offer suggestions that contribute constructively and meaningfully to the discussion or help in forming consensus.
TH	Haha! I laughed when I saw the environmental part~	Other unrelated chatting or discussion content.

This study utilized lag sequential analysis with the GSEQ (Generalized Sequential Querier) for comprehensive data processing. The coding scheme was based on established SRL frameworks and prior research on online behavior analysis, ensuring thorough coverage of learner activities. Behaviors were categorized into twelve types to capture the breadth and depth of interactions. Two researchers verified the coding schemes in each phase to ensure reliability. The behaviors were divided into two main categories: speakers (seven coding schemes) and respondents (five coding schemes). Kappa analysis was used to assess the consistency of these coding schemes. Table 1 presents the coding schemes used for analyzing progressive asynchronous online discussions in self-regulated learning.

4. Research Results

4.1 Frequency of online discussion behaviours in the three-phase cycle

Significant differences in behaviours across the three discussion phases were found (χ^2=77.46, p<.001), indicating notable engagement variations, as shown in Table 2.

Table 2. *The code occurrence frequency in asynchronous online discussion*

Code	Content	Frequecny of Phase 1	Percentage	Frequecny of Phase 2	Percentage	Frequecny of Phase 3	Percentage
RH	Paraphrase others' words	6	2.48%	2	1.28%	13	8.50%
EB	Summarise key points	89	36.78%	50	32.05%	42	27.54%
CT	Pose questions	14	5.79%	16	10.26%	10	6.54%
PO	Express one's own views	82	33.88%	38	24.36%	57	37.25%
HF	Provide reference resources	2	0.83%	7	4.49%	12	7.84%
OT	Engage in unrelated discussions	1	0.41%	0	0%	1	0.65%
RE	Respond to the questioner	1	0.41%	1	0.64%	0	0%
RF	Respondent offering positive reinforcement to the speaker	13	5.37%	8	5.13%	8	5.23%
CQ	Respondent engaging in discussion with the speaker and staying focused	13	5.37%	3	1.92%	1	0.65%
DF	Respondent providing supplementary explanations	11	4.55%	28	17.95%	5	3.27%
SF	Respondent offering suggestions	9	3.72%	1	0.64%	4	2.61%
TH	Respondent engages in unrelated discussions	1	0.41%	2	1.28%	0	0%
	Aggregation	242	100.00%	156	100.00%	153	100.00%

4.2 Frequency of online discussion behaviours in the three-phase cycle

This study analyses learning behaviours through a three-phase discussion, and categorised coding schemes into speaker behaviour patterns and responder behaviour patterns. Each phase was examined by two coders. The consistency level (Kappa value) was achieved in all three phases and the results of the sequence analysis are presented in below. Phase 1 of self-regulated learning, Kappa value: 0.67 A sequential analysis of self-regulated learning in asynchronous online discussions revealed significant relationships between various coding schemes across three phases. Z-scores were calculated to quantify the strength and direction of these relationships. Key findings include: Phase 1: Strong positive correlations between certain coding schemes, indicating a robust association between specific learning behaviors. Phase 2: Moderate inter-rater agreement (Kappa value: 0.72). Phase 3: Consistent findings with significant correlations between coding schemes, further emphasizing the interconnectedness of learning behaviors. A perfect inter-rater agreement (Kappa value: 1.0) was observed in this phase.

4.3 Decline phenomenon in different stages of online discussions within the three-phase cycle of self-regulated learning

Throughout the three phases of self-regulated learning, learners consistently summarized video key points and expressed their ideas, but engagement between speakers and responders declined over time. Positive reinforcement (RF) played a crucial role in maintaining discussion quality during prolonged online discussions. Identified Behavior Loops as below, First Loop: Focus on speaker's points (CQ) → Suggestions (SF) → Expressing views (PO) → Responding to the questioner (RE) → Positive reinforcement (RF) → Supplementary explanations (DF) → Return to CQ. Second Loop: Similar to the first loop, emphasizing feedback and critical thinking. Third Loop: When discussions deviate (TH), RF and DF help refocus the topic. Fourth Loop: SF, PO, RE, and RF cycles maintain discussion flow.
The first two loops emphasize the responder's role in stimulating discussion and critical thinking. The third loop highlights the importance of teachers in guiding discussions back on track when they deviate. The study recommends that teachers actively correct the direction of discussions to maintain their quality.

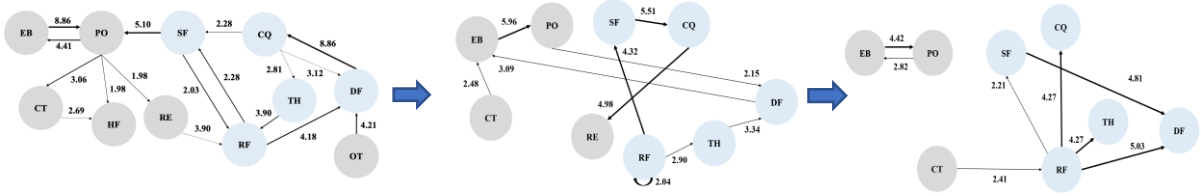

Figure 3. Behaviour transition diagram for asynchronous online discussions in the phase 1 to phase 2 to phase 3

The phase 2 of Figure 3 illustrates a key behavior loop: Supplementary explanations (DF) → Summarizing key points (EB) → Expressing views (PO), then returning to supplementation. This loop deepens knowledge and maintains engagement with the discussion topic. The loop typically starts with summarizing key points (EB), and posing questions (CT) can further stimulate this behavior. The study suggests that instructors pose questions during online discussions to prevent a rapid decline in engagement.

The phase 3 of Figure 3 shows that the main behavior loop is Summarization of key points (EB) ⇆ Expressing views (PO). This simple loop, similar to the first phase, may limit discussion to lower-level thinking without deeper exploration. Positive rei3nforcement (RF) plays a crucial role in initiating and maintaining engagement, especially in long-term discussions. Positive encouragement increases learners' willingness to participate, especially when they feel fatigued or unmotivated, helping to sustain the depth of discussion. It is recommended that instructors use positive reinforcement and supportive language alongside questioning to consistently engage learners. This approach aligns with self-determination theory, which emphasizes the importance of autonomy, competence, and relatedness for intrinsic motivation. Positive feedback enhances these aspects, motivating learners to expand discussions and improve interaction quality, thereby maintaining engagement and satisfaction.

5. Discussion and conclusion

Significant behavioral differences were observed across phases, with active engagement in early phases declining in the third phase, highlighting the need for strategies to sustain interaction. Sequential behavior analysis emphasizes the importance of timely guidance and positive reinforcement, especially in prolonged discussions. This study provides insights into learners' behavior patterns during three-phase self-regulated learning cycles, showing that active engagement and critical thinking in the first two phases give way to declining participation in the third phase, where interaction often reduces to summarizing key points and expressing personal opinions. This suggests that prolonged online discussions can diminish

learner engagement and enthusiasm. To address this, effective online learning activities should be tailored and continuously improved to stimulate intrinsic and extrinsic motivation, as noted by Zhou & Zhang (2024). Teachers are advised to use positive encouragement and supportive language to enhance learner autonomy and motivation. Additionally, timely intervention is crucial when discussions deviate from the main theme to maintain quality and continuity. In conclusion, maintaining participation and discussion quality requires real-time guidance and active encouragement strategies, which can enhance learner motivation, deepen participation, and ultimately improve overall learning outcomes.

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