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ARCHIE: EFL Learning Processes in Chatbot-Supported Active Reading using Transition Network Analysis

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Abstract: This study explores EFL learners' interaction patterns in chatbot-supported active reading. Although previous work has investigated learner behaviour while reading, little is known about their interactions with a chatbot while reading. Using Transition Network Analysis (TNA) to analyse combined log data from learners using a chatbot and e-reader, this research reveals engagement patterns with both tools, characterised by frequent and varied transitions between actions. The findings show learner behaviours such as sustained chatbot interaction, active text engagement (e.g., highlighting, memos), and the chatbot's role in re-engaging off-task learners. TNA effectively models these interaction sequences, providing insights for designing more effective AI-supported language learning tools.

Keywords: chatbots, e-readers, EFL, active reading, transition network analysis

1. Introduction and Related work

Reading is fundamental for language learning, as it exposes learners to meaningful vocabulary, grammar, and formulaic phrases at their own pace (Pigada & Schmitt, 2006). Effective language learning requires more than just passive decoding; active engagement with the text is required (Duke & Cartwright, 2021). Active reading, characterised by strategies like questioning, summarising, predicting, and making connections with self, others, and the world, has been consistently linked with improved comprehension (Yapp et al., 2021). However, active reading often requires explicit instruction and scaffolding. EFL learners especially, who may struggle with bottom-up processing (e.g., decoding letters), can benefit from learning and utilising active reading strategies to support their top down comprehension (Yang et al., 2019).

Chatbots can be useful and effective for providing interactive, non-judgemental, personalised, immediate feedback and support to learners across educational contexts (Deng & Yu, 2023; Wollny et al., 2021). In EFL learning, chatbots have demonstrated efficacy in significantly improving writing, grammar, and vocabulary skills (Wu & Li, 2024). Chatbots can also make learning exciting, encourage engagement, and simulate interactive learning (Mohamed & Alian, 2023). While the benefits of chatbots in language learning are recognised, research examining how learners interact with these systems and how these interactions relate to learning outcomes is still required. Understanding the decisions made by learners and learning processes that occur during chatbot-supported activities is crucial for designing more effective educational experiences.

Network analysis is a powerful tool for analysing and understanding complex relational systems and the patterns of connections within them. In the customer service context, Akhtar et al. (2019) analysed chatbot conversations using network analysis to model user-chatbot interactions as event sequences, revealing that ineffective responses could be identified by nodes with low in-degree centrality (i.e. few sequences lead to these nodes). Their findings demonstrated that network representations of temporal transitions could uncover actionable patterns in human-AI dialogue—a methodological insight directly applicable to educational chatbots. Epistemic Network Analysis (ENA) has been utilised to understand learner behaviours with a chatbot (Woollaston et al., 2025). However, ENA has difficulty fully capturing the temporal nature of learning processes. ENA primarily focuses on

the co-occurrence of elements within a defined timeframe, failing to adequately model the probabilistic directed transitions between behaviours, and limiting its ability to reveal the sequential patterns that underpin effective learning. Given these limitations, Transition Network Analysis (TNA) offers a framework to capture the dynamic, sequential nature of learner interactions, allowing for a deeper understanding of the transitions between behaviours. This study explores the following research questions:

1. What are the common transition patterns of learners with an active reading chatbot?
2. What are the common transition patterns of reading behaviours exhibited by learners in an e-reader?

2. Methodology

The dataset analysed in this study, originally introduced by Woollaston et al. (2025), was collected from 238 students (aged 15-16) attending a high-performing Japanese high school. These students participated for approximately three weeks, beginning July 31, 2024. Students were instructed to read at least six of the provided texts, and try each Archie activity (e.g., comprehension questions) at least once over the summer vacation. Three students opted-out and were excluded from the analysis. The study incorporated 18 informational texts, sourced from past national university admission examinations. These texts averaged 575 words in length and were assessed at a CEFR B1-B2 level.

3.3 System and Task Overview

Archie chatbot and Bookroll e-reader: Archie, a chatbot powered by `Gemini-1.5-Pro-001`, facilitated active reading with twelve activities (e.g., cloze, summarisation, roleplay). For each session, learners could access the readings and the chatbot from their LMS course webpage. To begin, Archie would confirm the learner had read the text, followed by activity questions, feedback, and guidance to encourage deeper engagement with the texts. Bookroll, an interactive e-reading app (learners had previously used) recorded learners' actions like navigation, highlighting, and memo creation.

3.4 Data Preparation and Analysis

Log Data: 17.5k learner messages sent to Archie were classified into five categories: `interactionControl`, `provideAnswer`, `askSeekHelp`, `offTask`, and `otherChat`. Classification was performed using `Llama3.1:70b` (Grattafiori et al., 2024). Two researchers assessed a random sample of 200 classifications: 88% were considered accurate with an interrater reliability of Cohen's $\kappa = 0.95$, indicating excellent agreement. Bookroll actions were categorised: `nextPage`, `prevPage`, `otherNavigation` (e.g., `pageJump`), `memo` writing, and highlighting (e.g., `markDifficult`, `markImportant`). Remaining Bookroll actions (e.g., Bookroll quizzes) were excluded from the analysis. Each session began with `startSession` and ended with `endSession`.

TNA is a novel framework to model, visualise, and analyse directed temporal patterns and relations in the learning process (Saqr, López-Pernas, Törmänen, et al., 2025). Behaviour sequences are modeled as probabilistic Markov chains. We utilised the TNA R package (López-Pernas et al., 2024). Data was formatted as long data, with each session as a unique actor. To see the learner behaviours for each system in more detail, actions taken within the Archie chatbot were aggregated into a single category, labelled `archieChat` when examining the network of learner behaviour on the Bookroll e-reader system, and vice versa. Edges with probabilities less than 0.1 were pruned to highlight more common transitions in the networks (Saqr, López-Pernas, & Tikka, 2025).

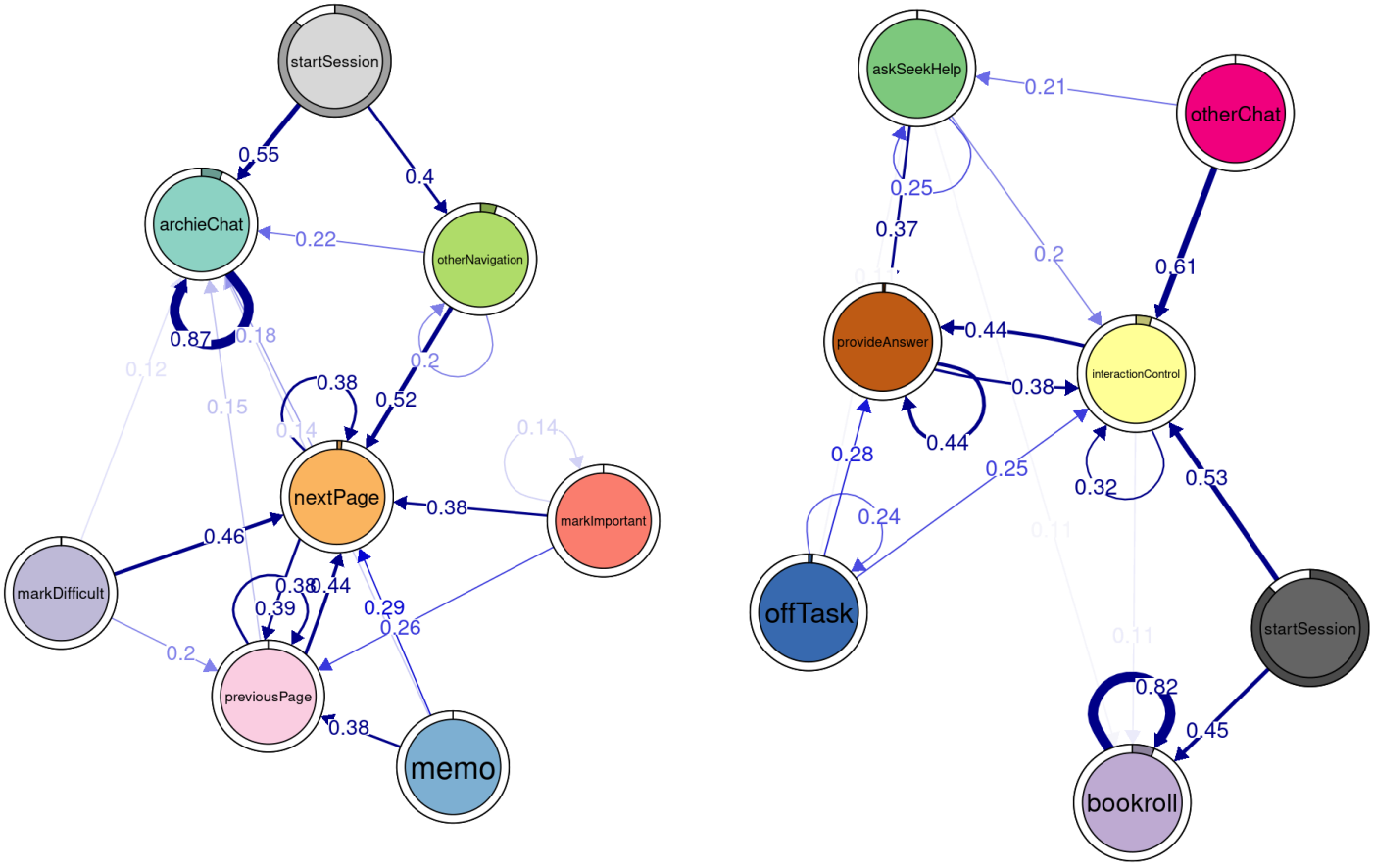
3. Results

Table 1 shows the summary metrics for each transition network created. The networks have

very high density; Bookroll actions being the most densely connected. This suggests that learners tended to move between a large proportion of the available behaviours. Reciprocity–the proportion of edges that are reciprocated (if there is an edge from node A to B, there is also an edge from B to A)–is also high for all networks, indicating a lot of back-and-forth movement between behaviours.

Table 1. *Summary metrics for Bookroll, Archie, and combined transition networks*

Metric	Bookroll	Archie	Combined Actions
Node Count	9	8	13
Edge Count	62	45	124
Network Density	0.86	0.8	0.79
Reciprocity	0.76	0.75	0.79



Bookroll Transition Network (A) Archie Chatbot Transition Network (B)

Figure 1. Pruned Transition Networks (min value = 0.1)

4.1 Bookroll E-reader Transitions

Figure 1 (A) shows the transition network for Bookroll (all Archie interactions collapsed into the `archieChat` node). Notably, learners often started their reading sessions by chatting with Archie rather than reading the text. Looking at the most likely transitions:

- `archieChat` → `archieChat` (0.87): Chatbot interactions highly likely to continue.
- `otherNavigation` → `nextPage` (0.52): General navigation actions were most often followed by moving to the next page
- `markDifficult`, `markImportant` → `nextPage` (0.46, 0.38): Learners who marked

text as difficult or important were highly likely to proceed to the next page.
- `previousPage` → `nextPage` (0.44) and `nextPage` → `previousPage` (0.39): suggests a back-and-forth reading pattern
- `memo` → `previousPage`, `nextPage` (0.38, 0.29): After creating a memo, learners were likely to return to the previous page or go to the next page.

4.2 Archie Chatbot Transitions

Conversely, Figure 1 (B) illustrates the Archie chatbot's transition network, with Bookroll data collapsed into a `bookroll` node.

- `bookroll` → `bookroll` (0.82): Indicates sustained engagement with the text
- `startSession` → `interactionControl` (0.53): At the start of a session, learners greeted Archie to start the session
- `provideAnswer` → `provideAnswer` (0.44): Learners frequently continued answering questions without switching to other actions, indicating sustained engagement
- `interactionControl` → `provideAnswer`, `interactionControl` (0.44, 0.32): Learners engaged with the chatbot's learning activities
- `offTask` → `provideAnswer`, `interactionControl` (0.28, 0.25): Learners who were off-task (e.g., sending messages unrelated to the task) were moderately likely to return to providing answers or normal interaction, suggesting that the chatbot helped re-engage them in the activities.

4. Discussion

This study employed TNA to examine the interaction patterns of EFL learners using Archie and Bookroll during active reading sessions. The findings reveal distinct behavioural sequences, providing insights into how learners engage with these tools together.

The transition networks showed high density, indicating that learners frequently switched between various actions. Sessions often began with interactions with Archie rather than reading the text first, suggesting that learners were motivated to use the chatbot—possibly preferring active interaction over passive reading (Mohamed & Alian, 2023). While using Bookroll, learners frequently navigated back-and-forth, highlighted text they found important or difficult, and wrote memos. These behaviours suggest active engagement with the text, involving processing and meaning-making beyond simple reading. In the Archie chatbot, sustained engagement was evident, with learners often continuing to provide answers (`provideAnswer` → `provideAnswer`) or navigating the chatbot's interface (`interactionControl` → `provideAnswer`). Notably, off-task behaviour (`offTask`) was sometimes followed by a return to task-related interactions, suggesting that the chatbot effectively re-engaged learners. The high reciprocity in both networks implies that learners frequently alternated between related actions rather than progressing in a fixed sequence.

This research contributes to the growing body of work on AI-supported language learning. To the author's knowledge, this is the first TNA analysis of chatbot and e-reader interactions together. The networks and related centrality metrics also highlight the nature of learner engagement, where learners frequently switch between reading and chatbot interactions rather than following a fixed linear process (Woollaston et al., 2025).

While the findings offer valuable insights into learner interaction patterns, the study has several limitations. These include the specificity of the task and sample, the focus solely on learner behaviours (excluding chatbot responses), and the coarse granularity of e-reader data (limited to page level). Future research could expand the scope by including more diverse tasks and participant groups, incorporating chatbot response analysis, and comparing learners across variables like English proficiency. Additionally, applying significance testing to transitions could help identify key interaction patterns. Further, the tendency to remain within either Archie or Bookroll rather than switching between apps may be attributed to the system design, momentum, perceived learning, or some other factor.

This study explored EFL learners' interaction patterns during chatbot-supported

active reading using TNA. The findings demonstrate that learners engaged dynamically with both the Archie chatbot and the Bookroll e-reader, frequently transitioning between actions rather than following linear pathways. High network density and reciprocity suggest flexible, back-and-forth engagement, while specific transitions revealed sustained interaction and re-engagement facilitated by the chatbot. By modeling these sequences, TNA offers a valuable lens for understanding learning processes in AI-supported reading contexts. These insights can inform the design of more responsive and effective educational tools that scaffold active reading and language development.

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