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Principle-Driven Micro-Script Generation for Informal Collaborative Learning on Discussion Boards

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Abstract

This paper introduces Principle-Driven Micro-Script Generation (PDMSG), a method that leverages large language models (LLMs) to dynamically generate context-aware collaboration micro-scripts for informal learning communities. PDMSG combines four inputs—(1) activity goals, (2) community constraints, (3) learning principles, and (4) recent discussion-board logs—into a single prompt for the LLMs, which return concise next-step recommendations for each participant. A pilot in the BookClub community demonstrated that PDMSG yields context-relevant, actionable suggestions, indicating its promise for informal collaborative learning. Future work will refine delivery interfaces and empirically evaluate learning outcomes.

Keywords: Collaboration Scripts, Informal Learning, Knowledge Building, Large Language Models.

1 Introduction

Integrating collaborative learning into formal courses is now commonplace. Nevertheless, simply grouping learners rarely yields the intended collaboration [1]. To tackle this problem, researchers have developed diverse support methods [2]. A prominent approach is the use of collaboration scripts, which pre-structure learning activities to steer learner interactions [3].

Pre-structuring is not always practical, especially in informal collaborative learning. Formal learning generally occurs within institutional settings such as schools, where objectives, schedules, and cohort structures are prescribed [4]. In informal contexts, these institutional constraints are largely absent, and participation is voluntary. As a result, learning goals, group composition, and available time can shift unpredictably, making it difficult to design collaboration scripts in advance.

When collaboration occurs asynchronously, constraints loosen even further and effective support becomes more challenging. In a discussion-board–based informal learning setting, Kondo [5] introduced a group-awareness intervention that visualized participation cues. Although the intervention increased posting frequency, it did not demonstrably deepen learning. This suggests that exposing participation information alone is insufficient; interventions must respect learner agency and focus on fostering depth of learning, not merely activity volume.

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Building on insights from collaboration-script research, we are investigating a framework that employs Generative AI to dynamically craft brief scripts that support collaborative learning in informal settings. The approach feeds large language models (LLMs) with machine-readable representations of theory-driven principles and the community's most recent activity logs; the LLMs then produce short sentences for learners. This pipeline enables the model to bridge the gap between abstract pedagogical principles and community-specific actions, enabling facilitators to obtain theory-aligned and context-adaptive interventions without manually authoring scripts. A preliminary study indicated that the automatically generated sentences were promising for learners [6].

This paper formalizes the generation principles, derives design guidelines, and identifies open questions for future empirical verification.

2 Collaboration Scripts in Informal Learning

2.1 Collaboration Scripts

In this paper, collaboration scripts are broadly defined as mechanisms that pre-structure learning activities—specifying member roles, sequences, and procedures—and guide subsequent interactions within that framework [7]. For example, when a formal course adopts group work, assigning roles such as questioner and summarizer has been shown to stimulate interaction and deepen understanding [8]. Building on such work, adaptive collaboration scripts have been widely studied [9]. In adaptive scripts, a facilitator dynamically delivers script prompts in response to learners' actions. The global task structure remains fixed, but pre-authored support sentences are switched on or off to match the emerging situation.

Not all collaboration scripts pre-structure an activity from start to finish. Some operate at a finer grain, offering moment-to-moment cues that tell learners what to do next; these are classified as micro-scripts [10]. By contrast, broader activity-wide frameworks are commonly referred to as macro-scripts.

2.2 Difficulties in Implementing Collaboration Scripts in Informal Learning

In informal settings—where learning goals, participant composition, and time frames all fluctuate—applying either macro- or micro-level collaboration scripts is difficult. Topics may shift during an activity, and member dropout or late entry is common, so role constellations and interaction patterns seldom stabilize; interventions become ad hoc. Existing scripts assume a designer-delimited script space and therefore do not transfer directly to informal contexts [11]. Although some studies dynamically select prompts from a predefined pool [12], their flexibility remains limited. Consequently, informal environments require a dynamic, generative approach that can create and adjust micro-level collaboration scripts on the fly to match evolving situations.

3 Research Target

As an illustrative case of an informal community that sustains collaborative learning, this study examines BookClub—an initiative we have facilitated (see [13])—and discusses methods for supporting it.

3.1 Objectives and Background of BookClub

BookClub invites members to read a book together and then discuss its content as a whole group. The activity is informal and voluntary: anyone may join regardless of residence, occupation, or age, and the community blends synchronous video-conference meetings with asynchronous discussion-board exchanges.

The primary aim is for each participant to deepen learning and broaden intellectual horizons through peer-to-peer dialogue on self-selected topics. Desired changes include realizing the limits of one's current understanding as comprehension deepens, or discovering how one's interests intersect with those of others as the scope of inquiry expands. Consequently, BookClub sets no predefined performance goals—neither knowledge-based nor skill-based—for its members.

3.2 Overview of BookClub

As of April 2025, the community has been active for more than four years; the longest-standing members have participated continuously for roughly eight years, counting a predecessor initiative [14]. BookClub currently has seven members: three graduate students, three working professionals, and the author-facilitator.

Activity unfolds in two complementary forms. First, members meet weekly in a video-conference session to discuss the book in progress; the designated pair for that cycle presents the content and prepares materials in real time. Second, members post to an asynchronous discussion board whenever they wish, extending meeting topics, introducing related issues, or reporting individual progress.

During a scheduled presentation, the responsible pair has about one hour to introduce the book and lead the ensuing discussion; further procedural details are provided in the next subsection.

3.3 Activity Flow in BookClub

A season lasts roughly four months, so the community completes about three seasons per year. Within each season, activity unfolds as follows.

1) ***Create working pairs.*** *Members create working pairs at the start of the season.*
2) ***Select a book and set the date.*** *Each pair chooses a book that matches their interests and sets a presentation date. If selection proves difficult, the facilitator may suggest titles or adjust the schedule.*
3) ***Prepare (about two months).*** *Pairs draw up their own schedules, arrange additional meetings outside the weekly session, and prepare for the presentation. They are accountable for presenting on the agreed date, although postponement is possible if additional time is needed.*
4) ***Refine work continuously.*** *During the preparation period, pairs report progress and related issues in the weekly online meeting, refining their work through discussion with the other pairs.*
5) ***Present and discuss.*** *On the scheduled date, the presenting pair introduces topics drawn from their book and moderates a whole-group discussion. The exchange is expected to surface points that were insufficiently explained or that merit deeper exploration.*
6) ***Reflect together.*** *In the following weekly meeting, the group spends about 30 minutes reflecting on the preceding discussion.*
7) ***Hold an intermission.*** *After all pairs have completed their presentations and reflections, the community observes an intermission of roughly one month. Members share how their interests*

or ideas have evolved and engage in any activities they consider necessary—such as searching for the next book—before the new season begins.

Each year, every member presents roughly three books and attends presentations on about six others. This estimate does not imply that members read only those books: during the preparation phase they often skim or fully read additional titles while searching for a focus, and the interests sparked in BookClub frequently lead them to pursue further reading on their own.

The entire workflow has evolved through ongoing facilitator–member interaction, drawing on the principles of Knowledge Building (KB) [15]. The facilitator therefore sometimes describes BookClub's purpose as "cultivating a taste for Knowledge Building." Its design aligns with key KB beliefs—for example, that learners can "learn more by building knowledge together" and that "learning is open-ended."

Members advance the community's knowledge by reading books and repeatedly preparing presentations, and the discussion records are archived for collective reference, further supporting communal progress. At the same time, individuals deepen their own understanding by acquiring new information from books, pairs, and peers, adding ideas to the discourse, and engaging in dialogue. Because members intentionally and repeatedly participate in these processes, the BookClub practice can be interpreted as an instantiation of KB.

3.4 Discussion-Board System to Support BookClub

Members share a private, thread-based discussion-board system that only they can access; the facilitator introduced it as an asynchronous counterpart to the weekly video-conferences. On this board, participants are expected to: (i) exchange materials while preparing their pair presentations; (ii) post questions and comments about other pairs' presentations; (iii) raise topics related to the books under discussion; and (iv) share personal experiences or relevant news items and debate them with the group.

4 Proposed Method

We propose Principle-Driven Micro-Script Generation (PDMSG), a method that automatically creates collaboration micro-scripts from members' activity histories. Scripts generated in this way are termed generative collaboration micro-scripts (hereafter "scripts"). PDMSG comprises four sequential steps, and the guiding principles that govern the processing required at each step are explained in the subsections that follow.

4.1 Step 1: Describe Intended Activities

The first step is to articulate the activities we want members to undertake. Stating the practice's goals—as well as the kinds of interactions that should therefore unfold—helps the LLM generate scripts that align with actual conditions.

Any constraints on individual members must also be spelled out. For example, Working-adult members have tight schedules, so lighter tasks are needed to keep them engaged.

Crucially, the learning theories and design principles that underpin the practice are embedded as a fixed frame. If the model receives only a vague prompt—"Generate scripts that stimulate ac-

tivity"—it will tend to return generic advice such as "Share information actively with others." By explicitly supplying the theoretical foundation, PDMSG directs the LLM beyond such boilerplate toward scripts that are genuinely appropriate to the community's context.

4.2 Step 2: Extract and Process Activity Logs

The second step is to retrieve what members have actually done in the past. Raw discussion-board posts (and, if available, meeting transcripts) are parsed and converted into a compact, machine-readable format, typically a CSV table, so that they can be supplied to the LLM as part of the prompt.

4.3 Step 3: Combine Step 1 and 2 into a Single LLM Prompt

The third step combines the descriptions produced in Steps 1(Section 4.1) and 2(Section 4.2) into one consolidated prompt for the LLM. In the BookClub case, we experimented with a four-slot prompt structure (Figure 1): Slots 1–3 contain the elements from Steps 1, whereas Slot 4 holds the processed activity log from Steps 2.

1) ***Purpose and instruction.*** *This slot states the community's overarching goal and explicitly instructs the LLM to propose actions for the* next week. *The instruction directs the model to consult the accompanying* Activity Log *and* Learning Principles *before formulating recommendations.*
2) ***Constraints.*** *This slot lists the conditions that must be respected when generating scripts—for example, the fact that nearly all members are geographically dispersed and can interact only via the network. It also specifies stylistic requirements, such as the tone to adopt when addressing each member.*
3) ***Learning principles.*** *Because BookClub is interpreted as a KB community, the prompt includes the field-standard twelve design principles for KB learning environments [15] verbatim.*
4) ***Activity log.*** *This slot embeds the community's recent history. For BookClub, we exported discussion-board data from the database and converted it to CSV, tagging each record as read, new post, or reply, and adding the timestamp, user name, and, when applicable, the post content.*

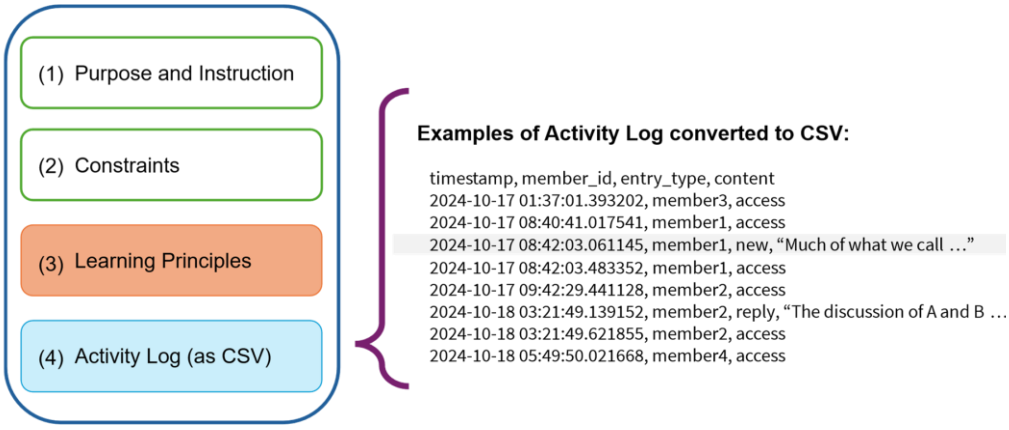

Figure 1: Four-slot principle-driven prompt structure and example CSV log (schema row + sample rows) used as the LLM input. The header row shows the schema (*timestamp, member_id, entry_type, content*); the gray-highlighted row illustrates how a *new* post is encoded.

4.4 Step 4: Generate Micro-scripts with the LLM

The consolidated prompt is fed to the LLM. Drawing on all embedded information, the LLM outputs a set of scripts that encourage each member to engage in appropriate activities during the coming week.

5 Sample Output of the Proposed Method

A prompt was constructed from two months of discussion-board activity in BookClub and supplied to the LLM; the resulting prompt file totaled roughly 170 kB of plain text. Table 1 presents translated excerpts from the LLM's output [6]. All processing was conducted with the informed consent of every member.

The LLM's output was not a set of generic "do more collaboration" tips; it consistently framed its advice as knowledge-building activities. For instance, the scripts addressed individual members by name, proposed concrete ways to engage—rather than merely urging them to post—and invited them to augment ongoing threads with new information or perspectives. Such moves match the actions valued in Knowledge Building. These results suggest that, even in a low-constraint, voluntary setting like BookClub, the proposed method can generate scripts that steer learners toward the kinds of activity regarded as desirable for collaborative knowledge advancement.

Table 1: Results of Generated Collaboration Scripts†

Member	Generated Collaboration Scripts
A	Thank you, as always, for contributing such multifaceted perspectives. During the coming week, choose one of the research themes or theories we have recently discussed and skim some sources or papers that the other members may not have seen. Then write a short memo that shares your own questions or points of interest and post it for everyone!
B	Thank you for your ongoing information gathering—it really energizes the group. Over the next week, could you revisit some of the points raised by other members and post brief follow-up comments or relevant links? Even the smallest questions are more than welcome!
C	Your timely insights at key moments are always invaluable—thank you. Over the coming week, whenever you have time, try taking one of the questions or hypotheses raised by other members and re-imagining how it might play out in practice. Then share a brief comment reflecting that practical perspective.
D	Thank you, as always, for your thoughtful feedback and concise summaries. Over the next week, would you share—briefly and in your own words—which parts of a recent idea or reading resonated with your personal experience or practice?
E	Thank you for always presenting such interesting topics and resources in a clear way. In the coming week, if the board gets a bit quiet, try posting a short question to spark discussion—even a small one is perfectly fine!
F	Thank you for always sharing your status with the group. Even though your schedule often conflicts, when you have a free moment this week, choose one thing you've been wondering about—or a point you didn't fully grasp in another member's post—and ask it openly!

† Excerpted, edited, and translated from [6] (LLM output for BookClub)

6 Limitations and Future Work

Although the preliminary results are encouraging, how to deliver the generated scripts remains unresolved. Depending on the delivery channel, the intervention could become intrusive and undermine learner agency; identifying a presentation method that supports engagement without diminishing agency is therefore a critical next step.

Second, the degree to which each script aligns with the twelve KB principles has not yet been assessed objectively. We plan an expert-rating study to evaluate principle–script fit.

Finally, the practical impact of PDMSG has not been tested in a live setting. A field deployment in the BookClub community is scheduled to examine whether the scripts actually stimulate the intended activities and to document any broader effects on participation and learning.

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