

# Examining Elementary Mathematics Teachers' Behaviors and Learning with an Online Professional Development Platform

HaeJin Lee<sup>1</sup>, Tiffany Reyes<sup>1</sup>, Sarah Burns<sup>2</sup>, Meg Bates<sup>3</sup>, Cheryl Moran<sup>2</sup>, Joseph Cimpian<sup>4</sup>, Hana Kearfott<sup>1</sup>, George Vythoulkas<sup>2</sup>, Michelle Perry<sup>1</sup>, & Nigel Bosch<sup>1</sup>

<sup>1</sup>University of Illinois Urbana–Champaign, <sup>2</sup>University of Chicago, <sup>3</sup>University of Illinois System, <sup>4</sup>New York University

## Abstract

In this project, we explore different ways **elementary school teachers** participate in **online learning** on the *Everyday Mathematics* Virtual Learning Community (VLC), a platform that includes videos, discussions, and other resources for mathematics teaching. Using this large-scale VLC for elementary teachers, we address which **common patterns** of teacher **online behavior sequences** can be identified through log data, and we examine how these patterns are associated with **teacher characteristics** (i.e., years in teaching mathematics and feelings about teaching mathematics).

## Research Questions

- RQ1. Which common patterns of teacher interaction sequences can be identified through log data? How are these patterns associated with teacher characteristics (i.e., years in teaching mathematics and feelings about teaching mathematics)?
- RQ2. How do different representations of teacher interaction patterns (specifically, simple behavior-based features versus sequence-based features) predict teacher engagement indicators, and how are these patterns associated with types of users?

## Background

- Improving learning of fundamental mathematics in young children (Ma, 2010) is a crucial concern. Accomplishing this depends not only on effective classroom instruction but also on how **teachers learn and engage in professional learning**. With the COVID-19 pandemic shifting many teacher learning opportunities online and enhancing teachers' adeptness in accessing online resources, it has become increasingly important to examine how elementary teachers leverage these online platforms to improve their mathematics teaching.
- Online professional development (PD) platforms offer opportunities for professional growth, allowing teachers to explore teaching resources and engage in discussions with other teachers (Dede et al., 2009; Holmes, 2013). Recent studies demonstrated the **effectiveness** of these professional learning platforms in promoting teacher development, leading to improvements in teaching practices (Bragg et al., 2021; Philipsen, 2019; Wong et al., 2023).

However, **teachers face significant challenges** in **accessing** and effectively **utilizing supports** within these environments.

While online professional learning environments can be helpful for teachers, actual engagement is often **low and shallow** (Chen et al., 2023).

Although previous studies have offered valuable insights into teacher engagement on online PD platforms, translating these insights into the **design and development of effective interventions** remains a key challenge. Motivated by this gap—and with the aim of identifying where teachers engage and where they fall off from interacting successfully with online PD—we employed a **data-driven** approach to identify **frequent interaction sequences**—that is, how teachers navigate an online PD platform.

## Method

We collected anonymous data from VLC users including records of their **observable behaviors** on the site (i.e., which pages and features they accessed) and **user-level information** they entered in their profiles (e.g., race/ethnicity). Data were analyzed from August 1, 2023, through May 31, 2024, so that the data would represent a typical school year. A total of **N = 2,546** users interacted with the VLC during that time—not including VLC staff or members of the research team, whose data were excluded.

## Participants

**Role.** Users were primarily teachers (77.8%). Other roles were instructional coaches (6.7%), special education teachers (4.1%), mathematics specialists (3.3%), school administrators (2.2%), or curriculum coordinators (2.2%), with all others under 2%.

**Time teaching.** Users reported their time teaching (i.e., years of teaching experience) by selecting from an ordinal response scale: 16+ years (40.7%), 11–15 years (17.6%), 6–10 years (18.0%), 2–5 years (15.6%), 1 year (or less than 1 year) (6.1%), and 0 years (2.0%). We encoded these, and the following self-reported measures, on a [0, 1, ...] ordinal scale for analyses.

**Time teaching EMC.** 16+ years (5.5%), 11–15 years (8.6%), 6–10 years (15.3%), 2–5 years (23.3%), 1 year (or less than 1 year) (20.6%), and 0 years (26.7%). This may suggest that teachers visited the site initially to learn about their new curriculum materials rather than to learn about mathematics teaching, per se.

**Feelings about teaching mathematics.** Most users reported “I always enjoy teaching mathematics” (52.4%), with some selecting “I usually enjoy teaching mathematics” (43.7%) or “I rarely enjoy teaching mathematics” (3.9%).

## Data processing and simple behavior-based feature extraction

Behavioral data consists of timestamped records of every page visit, with page URLs hierarchically organized into sections and subsections of functionality and content. We extracted the topmost level of each URL (e.g., “/resources”) that corresponds to the section of the VLC that users were on and counted occurrences of each of these for each user per month.

To uncover **frequent patterns**, we employed the **constrained Sequential Pattern Discovery** (CSPADE) algorithm (Zaki, 2000; 2001). If the interval between two interaction activities exceeded 30 minutes, we treated this as the end of one session and the start of a new one.

## Teacher engagement indicators

We selected engagement indicators, which included whether the **user returned to the VLC**, whether they performed **many actions per visit**, and **whether they visited any of the following VLC sections**: resources, collections, free PD, paid PD, and topics (discussion fora). 1,229 cases of users returned from one month to the next, and they produced 4,397 engagement indicators.

## Results

### RQ1. Common patterns of teacher interaction sequences

Table 1: Teachers' frequent behavioral sequences with corresponding support values and descriptions

Interaction sequence	Support	Description
resources page → resources download	.436	Teachers accessing the resource page and subsequently downloading material may indicate that they are using the VLC to get instructional resources.
resources download → resources search	.257	After downloading a resource, teachers often search for additional materials. This iterative behavior suggests that teachers are seeking complementary or alternative resources, indicative of a potential information-seeking process.
Main resources page → resources search	.232	Teachers shifting from browsing the resources page to using the search function may imply that teachers are specifically seeking material or content they have in mind. Frequent engagement in this sequence may imply that teachers are employing an information-seeking strategy.
resources download → resources page	.219	When teachers return to the resources page after downloading a resource, it may indicate a reflective process—either comparing available options or reassessing the content's relevance.
resources page → resources search	.203	Moving from browsing the resources page to using the search function suggests a shift from general exploration to targeted search. This behavior potentially indicates that teachers are refining their search to locate more specific resources.
collections → collections	.165	Frequent transitions between collections pages suggest that teachers are reviewing curated sets of resources. These consecutive visits may reflect an iterative evaluation process or a focused interest in exploring thematically organized content.
online-pd → online-pd	.135	Engaging in consecutive free online professional development modules indicates that teachers may actively seek to enhance their professional learning and self-improvement.

- The **collections → collections** sequence showed a significant positive association with time teaching ( $r = .105, p < .001$ ), suggesting that **more experienced teachers are more likely to revisit the collections** consecutively.
- Teachers' **feelings about teaching mathematics** were positively related to going from a **specific resources page to resources download** ( $r = .040, p = .003$ ) and from a specific resources page to a resources search ( $r = .049, p = .011$ ), and negatively related to engaging in consecutive pd modules ( $r = -.039, p = .047$ ).
- This suggests that teachers with more **positive attitudes** toward teaching mathematics are **less likely to engage in the free online-PD modules**, possibly because they feel less need for additional professional development.

### RQ2. Common patterns of teacher interaction sequences

- For many engagement indicators, the best predictor of that engagement indicator was itself in the previous month. There were, however, aspects of the VLC that users appeared to **transition** to rather than simply start at and remain in. Visiting the **topics** area of the VLC was best predicted by visiting or completing a large number of actions in the *groups* area.
- This finding suggests that many users browsed for relevant **discussion forums**, or directly visited a topic highlighted in email updates.

Table 2. Random forest feature importance values for teacher behaviors, averaged over cross-validation folds. Values larger than .05 (i.e., 5% of total importance) are highlighted, values corresponding to prediction of a behavior from its own previous month value are bold, and any predictors with no importance larger than .05 for any pseudo-outcome are faded to gray for conclusion.

Predictor (previous month)	Returned to MTLW	Many actions per visit	Outcome (next month)				Visited resources	Visited topics
			Visited collections	Visited free PD	Visited paid PD	Visited resources		
Many (>M) visits	.300		.000	.001	.000	.000		.000
Many (>M) actions	.084	.084	.023	.008	.002	.015	.017	
Many (>M) actions per visit	.001	.324	.023	.007	.002	.019	.020	
Visited homepage	.040	.080	.023	.005	.001	.019	.020	
Visited collections	.010	.007	.287	.013	.001	.013	.008	
High prop. (>M) actions in collections	.010	.006	.132	.006	.001	.024	.003	
Visited groups	.001	.003	.001	.010	.000	.000	.148	
High prop. (>M) actions in groups	.001	.001	.002	.001	.000	.000	.176	
Visited free PD	.010	.011	.018	.399	.045	.007	.003	
High prop. (>M) actions in free PD	.004	.004	.014	.160	.053	.019	.004	
Visited paid PD	.002	.001	.001	.061	.290	.020	.000	
High prop. (>M) actions in paid PD	.001	.002	.002	.112	.540	.040	.001	
Visited resources	.012	.017	.000	.004	.000	.211	.003	
High prop. (>M) actions in resources	.038	.013	.022	.041	.011	.307	.011	
Visited topics	.000	.000	.002	.000	.001	.001	.116	
High prop. (>M) actions in topics	.000	.001	.000	.004	.002	.002	.066	
Is subscribed to email updates	.072	.042	.074	.006	.001	.015	.073	
Years teaching experience	.064	.040	.076	.022	.004	.055	.043	
Years teaching EMC	.075	.063	.062	.014	.010	.030	.058	
Feelings about teaching math	.055	.010	.000	.014	.001	.012	.000	

## Implications and Future Work

- Teachers use the VLC for distinctive purposes. Some teachers may be missing some of the most helpful aspects of the website.
- We have collected survey data, and are collecting follow-up interviews, to see which groups of teachers access different portions of the website, so we might understand which teachers are finding and which teachers are missing the online support they need.
- We will use these results to build and test interventions to support teacher learning.**

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