Non-users, lurkers, and posters: Profiles of participation and engagement in a large-scale online teacher community

Kim Frumin[a], Christian Fischer[b], Chris Dede[a], Barry Fishman[b], Arthur Eisenkraft[c], Abigail Jurist Levy[d], Ayana McCoy[c], Frances Lawrenz[e], Yueming Jia[d]

[a] Harvard University
[b] University of Michigan
[c] University of Massachusetts at Boston
[d] Education Development Center, Inc.
[e] University of Minnesota

For more information about this paper or project, contact:
Arthur Eisenkraft, arthur.eisenkraft@umb.edu

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Abstract: This empirical study examined teacher self-reported participation (using or not using) and engagement (posting or lurking) in the online Advanced Placement (AP) Teacher Communities (APTC) coinciding with the redesigned AP Biology, Chemistry, and Physics exams and curricula. Prior analyses indicated that APTC participation has positive, direct associations towards teacher practice and students' scores, motivating further exploration. Based on teacher self-reported data, this analysis suggested that significant differences in teacher, teaching, and school characteristics predicted whether a teacher was using or not using the APTC. However, there were not substantive differences in most characteristics between the types of engagement, such as lurking and posting. Insights about teacher learning from online peer communities in this study might generalize to other national shifts in curriculum and assessment, such as the Next Generation Science Standards or Common Core State Standards.

Introduction

This is an empirical study of teacher behavior in a large-scale online teacher learning community. A major redesign of the Advanced Placement (AP) Biology, Chemistry, and Physics examination and course framework was introduced in 2013, 2014, and 2015 respectively, in response to recommendations from the National Research Council (2002). The revised courses emphasize scientific inquiry and reasoning, reduce the emphasis on broad content coverage, and focus on depth of understanding, in alignment with both the National Research Council's *Framework for K-12 Science Education* (2012) and the *Next Generation Science Standards* (NGSS Lead States, 2013). Hundreds of thousands of AP science students and over 16,000 AP teachers must prepare for this high-stakes test emphasizing the inquiry process, real-world applications of scientific principles, and synthesis of complex content knowledge.

To help teachers learn about and implement the revised AP curricula and exams, the College Board and other providers offer a range of professional development (PD) options, from weeklong summer workshops to short face-to-face courses, online self-paced courses, downloadable resources, and online peer-learning communities. In our prior research on the many forms of professional development teachers choose to support their AP teaching (Fishman et al., 2014), participation in the online AP Teacher Community (APTC)--a College Board portal where teachers can discuss teaching strategies, share resources, and connect with each other--had the largest positive, direct, and statistically significant associations with both teacher self-reported practice and student AP scores among all professional development options studied. Given the influence of the APTC in producing positive gains for teachers and students involved in a national, large-scale change in curricula and assessment, it is important to explore types of participation and engagement in this online learning community and the role it might play in supporting teacher learning.

Background and research questions

The AP program is offered by the College Board as a means of introducing rigorous, college-level material to high school students across a broad range of subject areas (College Board, 2015a). The College Board defines curriculum standards for AP courses and offers corresponding examinations that are administered in centralized locations under controlled conditions and graded centrally for quality control and norming. The examinations are scored as whole numbers on a 1 to 5 scale. Students who earn a 3 or higher, at the discretion of their institution of higher education, can use their scores towards college credit, both as a way to reduce the cost of college and as a way to place into advanced courses upon arrival at college. Increasingly, colleges view AP courses and AP exam performance as important information in the admissions process (Geiser & Santelices, 2006). There are no "official" College Board curriculum materials, though in each subject there is a range of well-regarded texts created by third parties, so teachers put together their own curriculum plans that must be reviewed and certified (i.e. audited) by the College Board before the course can officially be listed as "Advanced Placement" on high school transcripts.

The major facets of the AP science redesigned curriculum framework include (a) a refining of key concepts and content into Big Ideas, which encompass core scientific principles, theories, and processes, (b) articulated scientific skills that students should know and be able to do, and (c) student-directed inquiry labs, which provide students with "opportunities to take risks, apply inquiry skills, and direct and monitor their own progress" (College Board, 2015b). In order to assess these new components, the three-hour redesigned AP science examinations consist of a 90-minute section of multiple-choice questions and a 90-minute section of open-ended, free response questions. Both sections evaluate students' understanding of the Big Ideas and the ways in which this understanding can be applied through science practices, such as the use of modeling and/or mathematical processes to explain scientific principles, the manipulation and interpretation of data, and the making of predictions and justification of phenomena (College Board, 2015b).

Prior research on the various forms of professional development for the redesign (e.g. week-long summer workshops, day-long face-to-face courses, online self-paced courses, and online peer-learning communities) indicated that participation in the online APTC had the largest positive, direct, and statistically significant associations with both teacher self-reported practice and student AP scores (Fishman et al., 2014).

The APTC, a College Board portal where teachers can "discuss teaching strategies, share resources, and connect with each other" (College Board, 2015a), initially began as an independent, teacher-created listserv and evolved into a College Board-hosted electronic discussion board approximately 15 years ago. In 2013, the College Board upgraded the APTC experience to a web-based platform, which allows for posting, commenting, and sharing resources within each subject-specific online community. Each subject-specific APTC is comprised of six web pages:

- Landing page or *Home* page, which features the latest *Discussion Board* posts and most recent community activity;
- *Discussions Board* page, which features the online community and allows for subscription to certain discussion threads;
- *Resources* page, which features documents that members have uploaded and shared;
- *Curriculum Framework* page, which features the subject-specific AP Big Ideas and Sciences practices;
- *My Library* page to upload personal resources and bookmark resources that others have posted; and
- *Members* page, which lists all of the APTC members.

Also notable is the *keyword search box*, which is featured prominently at the top right on every APTC web page. Although the APTC is most directly accessed by logging into the web portal [https://apcommunity.collegeboard.org/], there is also an option to receive daily and weekly email digests of all discussions, particular topics and threads that a user wants to follow, or updates when members post new resources and comments (J. Clewley, College Board, personal communication, February 2016).

As of February 2016, the College Board reported that the Biology and Chemistry APTCs had 11,907 and 9,122 unique registered users respectively. However, this number is somewhat deceiving, as only approximately 7.5% and 6.4% of registered users were actively logging into the Biology and Chemistry communities, respectively, on average per week (J. Clewley, College Board, personal communication, February 2016). When disaggregated, these users are comprised of approximately 75% of returning users (those who have previously logged in at least once before) and 25% of new users (those logging in for the first time).

In order to examine teachers' APTC participation and engagement in this online community, a web-based survey was send to all eligible AP science teachers asking about their professional development patterns (including their APTC participation and engagement), as well as other aspects of the AP redesign. Based on teachers' survey responses, we defined the terms non-users, users, lurkers, and posters as follows: APTC *non-users* in this study referred to teachers who indicated on a web-based survey (sent to all AP Biology, Chemistry, and Physics teachers) that they did not participate in the APTC. APTC *users* referred to teachers' who self-identified as participants of the APTC on the same survey. APTC users are further subdivided into lurkers and posters based on follow-up survey questions. *Lurkers* were APTC users who self-reported as never having posted in APTC online forums and never having uploaded any teaching resources. *Posters* were APTC users who self-reported as having posted at least once in an online forum and/or uploaded at least one teaching resource. This paper attempts to answer the following research questions:

1. What patterns, if any, of teacher and school characteristics exist among self-reported APTC users and non-users (no participation in the APTC)?
2. What patterns, if any, of teacher and school characteristics exist among those who post at least once in the online forums (referred to as "posters") versus those who engage without posting (referred to as "lurkers")?

Theoretical framework

Professional development

The ultimate goal of professional development is to improve student learning and achievement (Darling-Hammond et al., 2009; Mundry, Spector, Stiles, & Loucks-Horsley, 1999). An accepted theory of action asserts teacher participation in high-quality professional development activities is associated with advancements in knowledge and skills that shift instructional practices and eventually lead to gains in student achievement (Desimone, 2009; Fishman, Marx, Best, & Tal, 2003; Loucks-Horsley & Matsumoto, 1999). A decade of systematic research has established common design elements constituting high-quality PD: *ongoing, connected to practice, focused on specific academic content, linked to school initiatives, and collaborative* (Borko, Jacobs, & Koellner, 2010; Darling-Hammond, 2009; Banilower, Heck, & Weiss, 2007; Borko, 2004; Desimone, 2009; Garet, Porter, Desimone, Birman, & Yoon, 2001). However, there are not yet studies analyzing characteristics of teachers related to their participation (use vs. non-use) and engagement (posters vs. lurkers) in particular online professional development activities. This study is a first step to close this gap, examining factors influencing the odds of teacher participation and engagement in online peer-learning communities such as the APTC.

Online learning communities

Online learning communities are groups of people who gather in an online space to "learn, interact, and build relationships, and through this process develop a sense of belonging and mutual commitment" (Wenger et al., 2002 in Booth, 2012). Barab, MaKinster, and Scheckler (2003) further defined an online community as "a persistent, sustained social network of individuals who share and develop an overlapping knowledge base, set of beliefs, values, history, and experiences focused on a common practice or mutual enterprise" (p.238). Specifically, online teacher communities potentially allow educators to learn while they are actively applying new ideas in their work settings, to provide and receive sustained coaching and feedback, and to cultivate a reflective collaborative professional community (Dede, 2006).

Profiles of engagement

Online communities typically follow an unbalanced participation model, with the majority of the contributions made by a minority of members (Kraut & Resnick, 2011). Several studies (Arthur, 2006; Katz, 1998; Mason, 1999 as cited in Schneider et al., 2013) noted the *90-9-1 principle*, which states that in collaborative websites, approximately 90% of users read posts, 9% of users comment or add to posts, and 1% generate new content. As a result of varying degrees of engagement, online community members are often categorized as either posters (who make contributions to an online community by commenting on other users' posts or starting new threads of conversation), or lurkers (who visit a community but view posts rather than directly contribute) (Sun, Pei-Luen Rau, & Ma, 2014; Marett & Joshi, 2009; Preece, Nonnecke, & Andrews, 2004). Notably, there are not universally established definitions for lurkers and posters; some examples include: "posters are defined as those who have posted at least one message in the community forum over the past three months, whereas lurkers are those who visit a community without posting any messages" (Lai & Chen, 2014, p. 296), "a lurker [is] someone who has not posted during the last three months" (Nonnecke & Preece, 2000, p. xx), and "[a lurker is] someone who has never posted in the community to which he/she belongs" (Preece et al., 2004, p. 9). The collected self-reported survey data did not allow for accounting of timeframes in the definition of lurkers and posters; therefore, this study will employ the definition of a lurker as someone who self-reported accessing an online discussion at least once, but did not self-report contributing to the online discussion or become “actively involved”.

Although researchers generally agreed on the basic characteristics that define lurkers, some draw attention to the problematic term “lurker,” highlighting its negative connotation and pejorative tone (Wise, Hausknecht, Zhao, 2013; Preece et al., 2004). Some researchers suggested that the term “online listener” is more appropriate to better describe the behavior of non-posters, emphasizing that these users are not passive; instead, they may be actively engaged with the discussion by reading different comment branches and integrating information from multiple users (Wise, Hausknecht, Zhao, 2013). Edelman (2013) described lurkers as active and valid participants, engaging in *legitimate peripheral participation* in *communities of practice* (Lave & Wenger, 1991). Lurkers may even be desirable, since too many posters would overwhelm the forum (Preece et al., 2004). Lurking behavior might also contribute positively to an online community, by allowing users to comprehend the norms of a community before contributing nuanced, thoughtful comments. The most popular reasons lurkers list for their behavior include that their needs were met through observation, they were still learning about the community, and they were shy about posting (Nonnecke et al., 2004).

Retaining active members is crucial for online communities to be successful and last over time. Without new content, current users would lose interest in the community, and it would not be able to attract new members (Kraut & Resnick, 2012; Rheingold, 2012).

Methodology

Data sources

This study mostly employed quantitative methodologies using survey data but also uses qualitative data from case study interviews to illuminate quantitative findings. The quantitative data source was a web-based survey emailed to every eligible AP Biology, Chemistry, and Physics science teacher who did not opt out of College Board communications. The survey asked about professional development participation, attitude towards professional development, teaching background, AP science instruction, school context, and concerns regarding the AP redesign. Additionally, the College Board provided AP examination score data for all students taking these AP science tests, as well as school-level data such as the number of students enrolled in free- or reduced-priced lunch programs.

Qualitative data was gathered through a multiple case study approach (Stake, 1995, 2000) which provides a complement to the survey results by exploring APTC participation and engagement and their relationship to teachers' experiences in preparing and teaching the redesigned AP curriculum. Hour-long telephone interviews were conducted four times with 34 AP science teachers across the United States to capture teachers' perspectives on the AP redesign, professional development participation, and school context. Besides more general questions about the AP redesign, teachers were asked about their APTC use, its role in their adoption of the redesign, and their engagement within the online community.

Population and sample

This study used teacher data from surveys sent to AP Biology, AP Chemistry, and AP Physics teachers in 2014 and 2015 (table 1), as well as interviews with a subset of survey

Table 1: Number of U.S. teachers responding to the survey.

Survey	N	Survey	N	Survey	N
Biology Year 2	2,231	*Chemistry Year 1*	2,271	*Physics Year 1*	1,733
Biology Year 3	2,240	*Chemistry Year 2*	2,038		

respondents. Teachers were included in the sample if they responded to at least one third of all survey questions. Given the staggered rollout of the AP redesign, 2014 was the second year of implementation for AP Biology teachers and the first year for AP Chemistry teachers; the following year, 2015, was the first year of the AP redesign for AP Physics teachers, the second year for AP Chemistry teachers, and the third year for AP Biology teachers.

Table 2: Non-response analysis for schools with teachers responding and not-responding to the web-based survey.

		N	Mean	SD	*t* or *z*	*p*	*d*
Average AP science scores							
Biology Year 2	*Respondents*	2,225	2.948	0.692	-11.98	<0.001	-0.286
	Non-respondents	6,181	2.747	0.703			
Biology Year 3	*Respondents*	2,274	2.938	0.675	-10.12	<0.001	-0.247
	Non-respondents	6,402	2.768	0.694			
Chemistry Year 1	*Respondents*	2,296	2.662	0.863	-13.35	<0.001	-0.358
	Non-respondents	4,079	2.353	0.864			
Chemistry Year 2	*Respondents*	2,043	2.643	0.858	-12.11	<0.001	-0.328
	Non-respondents	4,786	2.364	0.844			
Physics Year 1	*Respondents*	1,322	2.314	0.732	-3.06	<0.01	-0.099
	Non-respondents	3,263	2.241	0.738			
Average PSAT scores							
Biology Year 2	*Respondents*	2,176	164.735	17.887	-7.53	<0.001	-0.188
	Non-respondents	5,996	161.333	18.118			
Biology Year 3	*Respondents*	2,233	163.569	17.493	-6.62	<0.001	-0.163
	Non-respondents	6,214	160.636	18.111			
Chemistry Year 1	*Respondents*	2,269	172.204	17.434	-7.19	<0.001	-0.198
	Non-respondents	3,986	168.623	18.452			
Chemistry Year 2	*Respondents*	2,018	172.349	17.521	-7.14	<0.001	-0.193
	Non-respondents	4,684	168.835	18.556			
Physics Year 1	*Respondents*	1,309	168.045	16.358	-1.94	0.053	-0.063
	Non-respondents	3,215	166.966	17.591			
Enrollment percentage of free- or reduced-priced lunch programs (in %)							
Biology Year 2	*Respondents*	2,168	25.868	24.129	7.02	<0.001	0.176
	Non-respondents	5,981	30.257	25.192			
Biology Year 3	*Respondents*	2,223	28.969	25.535	6.08	<0.001	0.151
	Non-respondents	6,202	32.922	26.341			
Chemistry Year 1	*Respondents*	2,250	24.196	22.952	6.90	<0.001	0.184
	Non-respondents	3,967	28.585	24.294			
Chemistry Year 2	*Respondents*	2,008	26.330	23.825	7.01	<0.001	0.195
	Non-respondents	4,666	31.184	25.368			
Physics Year 1	*Respondents*	1,296	28.575	24.594	3.79	<0.001	0.124
	Non-respondents	3,186	31.687	25.186			

Teachers who responded to the surveys taught in schools with slightly higher average AP scores, slightly higher than average PSAT scores, and slightly lower enrollment percentages in free- or reduced-priced lunch programs compared to schools with no teachers responding to the survey, as indicated by independent t-tests and Mann-Whitney U tests (table 2) using data provided by the College Board.

Case study participants included 24 Biology and 10 Chemistry teachers, who volunteered themselves during the larger survey described above and were selected based on diversity of teaching experience and geographic location (Yin 2014; Stake 1995, 2000) (table 3). The goal of the case studies was to illuminate experiences noted in survey results.

Table 3: Demographics of case study participants

	AP Biology (N=24)	**AP Chemistry (N=10)**	**Total (N=34)**
Teacher gender			
Female	20	7	27
Male	4	3	7
Years of teaching AP science			
0-2 years	5	3	8
3-5 years	5	2	7
6-9 years	8	0	8
10-15 years	1	4	5
16+ years	5	1	6
Geographic representation			
Midwest	6	3	9
Northeast	5	3	8
Pacific	4	2	6
Rocky Mountains	1	0	1
Southeast	6	2	8
Southwest	2	0	2

Analytical methods

Data preparation strategies included missing data imputation with Markov Chain Monte Carlo (MCMC) imputation methods with 150 iterations and 40 imputations, separately for each domain, year, and research question (Cheema, 2014; Graham, 2009). Also, composite teacher and school-level variables were computed based on conceptual consideration, exploratory, and confirmatory factor analysis. Retention of factors was determined through the Guttman-Kaiser criterion and scree plot analysis. The standardized Bartlett factor scores were computed based on normalized oblimin oblique rotation methods (DiStefano, Zhu, & Mindrila, 2009). This led to eight composite variables – teachers' knowledge and experience, self-efficacy, PD inclination, challenges with the AP redesign, enactment of AP practices, enactment of AP curriculum, administrative support, and AP workload (table 4).

Table 4: Description of individual survey questions included for the computation of teacher- and school-level composite variables; ^{C}: Continuous variable, ^{O}: Ordinal variable, $^{\times}$: 5-point Likert scale item, $^{(-)}$: negative scoring coefficient.

Teacher-level composite variables	
Knowledge and experience	(a) Years teaching high school science ^{C}, (b) years teaching AP science ^{C}, (c) number of science teaching-related professional organizations^{C}, (d) number of conference attendances within past three years^{C}, (e) years serving as AP Reader, (f) years serving as AP Consultant ^{C}, (g) time of assignment to teach AP science^{O}
Self-efficacy	(a) Student performance is based my effort$^{\times}$, (b) students get better scores due to effective teaching$^{\times}$, (c) teaching overcomes inadequate students science backgrounds$^{\times}$, (d) extra teaching effort does not change AP scores$^{\times,(-)}$
PD inclination	(a) Importance of PD to instructional performance$^{\times}$, (b) importance of PD to student performance$^{\times}$, (c) effectiveness of self-teaching compared to formal PD participation$^{\times}$, (d) efficacy of PD participation$^{\times}$, (e) enjoyment of participation in face-to-face PD activities$^{\times}$
Challenges with the AP redesign	Challenges with (a) AP science content$^{\times}$, (b) organization of AP science content$^{\times}$, (c) labs$^{\times}$, (d) inquiry labs$^{\times}$, (e) format of questions/problems/exam$^{\times}$, (f) application of science practices$^{\times}$, (g) developing new syllabi$^{\times}$, (h) understanding the "exclusion statements$^{\times}$," (i) designing new student assessments$^{\times}$, (j) using the textbook$^{\times}$, (k) working with new or different textbooks$^{\times}$, (l) pacing of course$^{\times}$, (m) moving students to conceptual understandings of science$^{\times}$
Enactment AP practices	(a) Students work on laboratory investigations$^{\times}$, (b) provide guidance on integrated content questions$^{\times}$, (c) provide guidance on open/free response questions$^{\times}$, (d) students report laboratory findings to another$^{\times}$, (e) students perform inquiry laboratory investigations$^{\times}$ (f) use science practices outside of the classroom$^{\times}$,
Enactment of AP curriculum	(a) Refer to the "Big Ideas" of science$^{\times}$, (b) refer how enduring understandings relate to the "Big Ideas$^{\times}$," (c) refer to the learning objective from the AP curriculum$^{\times}$, (d) refer to the curriculum framework$^{\times}$
School-level composite variables	
AP workload	(a) Number of students across all AP section^{C}, (b) number of AP science sections^{C}, (c) number of preps per week$^{C,(-)}$
Administrative support	(a) Principal understands challenges for AP science students$^{\times}$, (b) principal understands challenges for AP science teachers$^{\times}$, (c) principal supports PD$^{\times}$, (d) lighter teaching load for AP science teachers$^{\times}$, (e) fewer out-of-class responsibilities for AP science teachers$^{\times}$, (f) AP science is given additional funding exclusively for the course$^{\times}$, (g) availability of equipment to perform labs$^{\Diamond}$, (h) availability of expendable (consumable) supplies to perform labs$^{\Diamond}$

In order to answer the research questions, the quantitative data was analyzed using logistic regression analyses to predict the odds for (a) teachers not using the APTC compared to teachers using the APTC, as well as (b) lurkers compared to posters. Qualitative data were analyzed using Atlas.ti software and an iterative process whereby first a sample of transcripts was read and initial codes were generated through an *emic* approach. These codes were then applied, reviewed, refined, and revised. With each round of review, additional transcripts were added to the sample for coding and subsequent analysis. Throughout this process, potential themes emerged and were tested and refined with each round of review and discussion.

Measures

The *dependent variables* used in the logistic regression analyses were dichotomous variables which indicated (a) whether a teacher participated in the APTC or not and (b) whether a teacher was a lurker or a poster (table 5). *Lurkers* were APTC users who self-reported as never having posted in APTC online forums and never having uploaded any teaching resources. *Posters* were teachers who self-reported as having posted at least once in an online forum or uploading at least one teaching resource. A sensitivity analysis on different lurking-posting thresholds (2.5%, 5.0% of time posting) indicated no substantial differences in directionality and significance levels for varying lurking-posting thresholds (Fischer et al., 2015).

Table 5: Descriptive statistics for the dependent variables.

Survey	N [all]	N [non-user]	N [APTC user]	N [lurker]	N [poster]
Biology year 2	2,231	964	1,267	715	516
Biology year 3	2,240	942	1,298	737	561
Chemistry year 1	2,271	1,092	1,179	747	432
Chemistry year 2	2,038	969	1,069	620	449
Physics year 1	1,733	1,003	730	410	320

Teacher demographics *independent variables* included teachers' birth year, gender, and racial/ethnical background, and teachers' knowledge and experience. Teaching- and school-level independent variables included the composite variables teachers' self-efficacy, professional development inclination, challenges with the AP redesign, enactment of AP practices, enactment of AP curriculum, administrative support, and AP workload. APTC participation independent variables included the frequency of APTC visits, the duration of APTC visits, professional development characteristic (responsiveness of agenda, focus on student work, modeling teaching, opportunities to build relationships, and effective support for teaching the redesigned AP course), and reasons for APTC participation (access resources, ask questions, search for advice for responding to the AP redesign, sharing of own ideas and insights, and social interactions with colleagues) (table 6).

High-level qualitative codes (code families) included *APTC benefit to teacher* (lesson support, emotional support / community, ongoing/continuous), *frequency of login* (never, once every few months, once a month, twice a month, once or twice a week, several times a week, almost daily), *length of use* (less than 5 minutes, 5 to 10 minutes, 10 to 20 minutes, 20 to 40 minutes, and more than 40 minutes), *setting of use*, *type of use* (posting, lurking, commenting, following links, specific-search, test-related), and *barriers to use* (community, interface, time). In addition to code families, memos were also used to track *usefulness to new teachers*, *receipt of daily email digest*, *value of face-to-face interactions*, and *discomfort with social media/barrier to posting*.

Table 6: Descriptive analysis for all independent variables; ^{C}: composite variable.

	Biology year 2		*Biology year 3*		*Chemistry year 1*		*Chemistry year 2*		*Physics year 1*	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
Teacher demographics										
Birth year	1968.4	10.5	1969.1	10.5	1967.3	11.0	1967.9	10.9	1969.7	11.0
Female	71.45%		70.84%		61.32%		61.11%		37.51%	
Racial background										
White	86.77%		86.61%		85.59%		85.24%		87.90%	
Native American or Pacific Islander	0.52%		0.47%		0.50%		0.66%		0.49%	
Asian or Asian American	4.13%		3.92%		5.14%		5.60%		3.77%	
Black or African American	2.35%		2.24%		3.00%		2.80%		1.46%	
Hispanic	0.56%		0.66%		0.59%		0.31%		0.43%	
Multiracial	5.68%		6.11%		5.18%		5.39%		5.96%	
Knowledge and experience^{C}	0.000	1.200	0.000	1.185	0.000	1.172	0.000	1.186	0.000	1.197
Teaching and school characteristics										
Self-efficacy^{C}	0.000	1.328	0.000	1.281	0.000	1.338	0.000	1.306	0.000	1.272
PD inclination^{C}	0.000	1.092	0.000	1.085	0.000	1.074	0.000	1.066	0.000	1.070
Challenges with AP redesign^{C}	0.000	1.067	0.000	1.049	0.000	1.063	0.000	1.047	0.000	1.056
Enactment: AP practices^{C}	0.000	1.195	0.000	1.158	0.000	1.153	0.000	1.141	0.000	1.197
Enactment: AP curriculum^{C}	0.000	1.104	0.000	1.105	0.000	1.085	0.000	1.083	0.000	1.092
AP workload^{C}	0.000	1.114	0.000	1.120	0.000	1.142	0.000	1.113	0.000	1.079
Administrative support^{C}	0.000	1.091	0.000	1.096	0.000	1.090	0.000	1.095	0.000	1.091
APTC participation characteristics (APTC users only)										
Frequency										
Once per month or less	47.90%		50.27%		44.86%		49.58%		53.85%	
Every other week	19.56%		18.84%		19.37%		20.99%		20.05%	
Once or several times a week	24.23%		27.03%		23.70%		24.55%		22.39%	
Almost every day	8.31%		3.86%		12.06%		4.87%		3.71%	
Duration										
Less than 5 minutes	3.09%		3.32%		5.03%		4.50%		6.04%	
5 to 10 minutes	22.35%		18.60%		25.72%		23.73%		25.55%	
10 to 20 minutes	37.16%		40.43%		40.89%		41.46%		38.19%	
20 to 40 minutes	29.95%		29.24%		22.57%		24.48%		24.59%	
More than 40 minutes	7.45%		8.41%		5.79%		5.82%		5.63%	
PD characteristics										
Responsive agenda	3.534	0.928	3.481	0.996	3.366	0.888	3.487	0.971	3.323	1.010
Focus on student work	2.463	1.124	2.548	1.139	2.214	1.047	2.412	1.036	2.335	0.998
Modeling teaching	2.437	1.101	2.508	1.131	2.186	0.995	2.284	1.031	2.306	1.009
Building relationships	3.470	1.141	3.442	1.158	3.251	1.080	3.266	1.095	3.170	1.128
Effective support	3.518	0.947	3.550	0.956	3.258	0.894	3.362	0.895	3.108	0.905
Participation reasons										
Access resources	67.72%		87.67%		67.85%		79.79%		79.59%	
Ask questions	29.28%		34.90%		27.40%		33.58%		30.96%	
Advice for AP redesign	73.80%		91.76%		76.34%		94.11%		92.60%	
Share ideas/ insights	10.50%		10.63%		8.31%		9.54%		10.14%	
Social interactions	7.10%		7.32%		5.60%		7.02%		6.71%	

Findings

Research question 1: Which types of teachers were more likely to participate in the APTC?

Overall, the results suggested that there were significant differences in teacher, teaching, and school characteristics that predicted whether a teacher was using or was not using the APTC (table 7). This finding suggested that participants with certain characteristics were more inclined than others to use the APTC.

With respect to teacher demographics, we found that, across all years and domains, female teachers and teachers with greater knowledge and experience were significantly more likely to participate in the ATPC. With the exception of multi-racial teachers being less likely to participate in the APTC compared to white teachers for the first year of the AP Chemistry redesign implementation, no other significant differences for teachers' racial/ethnical background were found across all domains and years. Holding all else constant, females had odds of being APTC users compared to not using the APTC that were 33-82% greater than those of their male counterparts (Biology year 2: 73.2%; Biology year 3: 82.2%; Chemistry year 1: 32.7%; Chemistry year 2: 43.6%; Physics year 1: 62.4%). Roughly every standard deviation increase in teachers' knowledge and experience was associated with a 24-37% increase in the odds of teachers participating in the APTC (Biology year 2: 34.7%; Biology year 3: 27.2%; Chemistry year 1: 24.7%; Chemistry year 2: 25.8%; Physics year 1: 24.2%). Also, younger-aged Biology and Chemistry teachers were significantly more likely to engage in the APTC across all years. This can also be illustrated through calculating the predicted probabilities for APTC use. For instance, figure 1 suggests that, the younger a teacher is (continuous variable based on teachers' birth year) and the higher teachers' knowledge and experience (standardized composite

Table 7: Logistic regression analysis exploring the likelihood of teachers being non-users or users of the APTC; $N_{Bio,year2} = 2,231$, $N_{Bio,year3} = 2,240$, $N_{Chem,year1} = 2,271$, $N_{Chem,year2} = 2,038$, $N_{Phy,year1} = 1,733$; ^{C}: composite variable; $^{*}p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$.

	Biology year 2		*Biology year 3*		*Chemistry year 1*		*Chemistry year 2*		*Physics year 1*	
	B	**OR**	***β***	**OR**	***β***	**OR**	**B**	**OR**	***β***	**OR**
Intercept	-54.209***		-60.782***		-41.632***		-35.710***		-13.571	
Teacher demographics										
Birth year/100	2.750***	15.644***	3.084***	21.850***	2.114***	8.280***	1.810***	6.109***	0.665	1.944
Female	0.549***	1.732***	0.600***	1.822***	0.283**	1.327**	0.362***	1.436***	0.485***	1.624***
Racial background *(vs. White)*										
Native American or Islander	0.446	1.562	0.394	1.483	0.118	1.125	0.281	1.325	-0.382	0.683
Asian or Asian American	-0.089	0.915	-0.024	0.976	-0.153	0.858	-0.052	0.949	-0.241	0.786
Black or African American	-0.541	0.582	-0.557	0.573	-0.466	0.627	-0.371	0.690	-0.793	0.452
Hispanic	-0.087	0.917	-0.208	0.812	-0.344	0.709	-1.018	0.361	-1.136	0.321
Multiracial	-0.149	0.861	-0.352	0.703	-0.504*	0.604*	-0.118	0.889	-0.339	0.713
Knowledge and experience^{C}	0.298***	1.347***	0.240***	1.272***	0.221***	1.247***	0.230***	1.258***	0.216***	1.242***
Teaching and school characteristics										
Self-efficacy^{C}	0.040	1.040	-0.041	0.960	0.017	1.017	0.092*	1.096*	0.058	1.060
PD inclination^{C}	0.192***	1.212***	0.114**	1.121**	0.025	1.025	0.066	1.068	0.021	1.021
Challenges with AP redesign^{C}	0.065	1.067	0.051	1.053	0.122**	1.129**	0.051	1.053	0.224***	1.251***
Enactment: AP practices^{C}	0.057	1.059	0.154***	1.166***	0.133**	1.142**	0.070	1.073	0.222***	1.248***
Enactment: AP curriculum^{C}	0.051	1.052	0.046	1.047	0.011	1.011	-0.037	0.964	0.076	1.079
AP workload^{C}	0.159***	1.172***	0.108**	1.114**	0.132**	1.142**	0.206***	1.228***	0.116*	1.123*
Administrative support^{C}	0.021	1.021	0.039	1.040	-0.007	0.993	-0.006	0.994	0.085	1.089

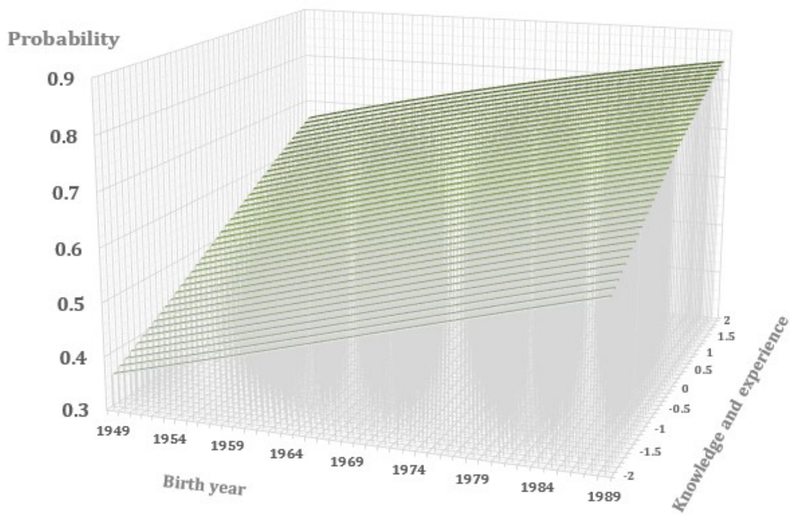

Figure 1: AP Biology teachers' predicted probability to use the APTC in the third year of the AP redesign.

variable created through multiple survey items [table 4]), the higher the predicted probability for APTC use, holding all other variables at their respective mode and mean values.

Regarding teaching and school characteristics, the main significant findings were the following: A higher AP workload was significantly associated with greater odds to participate in APTC across all domains and years. Holding all else constant, roughly every standard deviation increase in teachers' AP workload was associated with 11-23% greater odds to participate in the APTC (Biology year 2: 17.2%; Biology year 3: 11.4%; Chemistry year 1: 14.2%; Chemistry year 2: 22.8%; Physics year 1: 12.3%). Additionally, during the first year of the implementation, teachers' self-reporting greater challenges with the AP redesign were significantly more likely to participate in the APTC. Roughly every standard deviation increase in teachers' perceived challenges with AP redesign was associated with a 13-25% increase in the odds to participate in the APTC (Chemistry year 1: 12.9%; Physics year 1: 25.1%). For the second and the third year of the AP redesign, these associations were not significant.

Similarly, teachers during the first year of the AP redesign implementation (and Biology teachers in the third year of the AP redesign implementation) who enacted more elements of AP practices in their instruction were significantly more likely to participate in the APTC. Roughly every standard deviation increase in the enactment of AP practices was associated with a 14-25% increase in the odds of participating in the APTC (Biology year 3: 16.6%; Chemistry year 1: 14.2%; Physics year 1: 24.8%). Furthermore, Biology teachers with a higher professional development inclination were significantly more likely to use the APTC as an opportunity for professional learning. Roughly every standard deviation increase in teachers' professional development inclination was associated with a 12-21% increase (Biology year 2: 21.2%; Biology year 3: 12.1%) in the odds of APTC participation.

Thus, teachers who were more likely to use the APTC were overall different from teachers not using the APTC. Across all domains and years, younger teachers (except Physics), female teachers, teachers with greater knowledge and experience, and teachers reporting a higher AP workload were more likely to participate in the APTC. Additionally, teachers in the first year of the redesign were more likely to participate in the APTC if they felt more challenged with the AP redesign and enacted more AP practice elements in their instruction.

Research question 2: Which types of teachers were more likely to be posters?

The results of the logistic regression analyses of APTC user engagement suggested that most teacher, teaching, and school characteristics did not determine whether a teacher was a lurker or a poster (table 8). *Lurkers* were APTC users who self-reported as never having posted in APTC online forums and never having uploaded any teaching resources. *Posters* were teachers who self-reported as having posted at least once in an online forum or uploaded at least one teaching resource.

The reasons for APTC participation had the strongest significant associations predicting whether teachers were posting or lurking (table 8). Across all domains and years, teachers who participated to ask questions and share their own ideas and insights were significantly more likely to be posters instead of lurkers. Holding all else constant, teachers' who indicated that they participated in the APTC to ask questions had a 340-720% increase in the odds of being a poster (Biology year 2: 721.0%; Biology year 3: 336.7%; Chemistry year 1: 564.2%; Chemistry year 2: 568.6%; Physics year 1: 542.0%). Teachers' who indicated that they participated in the APTC to share their own ideas or insights had a 170-2,400% increase in the odds of being a poster

Table 8: Logistic regression analysis exploring the likelihood of teachers being lurkers or posters of the APTC; C: composite variable; *p<0.05, **p<0.01, ***p<0.001.

	Biology year 2		Biology year 3		Chemistry year 1		Chemistry year 2		Physics year 1	
	β	OR	β	OR	β	OR	β	OR	β	OR
Intercept	-45.034*		-31.815*		-2.189		-6.500		-16.551	
Teacher demographics										
Birth year/100	2.441**	11.486**	1.610*	5.005*	0.220	1.246	0.283	1.327	0.760	2.139
Female	-0.167	0.846	-0.082	0.921	0.274	1.315	-0.186	0.830	-0.393*	0.675*
***Racial background** (vs. White)*										
Native American or Islander	-1.138	0.320	-0.179	0.836	-0.813	0.444	-0.030	0.970	-1.675	0.187
Asian or Asian American	-0.037	0.964	-0.098	0.906	-0.289	0.749	0.347	1.415	0.585	1.795
Black or African American	-0.021	0.979	-0.156	0.855	-0.614	0.541	-0.189	0.828	0.467	1.595
Hispanic	0.274	1.315	-0.692	0.500	-1.898	0.150	5.901	365.225	-1.381	0.251
Multiracial	0.548	1.730	0.149	1.160	-0.113	0.893	-0.123	0.884	0.175	1.191
Knowledge and experience[C]	0.235**	1.264**	0.239**	1.270**	0.083	1.086	0.121	1.129	0.144	1.155
Teaching and school characteristics										
Self-efficacy[C]	0.106	1.112	0.024	1.024	-0.067	0.935	-0.063	0.939	0.051	1.053
PD inclination[C]	-0.115	0.892	0.045	1.046	-0.118	0.888	-0.024	0.977	-0.066	0.936
Challenges with AP redesign[C]	0.047	1.049	-0.054	0.947	-0.053	0.949	-0.036	0.965	0.089	1.093
Enactment: AP practices[C]	-0.078	0.925	0.050	1.052	-0.008	0.992	-0.009	0.991	0.007	1.007
Enactment: AP curriculum[C]	0.052	1.054	0.047	1.049	-0.032	0.968	-0.077	0.926	-0.112	0.894
AP workload[C]	0.114	1.121	0.020	1.020	-0.070	0.932	0.145*	1.156*	-0.022	0.979
Administrative support[C]	-0.053	0.948	0.022	1.022	0.008	1.008	-0.011	0.989	-0.035	0.965
APTC usage characteristics										
***Frequency** (vs. once/month or less)*										
Every other week	-0.311	0.733	0.206	1.229	-0.185	0.831	0.402*	1.495*	0.188	1.207
Once or several times a week	0.416*	1.515*	0.122	1.130	-0.151	0.860	0.315	1.370	0.332	1.394
Almost every day	0.446	1.562	0.264	1.302	0.071	1.073	0.116	1.123	0.049	1.051
***Duration** (vs. less than 5 minutes)*										
5 to 10 minutes	-0.566	0.568	-0.765*	0.465*	0.163	1.178	0.181	1.199	0.661	1.936
10 to 20 minutes	-0.874	0.417	-0.716*	0.489*	0.205	1.227	0.404	1.497	0.684	1.982
20 to 40 minutes	-1.122	0.326	-0.786*	0.456*	0.289	1.335	0.385	1.469	0.635	1.887
More than 40 minutes	-0.225	0.799	-1.251**	0.286**	-0.188	0.829	0.285	1.329	0.278	1.320
PD characteristics										
Responsive agenda	0.105	1.111	0.023	1.023	-0.095	0.909	0.041	1.042	-0.024	0.976
Focus on student work	0.082	1.085	-0.132*	0.876*	-0.060	0.941	-0.062	0.940	0.123	1.131
Modeling teaching	0.035	1.035	-0.109	0.896	0.000	1.000	-0.002	0.998	-0.057	0.945
Building relationships	-0.079	0.924	0.078	1.081	-0.002	0.998	-0.033	0.967	0.156	1.169
Effective support	0.084	1.088	-0.047	0.954	0.214	1.238	0.006	1.006	-0.055	0.946
Participation reasons										
Access resources	-1.030***	0.357***	0.055	1.057	-1.087***	0.337***	-0.037	0.964	-0.096	0.909
Ask questions	2.105***	8.210***	1.474***	4.367***	1.893***	6.642***	1.738***	5.686***	1.859***	6.420***
Advice for AP redesign	-2.842***	0.058***	0.253	1.288	-2.680***	0.069***	-0.455	0.635	-0.336	0.715
Share ideas/insights	0.991**	2.694**	1.906***	6.727***	1.964***	7.128***	1.887***	6.602***	3.219***	24.999***
Social interactions	0.336	1.400	0.209	1.233	-0.158	0.854	0.482	1.619	-0.124	0.883

(Biology year 2: 169.4%; Biology year 3: 572.7%; Chemistry year 1: 612.8%; Chemistry year 2: 560.2%; Physics year 1: 2,499.9%). Also, first year Chemistry and second year Biology teachers who indicated that they participated in the APTC to access resources and seek advice and recommendations regarding the AP redesign were significantly less likely to be posters.

Holding all else constant, teachers' who indicated that they participated in the APTC to access resources had a 93%-94% decrease in the odds of being a poster (Biology year 2: 94.2%; Chemistry year 1: 93.1%). Teachers who indicated that they participated in the APTC to seek recommendations regarding the AP redesign had a 64-66% decrease in the odds of being a poster (Biology year 2: 64.3%; Chemistry year 1: 66.3%). This might indicate that teachers were more strategic in their approach to using the APTC to retrieve the information they needed through lurking.

Based on case study data, APTC users attributed their lurking, or lack of posting, to the desired content already being posted, which engendered the use of searching for specific items and then lurking, rather than posting. For example, when conducting specific searches, APTC users most frequently mentioned that they were seeking lesson support (e.g. resources, answers to questions, advice) and community support (e.g. emotional support, sharing challenges and setbacks). Another explained, "I used it [the APTC] a lot -- mostly skimming to read what other people had posted, in searching for specific topics because I found most stuff I wanted was already there." Searching for specific topics and lurking, the most common uses cited by APTC case study teachers, distinguished the APTC from other forms of PD by tailoring the experience to the user. One user described, "What I like about the Teacher Community is you can search. When you go to PD, you're at the mercy of the presenter -- you're going to get some ideas but you're also going to get a lot of things that you're really not interested in." The APTC provides anywhere, anytime personalized access to PD that can be easily searched. The ability to find plentiful information often leads to lurking, rather than posting. Lurkers of the APTC cite that *time*, a *non-user-friendly interface*, and *"unsupportive" community voices* are also reasons that they choose not to participate more visibly.

While the reasons for APTC participation helped to predict whether teachers were more likely to demonstrate posting or lurking behavior other APTC usage characteristics did not indicate significant likelihood changes (table 8). The frequency and duration of teachers' self-reported APTC participation on the web-based surveys were mostly not associated with predictions whether teachers were posters or lurkers. Similarly, teachers' perception of the APTC in terms of 'high-quality' features of professional development (responsiveness of agenda, focus on student work, modeling teaching, building relationships, and effective support for teaching for the redesigned course) were not significantly associated with changed likelihoods for teachers being posters or lurkers across years and domains. This implied that the perceptions of the opportunities to build relationships among colleagues in this online community were not substantially different for posters and lurkers. The only exception was that Biology teachers in the third year of the AP redesign who reported a higher focus of the APTC on student work were significantly less likely of being posters instead of lurkers. Holding all else constant, roughly a standard deviation increase in teachers' perceived focus on student work was associated with a 12.4% decrease in the odds of being posters instead of lurkers. This might be explained through the saturation with content already posted on the online community by the third year of the AP redesign. As a case study participant described, "I didn't really have to ask [post] a question because somebody else had already asked it. Or, they'd ask a question I hadn't even thought yet to ask so it was really beneficial."

Although, some teacher-level demographic variables were associated with likelihood changes of participating in the APTC as lurkers or posters for Biology teachers and Physics teachers, these variables had no significant associations for Chemistry teachers. A teacher's racial/ethnical background was not associated with changes in the likelihood of being a poster or lurker, across all domains and year. Also, none of the teaching and school characteristics (self-efficacy, professional development inclination, perceived challenges with the AP redesign, enactment of AP practice elements, enactment of AP curriculum elements, AP workload [except for Chemistry year 2], and administrative support) were significantly associated with changes in the likelihood for teachers to be lurkers or posters across all domains and year. This indicated that the teacher population participating in the APTC was relatively homogenous with respect to their APTC engagement behavior (that classified a teacher either as a lurker or a poster). The only significant teacher, teaching, and school characteristic variable that significantly predicted ATPC engagement behavior for Physics teachers was gender. Holding all else constant, female teachers had odds of being posters compared to lurkers that were 32.5% smaller than those of their male counterparts. For Biology teachers, the only significant teacher, teaching, and school characteristic variables predicting APTC engagement were teachers' age and teachers' knowledge and experience. Younger Biology teachers were more likely to be posters than lurkers. Also, holding all else constant, roughly every standard deviation increase in Biology teachers' knowledge and experience was associated with a 26-27% increase (Biology year 2: 26.4%; Biology year 3: 27.0%) in the odds of being a poster compared to being a lurker.

Thus, teachers' engagement in the APTC could be more determined through their participation reasons instead of more general teacher, teaching, and school characteristics.

Lurking was a common phenomenon and some teachers deliberately chose not to engage in the APTC as posters for a variety of reasons.

Discussion

Conclusion and implications

Understanding teacher factors that predict participation and engagement patterns in peer-based online learning is vital for providing effective professional development. The results of this study illuminated variables related to why teachers might choose to use (or not use) the APTC, as well as whether or not they demonstrated posting behavior. This study is designed to advance the research base on participation and engagement in online communities by exploring both users and non-users of the APTC and by examining the associations between teacher, teaching, and school characteristics as factors that affect engagement (posting or lurking) within the online community.

Three main findings emerged from this study: First, there were specific participation patterns for different teacher types in the APTC. Younger teachers, female teachers, teachers with greater knowledge and experience, and teachers reporting higher AP workload were more likely to participate in the APTC. Second, longitudinal differences in APTC were identified. Teachers during the first year of the AP redesign who felt more challenged by the changes of the AP redesign were more likely to participate in the APTC. Therefore, teachers using the APTC as a professional learning opportunity might not be the same as the overall AP science teacher population who responded to the web-based surveys. The specific teacher population participating in the APTC might also help explain the positive associations of teachers' APTC participation on students' AP scores (Fishman et al., 2014). Third, almost none of the included teacher, teaching, and school characteristics were significantly associated with changes in the likelihood of teachers being posters or lurkers. The most influential and significant variables that predicted teachers' APTC engagement were teachers' reasons to participate in the APTC. This indicated that teachers' participation was based on inherent personal and contextual factors. This finding emphasizes the importance of teachers' decision-making when engaging in professional learning and also indicates that the design of the APTC did not discourage certain teacher populations from expressing lurking or posting behavior. Also, lurking and posting serve different needs of APTC participants.

This study implies that an analysis of lurkers and posters might not be sufficient by itself for generalizing the sample of online community users to an overall population. It is equally important to analyze non-users in comparison to users in order to detect participation selection effects. If online community providers attempt to serve an overall representative population, conducting similar analyses might also lead to increased efforts to recruit users with certain demographics in order to achieve a more equitable representation of the overall population.

Limitations and future work

Limitations of this study include cautions about the generalizability of its findings. Although the survey data provides a large nation-wide representation of AP science teachers, teachers responding to the survey taught in schools with slightly higher achieving students and slightly lower enrollment rates in free- and reduced-priced lunch programs.

This study is also limited by the nature of the data collected. Both survey and case study interview data relied on teacher self-report. While case study interview data was linked to survey data, teachers' visible engagement in the APTC could not be connected to the data sets used in the study. Therefore, this study did not examine directly how teachers engaged in the APTC. Future research might include temporal, discourse, and content analysis of purposefully selected sections of the APTC. In-depth explorations of teachers' interaction with the APTC might provide additional insights for better design of collaborative online learning environments for teachers.

A different study might explore how teachers' participation and engagement in the APTC complemented more traditional forms of professional development (e.g., weeklong face-to-face workshops during the summer before the start of the school year, self-paced online courses accessible anytime on web pages, etc.) and material use (e.g., AP lab manual, textbook, teaching materials from colleagues, etc.) within teachers' individual mix of professional learning in response to this large-scale science curriculum reform. This study might provide additional insights into why certain types of teachers chose to participate in the APTC, while others chose not to participate.

Scholarly significance

This study provided a unique opportunity to advance current research in the context of College Board's mandated large-scale top-down redesign of the AP examinations and curricula. Teachers were forced to adapt to these changes. This may have led to them being more likely to engage in professional learning opportunities leading to a broader teacher population participating in a broad range of professional development activities including online learning opportunities such as the APTC. Insights about teacher learning from this study may generalize to other national shifts in curriculum and assessment, such as the Next Generation Science Standards or the Common Core Standards. Additionally, most online-community research has solely examined the online engagement patterns of lurkers and posters. This study extended this dichotomy by also being able to compare ATPC users to non-users given the nation-wide longitudinal samples of AP Biology, AP Chemistry, and AP Physics teachers. Understanding online user patterns allows for more personalized professional development activities and educational policies that support teachers in navigating large-scale changes in curricula and exams and in preparing students for 21st century demands.

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