Journal of Mathematics and Science Teacher
2022, 2(2), em010
e-ISSN: 2752-6054
https://www.mathsciteacher.com/

MODESTUM

Research Article

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Blended, active, and persistent: An investigative study of blended learning affordances for active learning and student persistence in university-level introductory science courses

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Citation: Such, B. (2022). Blended, active, and persistent: An investigative study of blended learning affordances for active learning and student persistence in university-level introductory science courses. *Journal of Mathematics and Science Teacher, 2*(2), em010. https://doi.org/10.29333/mathsciteacher/12171

ARTICLE INFO

Received: 22 Mar. 2022

Accepted: 20 Jun. 2022

ABSTRACT

Higher education has seen the accelerated development of blended learning (BL), active learning (AL), and STEM education. This study explores a proposed framework showing that BL affordances enable or constrain AL and that the relationship between BL affordances and AL influences student persistence in introductory science courses and the sciences. A multiple-case study examined an introductory physics course and an introductory chemistry course. Interviewed were two student volunteers from high-, average-, and low-performing groups from each course. Course documentations underwent content analysis, and in-class and online observations were evaluated using the practical observation rubric to assess active learning (PORTAAL). The researcher developed a survey instrument, blended learning for active learning (BL4AL), capturing students' perspectives concerning AL through traditional and nontraditional learning methods for their persistence in the sciences. Findings indicated students from all levels had varying views of BL affordances. However, in-class clicker questions and a third-party tutoring service were discovered to consistently enable AL. Students' perceptions of BL for AL had a medium effect on whether they would continue in the sciences.

Keywords: higher education, STEM, high enrollment, educational technology, case study

INTRODUCTION

As higher education continues to evolve, three prominent trends have emerged in 21st century higher education: the focus of funded support for science, technology, engineering, and mathematics (STEM) education, the push for active learning (AL) within the STEM courses, and the increase of courses with blended learning (BL) designs as the means to facilitate AL. A focus within STEM education has been the efficacy of AL, which is defined as students actively engaging in the learning process through reading, writing, discussing, and being engaged in problem solving, all the while using higher-order thinking tasks of analysis, synthesis, and evaluation (Bonwell & Eison, 1991). The practice of AL has challenged still common practices in science education, particularly in large-enrollment introductory courses, in which the instructor lectures and students take notes, read text, and take assessments rather than practicing higher-order thinking tasks (Kober, 2014). As seen with Freeman et al.'s (2014) meta-analysis of 225 studies comparing courses with AL versus lecture-based courses, the student examination performance increased close to half a standard deviation through AL, and the failure rates increased by 55% within a lecture-styled environment. The change in standard deviation translated to a 0.3 increase in the average final grade among students.

Related to BL, Means et al. (2010) discovered in their meta-analysis that BL had a larger effect size in K-12 environments than purely face-to-face (FTF) or online learning in those environments (+0.35, $p<.001$). Means et al.'s (2013) meta-analysis of the empirical literature concerning BL and FTF learning in higher education also confirmed that the BL mode was more effective than the FTF learning environment.

BLENDED LEARNING FOR ACTIVE LEARNING

In this study, BL follows Graham's (2006) definition having four dimensions of interaction–BL being defined as not only the blend of FTF and online space but also the blend of:

- synchronous and asynchronous practices (related to time),

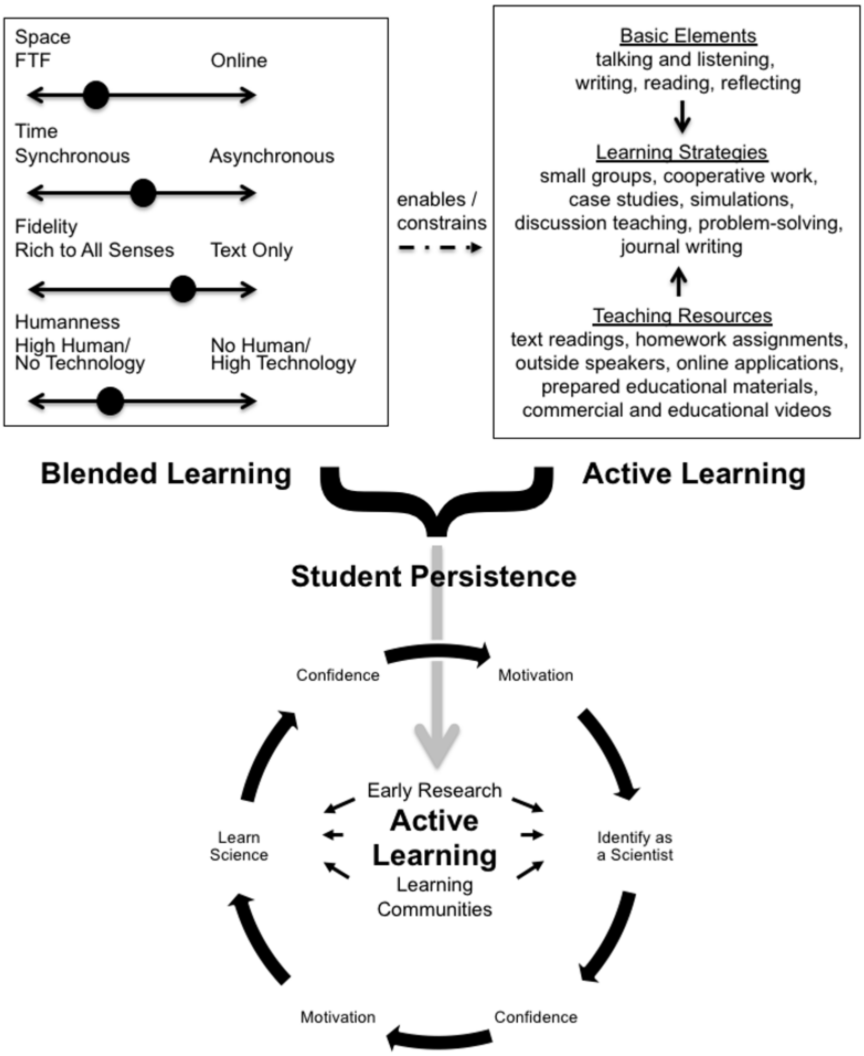

Figure 1. Conceptual framework of blended learning affordances for active learning and student persistence in the sciences (Graham, 2006; Graham et al., 2013; Meyers & Jones, 1993).

- text-only content and content rich to all senses (fidelity), and
- high human interaction with little technology and low human interaction with more technology (humanness).

Active learning manifests as “any instructional method that engages students in the learning process” (Prince, 2004, p. 1). **Figure 1** illustrates the conceptual framework for how the affordances of BL relate to AL and how the two influence student persistence in the sciences. The left side of the framework shows a modified version of Graham’s (2006) four dimensions of interaction in FTF and online environments. The right side of the framework is Meyers and Jones’ (1993) proposed AL structure. Thus, the framework presented by Meyers and Jones (1993) provides a practical representation of AL, showing how the combination of basic learning elements like reading and writing and teaching resources like readings, assignments, and videos can lead to active strategies such as small groups and discussion teaching. The bottom part of **Figure 1** indicates the relationship between BL and AL and how AL contributes to Graham et al.’s (2013) framework for student persistence.

Within the framework, each of the four dimensions of BL has its own scale. The marking on each scale indicates that introductory science education currently tends to: focus on learning in the FTF environment, be split between synchronous and asynchronous learning, depend on more text-based media, and depend on more in-person lectures than on technology-based lectures. Specific BL affordances are the practical manifestations of the BL learning experience, e.g., FTF lectures with online homework. Between the BL and AL within the framework is a dashed arrow indicating that supports BL affordances can enable or constrain AL—stemming from the argument that media affordances can enable or constrain pedagogical methods (Graham, 2013; Kozma, 1991, 1994). The arrow is not a solid one indicating that the affordances may not be direct causal factors but

> “represent classes of pedagogies distinct enough to enable [or constrain] differences to be measured in meta-analyses where researchers have not yet identified the actual causal factors” (Graham, 2013, p. 340).

Finally, the framework shows how the relationship between BL affordances and AL can influence student persistence, consisting of the four factors of students’ motivation, confidence, learning of science, and identity as a scientist. In this study, student persistence was gauged by the students’ willingness to complete their respective physics or chemistry course and whether they intended to take another science course.

CURRENT RESEARCH

In the context of undergraduate science education, the development toward blended learning for active learning (BL4AL) is still in the early stages. Transferring courses online due to COVID-19 has forced science departments to consider what online components can be added to the instructional delivery. Nevertheless, the literature shows in-class lectures and laboratory times are still common practice, especially in the large introductory-level science courses that are the gateway to other science courses in a student's major (Kober, 2014). A BL science course may simply include the addition of online components or technological interventions to FTF instruction or out-of-class work; at times, seat time is replaced with the online components or technological interventions as well. Baepler et al. (2014) compared students in solely in-person undergraduate chemistry courses to students in BL courses having online content delivery and in-person interactions in a classroom set up for AL. The online delivery methods were optional online lectures, computer simulations within the FTF environment, and clicker interactions during class. In Gonzalez' (2014) study comparing a traditional FTF class, a class infusing lecture and laboratory time, and a BL class, the BL class was a blend of FTF time and online activities, which included online lectures and video clips. Elmer et al. (2016) used video demonstrations to prepare students for undergraduate physiology laboratories. There was no significant difference between the student performance of students having a BL experience versus that of students in a traditional format, but students perceived that they were more prepared during laboratories.

Although there have been the comparative studies of courses with BL practices and those that follow more traditional practices, more research is required to specifically designate BL affordances and their relationship to AL and student persistence in the sciences, this study addresses the questions:

1. How do BL affordances for AL practices manifest in introductory science courses with large enrollments?
2. According to the perceptions of students, how do BL affordances for AL practices influence their persistence and course performance in these science courses?

METHODOLOGY

Within a large research university in the United States, a mixed-method, multiple-case study was conducted to investigate an introductory-level physics with calculus course and an introductory-level chemistry course. The multiple-case design followed replication instead of sampling logic, indicating that the

> "major insight is to consider multiple cases as one would consider multiple experiments" (Yin, 2014, p. 57).

A replication framework based on the study's conceptual framework was created for case selection–each course needed to incorporate BL affordances, encourage AL practices, and were introductory-level science courses. Upon data collection and analyses, a report was written for each case, and a cross-case analysis was conducted and reported.

Both qualitative and quantitative methods were used for the data collection and analyses, i.e., interviews, observations with the practical observation rubric to assess active learning (PORTAAL), review of documentations on the course website and the learning management system Canvas, and the BL4AL survey developed for the study.

Interviews

Semi-structured interviews were conducted with the lead instructors and teaching assistants of the courses. Following the BL4AL framework, the interview questions related to the FTF learning and online learning experiences in the course, AL practices, and considerations related to persistence in studying the sciences. Student volunteers for the interviews were chosen based on their academic performance in the course. As a way to collect diverse feedback, interviews from each course included two students who were low performing (having a C or lower letter grade in the course at the time when volunteers were requested), two students who were average performing (having a letter grade from a C+ to a B), and two students who were higher performing (having a letter grade from a B+ and A+). Thus, 12 students, six from each course, were interviewed.

The interviews were transcribed and underwent thematic analysis. Rounds of coding were conducted to see what themes surfaced—a code being defined as

> "a word or short phrase that symbolically assigns a summative, salient, essence-capturing, and/or evocative attribute for a portion of language-based or visual data" (Saldaña, 2015, p. 4).

Following Braun and Clark's (2006) recommendations for thematic analysis, in the initial stage of coding the researcher became familiar with the data through reading and rereading the data and writing down initial notes. Once the instructor's interviews were coded, the students' interviews were coded in comparison. The interviews with students who were higher performing were coded first because their responses could potentially align more similarly with the instructor's since they were doing well in the course. The interviews with students who were lower performing were coded last. Evidence of when BL affordances enabled AL was noted when students mentioned how a BL affordance encouraged practices of AL (e.g., talking and listening, reading, writing, and reflecting). Constraints were noted when BL did not encourage AL practices.

In order to address the second research question about student persistence, the same coding process occurred in that instructors' interviews were first coded to note their considerations of the students' persistence in the forms of motivation, confidence, science learning, and identification as a scientist; then the students' interviews were coded. Because instructors and students were directly asked about their perspectives related to the four areas related to student persistence, their responses were coded according to why they positively or negatively felt about their own motivation, confidence, science learning, and identification as a scientist. Examples include "motivated to pass exam and to earn good grade" and "less confident due to not achieving expected exam grade." Once the initial codes were made, the codes were reviewed for themes.

Review of Documentations

The review of documentations answered the first question about the manifestations of BL affordances for AL. The term "documentations" was chosen instead of "artifacts," as Yin (2014) distinguishes documentations as written evidence like emails, announcements, and administrative documents, while he defines artifacts as evidence that is produced like a technological device, a work of art, or an instrument. For each case, the researcher reviewed the physics course website that acted as the course's syllabus, the electronic copy of the chemistry course syllabus, and online course announcements.

Elo and Kyngäs's (2008) recommendations for content analysis were chosen, following a preparation phase and an organizing phase. The first phase required the review of the data before selecting the unit of analysis, and the second included open coding and the creation of categories. Because of the online nature of all the documentations to be more like webpages (except the chemisry course syllabus that was a .pdf), the researcher noted on a spreadsheet the open codes and where in the documentation the open code referenced. Examples of codes included in "course overview" were "students supposed to attend lecture" and "be proactive and ask questions." The open codes were then grouped under higher-order headings that related to each of the research questions. For example, "constraints to AL" and "enablements to AL" were headings to the grouped open codes.

Observations

When observing in a class, the researcher used Eddy et al.'s (2015) validated observation tool PORTAAL. Although there are a number of observation tools available, PORTAAL was particularly designed to capture research-supported components within AL occurrences in undergraduate STEM classrooms. The instrument included four dimensions: practice, i.e., students practicing the information that they will be tested on; logic development, i.e., students exercising critical thinking to understand concepts rather than just answer lower-level questions; accountability, i.e., instructor's raising the incentive for students to participate through graded assignments, peer work, and/or cold calling in class; and reducing apprehension, i.e., instructor's calming students to participate.

Within the online learning environment, the researcher needed to distinguish between documentations and observations because text constituted most of the online environment. Documentations were considered to be unidirectional, meaning that the instructor was able to share information with students, but students did not have the direct opportunity to act or to give feedback. Observations were made of interactions among students or between students and the instructor within the online environment, and a modified version of PORTAAL was used. The resulting rubric scores from each observation for a course was averaged, then compared with each other.

BL4AL Survey

Because there is not a single previously validated measure of the perceived effects of BL on the AL with a focus on student persistence, the BL4AL survey was created and based on the following: the researcher's proposed conceptual framework; Eddy et al.'s (2015) four dimensions of best practices for AL as seen in PORTAAL; and Johnson and McClure's (2004) version of the constructivist learning environment survey (CLES), also called CLES 2(20).

The BL4AL survey with a 5-point Likert scale (from 1 strongly disagree to 5 strongly agree) focused on how BL affordances on AL related to student persistence. The 32-item survey had a factorial structure, in which four major factors were identified to indicate student persistence according to the framework by Graham et al. (2013): student motivation, student confidence, science learning, and identification as a scientist. Each factor had eight items so that each dimension of BL (i.e., space, time, fidelity, and humanness) would be represented by two items. For example, a couple of the items within the factor of confidence included "I feel confident in finding resources to help my learning" and "I feel comfortable discussing science topics with my peers".

The survey instrument underwent scrutiny for content validity with two professors in the field but not participating in the study. Two undergraduate students who were studying the sciences but not participating in the study reviewed the wording of the items and the survey's usability. A confirmatory factor analysis (CFA) was conducted to determine the correlations between the survey items and latent variables of student motivation, student confidence, science learning, and identifying as a scientist in relation to traditional learning methods (e.g., in-person lectures and paper exams) and to nontraditional learning methods (e.g., online homework and online videos). The models for both courses exhibited acceptable fit for a low stake's study (RMSEA<.10)—with the chemistry models showing better fit than the ones for the physics ones (Browne & Cudeck, 1993; DeCoster, 2009). MPlus was used to estimate the CFA models, while SPSS was used to perform the multiple linear regression analysis.

A higher percentage of students in the chemistry course (43.1%) responded to BL4AL in comparison to students in the physics course who responded (30.2%). **Table 1** shows the demographics of the respondents to the BL4AL survey from each course.

FINDINGS

Through the triangulation of the findings from the interviews, documentations, observations, and the BL4AL survey, the findings from the cross-case analysis of the two cases supported the argument that BL affordances can enable or constrain

Table 1. Demographics of respondents in physics and chemistry courses, respectively

Characteristics	Physics (n=228)		Chemistry (n=302)	
	n	%	n	%
Year				
Freshman	185	81.1	211	69.9
Sophomore	40	17.5	72	23.8
Junior	3	1.3	18	6.0
Senior	0	0.0	1	0.3
Gender				
Male	139	61.0	100	33.1
Female	87	38.2	201	66.6
Transgender female	1	0.4	0	0.0
Gender variant /non-conforming	1	0.4	1	0.3
Ethnicity				
Asian or Pacific Islander	35	15.4	56	18.5
Black	9	4.0	10	3.4
Hispanic	33	14.4	40	13.2
White	120	52.6	159	52.6
Multi-racial	31	13.6	37	12.3

learning. However, among the high-performing, average-performing, and low-performing students interviewed no patterns emerged regarding how they responded to which BL affordances enabled or constrained their AL in the courses. For example, from the interviews, students at all levels had conflicting feedback about online videos, indicating they were immemorable and redundant to being helpful in priming information before a class. The following sections share the major findings from the data analyses rather than the more minor findings like the students' use of online resources like YouTube and Chegg and the varying degrees of help from the separate class times designated for the discussion about homework problems.

Face-to-Face Lectures and In-Class Clicker Questions

Because introductory science courses focused on FTF lectures, the affordance of FTF lectures became one of the most identified themes from the interviews. In the physics course, students considered the FTF lectures a required spectacle, in which students watched and listened to the instructor present physics concepts but could avoid class participation. Depending on where students sat in the classroom, information whether written on the board or presented with a Microsoft PowerPoint was at times inaccessible to students. From the in-class observations, students were unable to read the information from where they sat in the large lecture hall, and the notes written on the chalkboards were not shared electronically for them to follow. For the physics course, the students reported that the FTF lecture did not adequately prepare them to visualize the physics concepts, which, as the instructor indicated, should be one of the major practices for students when completing the online homework.

Although the FTF lecture was also required in the chemistry course, the style of the lecture was more of an interactive "conversation" between the instructor and students. From the in-class observations, the students mainly watched or listened to the instructor as she also presented using multimedia like simulations or PowerPoint presentations. Her interactions with the students more actively engaged their critical thinking and helped them to verbalize their thoughts. In the interview with the students all of them spoke highly of the instructor, which lends to the possibility that the instructor's personality can influence the students' perception of having a positive lecture experience. Despite the general consensus that the FTF lectures enabled AL, an emerging theme from the interviews was that the lecture itself was unable to help students solve problems on their own. Students requested more ways to participate in class and more specific directions as to what and how much information from the lectures to retain.

For both classes, the in-class clicker experiences were designated consistently as an enablement to AL, encouraging direct, immediate instructor feedback or discussion among neighboring students. The timing of the questions also enabled students to immediately check their understanding of the lecture and be able to teach one another the information.

Table 2, **Table 3**, and **Table 4** present:

1. the specifically identified BL affordances in each course,
2. the position on the spectrum they can tend to be within a particular BL dimension,
3. the AL components attempting to be activated, and
4. whether the BL affordance became a constraint, an enablement, or both to AL.

Online Videos and Online Homework

Although online videos in both courses were required to be watched, in the physics course students considered the videos not memorable and optional to watch. On average the instructor had created about six, studio-produced videos, totaling about 1.5 hours, for each module. The videos were intended to prepare students for the class time and to provide supplemental guidance as students worked on homework. Within the chemistry course, the instructor created short update videos in her office, and students identified the videos as ways to "prime" the brain. However, some did note the information in the videos seemed to be too redundant to the information that the instructor would cover at the beginning of the classes, thus discouraging them from being more attentive during the review time in class.

Table 2. Relationship between AL and FTF lectures and in-class clicker questions

Course	**BL affordance**	**BL dimensions**		**AL components**			**Constraint/ enablement/both**
		Fidelity	**Humanness**	**Basic elements**	**Teaching resources**	**Learning strategies**	
	FTF lectures						
Physics		Middle of text only and rich to all senses	Mid human/mid technology	Writing and reflecting	Prepared content and questions	Problem solving	Constraint
Chemistry		Middle of text only and rich to all senses	High human/mid technology	Talking and listening	Prepared content and questions	Discussions	Both
	In-class clicker questions						
Physics		Middle of text only and rich to all senses	High human/ high technology	Talking, listening, reflecting	Questions, educational technology	Discussions, problem solving	Enablement
Chemistry		Middle of text only and rich to all senses	High human/ high technology	Talking, listening, reflecting	Questions education technology	Discussions, problem solving	Enablement

Note: The BL dimensions of space and time have been removed in this comparison because the affordances needed to be FTF and synchronous

Table 3. Relationship between AL and online class videos and online homework

Course	**BL affordance**	**BL dimensions**		**AL components**			**Constraint/ enablement/both**
		Fidelity	**Humanness**	**Basic elements**	**Teaching resources**	**Learning strategies**	
	Online class videos						
Physics		Middle of text only and rich to all senses	Medium human/ high technology	Watching, reflecting	Prepared materials, multimedia	Problem solving	Constraint
Chemistry		Middle of text only and rich to all senses	Medium human/ high technology	Watching, reflecting	Prepared materials, multimedia	Problem solving	Both
	Online homework						
Physics		Text only	Low human/high technology	Reflecting	Problems	Problem solving	Both
Chemistry		Text only	Low human/high technology	Reflecting	Problems	Problem solving	Both

Note: The BL dimensions of space and time have been removed in this comparison because affordances needed to be online and asynchronous

Table 4. Relationship between AL and the third-party tutoring service

Course	**BL affordance**	**BL dimensions**	**AL components**			**Constraint/ enablement/both**
		Space, Time, Fidelity, & Humanness	**Basic elements**	**Teaching resources**	**Learning strategies**	
	Tutoring service					
Physics & chemistry		Varying on spectrum	Listening, writing, reading, and reflecting	Outside speakers, online applications, prepared educational materials	Discussions, problem solving	Enablement

The online homework also resulted in mixed reactions to its being an enablement or constraint to AL. Students indicated the homework helped them identify what they did know as well as encourage them to find possible solutions or supplemental information about questions they did not know. However, the problem-solving process was thwarted when students could not progress if they missed an initial question.

Questions were often written in a way that if an initial answer was incorrect, the subsequent answers were incorrect. A disconnect between practice and learning objectives emerged as the online homework would indicate students did not understand a concept when they may have incorrectly typed the answers into the system. Formulas had to be entered in a certain way, so the homework may have assessed the students' technical skills rather than their understanding of the materials.

Table 5. Mean of aggregate scores and average standard deviation for each of the four persistence dimensions in context of traditional or nontraditional learning in both courses

Variable	Physics		Chemistry	
	M	SD	M	SD
Motivation (traditional learning methods)	2.47	1.02	2.36	1.04
Motivation (nontraditional learning methods)	2.57	1.07	2.55	1.06
Confidence (traditional learning methods)	2.45	1.03	2.33	0.97
Confidence (nontraditional learning methods)	2.55	1.08	2.51	1.02
Science learning (traditional learning methods)	2.35	0.96	2.30	0.96
Science learning (nontraditional learning methods)	2.50	1.03	2.45	1.00
Identification as a scientist (traditional learning methods)	2.58	1.05	2.56	1.07
Identification as a scientist (nontraditional learning methods)	2.68	1.09	2.65	1.07

Student-Identified Tutoring Service

An unsuspected BL affordance enabling AL was discovered when students in both courses identified a tutoring service that mirrored their courses but were additional costs to students. The service essentially provided students with the same BL affordances as their courses: FTF lectures, online videos to reinforce concepts or to prepare for lectures, practice exams, and individual tutoring similar to office hours. Nevertheless, students paid $25, $50, or $75 to use the third-party affordances rather than the ones provided by the instructor. For example, students devoted time to attend the third party's in-person sessions and to watch their recorded videos but never attended the university instructor's office hours or watched the instructor's many studio-produced videos. Although some students indicated that doing well on the practice exams from the third party gave them a false confidence, they still engaged in AL practices with the materials provided.

Influence of BL Affordances on AL for Student Persistence

In response to BL4AL, students in both courses generally indicated that they either agreed or were neutral to BL and AL practices helping them continue in their respective courses and to take another science course. **Table 5** compares the mean aggregate scores and the average standard deviations of the responses in both courses. The students were asked to express how much they agreed or disagreed with a particular statement that related to student motivation, confidence, science learning, and identification as a scientist in the context of traditional learning (e.g., FTF lectures, office hours, and exams) or nontraditional learning (e.g., in-class clicker questions, online videos, and the learning management system).

The BL4AL survey also asked the students to rate how much the course influenced them to take another science course. Of the respondents, 57.4% of students in the physics course strongly agreed or agreed the course did influence, while 68.9% of students in the chemistry course strongly agreed or agreed. Using the results of the BL4AL as predictors to the students' persistence in the sciences, a significant regression equation with a medium effect size was found for both courses—$F(8, 218)=7.69$, $p<.01$, $f^2=.28$ for the physics course and $F(8, 293)=6.84$, $p<.01$, $f^2=.19$ for the chemistry course. The students' perceptions of BL for AL impacting their motivation, confidence, science learning, and identification as a scientist had a medium effect on whether they would continue their studies in the sciences.

Two BL4AL predictors (i.e., the students' motivation and confidence with traditional learning methods) were significant to predict whether the physics students would continue their study in the sciences. Only one predictor in the chemistry course, the students' confidence with traditional learning methods, was significant to predict whether they would continue in the sciences. The BL4AL results in the physics course explained 19% of the variance, while the results in the chemistry course explained 13% of the variance. This major finding indicates that, the students' motivation and confidence with traditional learning methods are significant predictors to why students may continue their studies in the sciences.

DISCUSSION

BL4AL Course Design and Implementation

The research findings indicate a discrepancy between how instructors design and how students consider which BL affordances enable or constrain AL. The physics and chemistry instructors intended the BL affordances, including FTF lectures, in-class clicker questions, online videos, and online homework, to help the student learning, yet the students' experiences indicated the BL affordances enabled, constrained, or did both for AL. For example, online homework can be more convenient for instructors and students to practice solving science problems, yet more specific instruction was required to help students solve a problem with multiple, interdependent parts.

Instead of focusing on whether a video was produced in a studio or in an office, students seemed to desire more poignant videos focusing on solving exam questions as seen by the time they spent watching the videos produced by the third-party tutoring service. The students' reporting of the service as a motivating and confidence-building factor was an unforeseen result to the research. More research is needed concerning the phenomenon highlighting that students paid extra money in addition to their tuition for similar BL affordances offered by the course (e.g., practice exams, online videos, FTF lectures) and that the extra cost motivated students to continue their studies in the course. Implications from research on student usage of outside tutoring services may influence future instructional practices and possibly even business models as to what BL affordances the university will provide versus the provisions of a third party. Additionally, related to student persistence, students may be more likely to continue with science courses that have a third-party counterpart that they may use to supplement them at-university learning experience.

Nevertheless, according to the multiple case study analysis, the BL affordance that showed the most promise for AL was the in-class clicker questions. Although research has shown that the use of clickers as an intervention can benefit learning of factual knowledge (Haak et al., 2011; Lin et al., 2013; Shapiro & Gordon, 2012) yet not help with the learning of conceptual knowledge (Shapiro et al., 2017), the students' practice in class and their reported use of in-class clickers may provide more insight to how other BL affordances can be used. As a low-stakes activity, students reported the in-class clicker questions helped them to establish their understanding of fundamental concepts and immediately pushed them to apply information just heard from the instructor to discussion or problem solving with their peers. The practice also aligned with the factors for student persistency by motivating students, increasing their confidence as students, increasing their science learning, and building a community as they speak to each other as if they were practicing scientists. More research is needed in how the principles of this activity, as seen also in mobile applications, can translate to other practices along the other dimensions of BL, e.g., in an online, asynchronous environment.

Status of BL for AL and Student Persistence

Despite efforts for more BL affordances to support science courses, the BL4AL survey results indicate that the students' motivation and confidence with traditional learning methods in science courses can predict students' persistence in studying the sciences. The results confirm that the students do not perceive the use of nontraditional learning methods as necessary to persisting in the sciences. One major implication may be that more training is needed for students to understand the use or how to value nontraditional learning methods as much as the instructors do or that the instructors may need more training. A second implication may be a more systemic one, in which science degree programs have not fully blended traditional and nontraditional affordances within their courses and still emphasize the need for and reward the students' attention to FTF lectures and in-person exams.

Funding: No funding source is reported for this study.

Ethical statement: The study was approved by the Institutional Review Board of University of Florida on October 30, 2015 with approval code: #2015-U-1224. All participants provided informed consent.

Declaration of interest: No conflict of interest is declared by the author.

Data sharing statement: Data of this article will not be made publicly available.

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