PRE-SERVICE SCIENCE TEACHERS' PERCEPTIONS ABOUT EFFECTIVE DESIGN OF BLENDED UNIVERSITY CHEMISTRY COURSES

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ABSTRACT

The aim of the study is to examine how blended learning can be used more effectively for university chemistry courses, based on the perceptions of students. The sample included 179 pre-service science teachers in year one through year four who had taken a university chemistry class. Qualitative data were gathered through open-ended questions and semi-structured interviews. The data were analyzed by using descriptive statistics and thematic content analysis.

The results revealed necessary design characteristics for an effective blended chemistry course from students' point of view regarding content of online instruction, the teaching methods, interface design, use of media and other visual elements, usability, design techniques, and facilitator role.

The results showed that instruction should be carefully planned and must be appropriate to student needs and characteristics, the content should not be too long or complicated, content should be prepared by experts in chemistry, include reliable and valid information, designed to promote the learning process by choosing appropriate visual elements and media, be consistent with the learning outcomes, and include evaluation questions.

Blended instruction should include various updated and easily accessible technological resources and tools to facilitate learning. The results also revealed that blended learning environment is most suitable for specific topics such as organic chemistry, acids and bases, the structure of atom and matter.

Finally, a blended learning component matrix was created and suggested to show the interactions between the categories based on the perceptions of the participants. The results of this study, therefore, suggest important implications for instructors when designing effective blended chemistry courses for pre-service science teachers.

Keywords: Blended learning, learner analysis, instructional design, chemistry, pre-service science teacher education.

INTRODUCTION

Blended learning, which links traditional classroom learning to e-learning activities (Singh, 2003), has gained the attention of educational researchers throughout the past decade. Blended learning combines various activities, including face-to-face instruction, live e-learning and self-paced learning. Graham (2006) defined several categories of blended learning systems: *enabling blends* provide additional flexibility and opportunities for learning through a different modality; *enhancing blends* provide additional resources and some supplementary materials online in a traditional face-to-face learning environment; and *transforming blends* are a radical transformation of the pedagogy, enabling intellectual activity that was previously impossible without the current technology. In blended learning, constraints on the schedule and location of learning are decreased, and self-paced learning opportunities (Wang, 2006) promote effective interaction between peers and the instructor (Delialioglu & Yildirim, 2007).

Institutions of higher education have readily adopted technological innovations, especially blended learning applications. Recent studies have shown that integrated online technologies and media enhance instruction and that face-to-face instruction can be supported by these technologies (Chew, 2008). Similarly, Delfino and Persico (2007) and Kay (2007) believe that integrating technology into pre-service teacher education programs is extremely important so that the next generation of teachers has heightened facility with instructional technology.

Numerous studies have been conducted to examine the effectiveness of blended learning applications for teacher education. Mouzakis (2008) found that blended learning is effective for advancing in-service teachers' information and communication technology knowledge, collaborative learning processes and educators' daily teaching practices. Specifically, a number of blended learning application studies have focused on science education. Pereira et al. (2007) found that blended learning was more effective than the traditional instruction of human anatomy in biology courses offered in the undergraduate curriculum. The authors observed that learners who experienced blended learning as part of their instruction improved their academic performance. Sancho et. al (2006) noted that virtual laboratory tools effectively complement face-to-face microbiology courses, providing experiments via simulations that would be costly to provide using real materials. Garrison and Vaughan (2007) showed that a blended chemistry course was effective when it was complemented by appropriate lectures, problem solving opportunities and direct feedback given to the learners.

Researchers have proposed a number of key factors that will aid the effort to use blended learning in the classroom. Pereira et al. (2007) stated that the achievement of blended learning is particularly dependent on organising the course in terms of student needs, the nature of the course content and the course objectives.

Palmer and Holt (2009) noted that students' satisfaction with online learning correlated to the quality of content supported by online activities, getting helpful and timely feedback on what they need to know to become successful and continuing interaction between instructors and learners as well as between learners and learners. Wagner, Hassanein and Head (2008) emphasised that the success of e-learning is dependent upon the collaboration of stakeholder groups: learners, instructors, educational institutions, content providers and technology providers.

This kind of collaboration increases motivation and allows a variety of concerns to be addressed. Yukselturk and Bulut (2007) stated that course content should include real-life patterns and should include interactive examples, multimedia applications and references. In addition, to create a high-quality learning environment, the content of the course should be updated frequently to meet the students' needs, and new technologies should be integrated. Delialioglu and Yildirim (2007) stated that not only should the blending of technologies occur, but also the blending of pedagogies, theories and instructional design. Mouzakis (2008) noted that the facilitator's support is critical to the success of blended courses to assure that the materials are appropriately designed to engage the learners and to encourage learning. Zheng and Smaldino (2003) emphasized that interactivity, adequate and frequent feedback from the instructors to support learners, support related to system use, learner satisfaction and planning the content to meet the needs of the learners in terms of learner characteristics should be taken into account. Lan (2001) noted that technology infrastructure should be another priority for institutions that intend to offer blended or online courses. Updated and adequate technology infrastructure increases the possibility of regular use of technology for educational purposes by both faculty and students.

Chemistry Courses in Science Teacher Education Program

Chemistry is one of the required courses in the science teacher education program in Turkey. Chemistry I and Chemistry II courses are offered in the first year of the program, and Chemistry III and Chemistry IV are offered in the second year (first, second, third, and fourth semesters of the program, respectively).

The first three chemistry courses include a four-hour theoretical session, and the last course includes a two-hour theoretical session per week throughout the fourteen-week semester. Students also have a two-hour laboratory both in the first and second semester of their first year of education.

Chemistry education cannot be exclusively taught through e-learning as complete mastery requires that lessons be supported by hands-on laboratory activities. On the other hand, simulations are very useful for developing practical skills (Burewicz & Miranowicz, 2005).

Moreover, Dalgarno et. al (2009) stated that a virtual chemistry laboratory is a very effective tool for familiarising beginner students with chemistry experiments. Therefore, blended learning might be suitable for teaching chemistry.

METHOD

Purpose

This study is designed to determine how blended learning can be applied effectively to the chemistry courses of pre-service science teachers by conducting a content analysis using various sources of information.

This study specifically focused on how instructional materials and technological tools should be designed to support chemistry learning in a blended environment by considering learners' expectations and priorities to use blended learning.

Research Questions

The following research questions were investigated:

- **What are pre-service science teachers' recommendations for the most suitable chemistry topics for blended learning?**
- **What are pre-service science teachers' perceptions about necessary design characteristics for an effective blended chemistry course?**

Sample and Participants

The sample included 179 pre-service science teachers during the 2010 spring semester. The participants' perceptions about the instructional design of a blended chemistry course were gathered through open-ended questions and semi-structured interviews.

The study also involved a comprehensive learner analysis process including the following steps, which were adopted from Dick, Carey, and Carey (2005):

- **Entry behaviours: The skills and facilities necessary to implement blended learning, such as a learner's level of computer and Internet use, were determined.**
- **Pre-service science teachers' recommendations for the most suitable chemistry topics for blended learning-we examined those learners having the most difficulty with chemistry topics in their chemistry courses rather than analysing prior knowledge levels of learners.**
- **General characteristics - The pre-service teachers' demographic data and their science backgrounds were examined through the assessment of self-reported data.**

The participants were selected using purposive sampling method based on the student being enrolled in or having completed a college-level chemistry course and currently being enrolled as science education majors while the survey was administered. Out of 188 possible participants, 179 responded to the survey. The distribution of the participants was as follows: 31.8% (57) 1st year, 22.3% (40) 2nd year, 22.3% (40) 3rd year, and 23.5% (42) 4th year. Overall, 50.8% of the learners had personal computers, 52% had Internet access, and 96.1% had an e-mail account.

In addition, the levels of computer use were as follows: 3.9% of participants were poor; 45.8% were medium; 45.3% were good; 4.5 % were excellent. The levels of Internet use were as follows: 4.5% of participants were poor; 37.4% were medium; 48.0% were good; and 8.4% were excellent.

The pre-service teachers ranged in age from 17 to 25 with a mean of 20.7. While 40.4% (73) of the participants were male and 59.6% (106) were female. In addition, most had a science background during their either secondary school or high school.

Data Sources

The data for this study were gathered using the following tools:

Open-Ended Questions and Interviews

Qualitative data were collected by having participants respond in writing to two open-ended questions, and through 15-20 minute semi-structured interviews with ten of the participants by the authors. The two written items were:

- **Please briefly describe the major factors that you think are the most important in designing a blended chemistry course.**
- **Which chemistry topics are best learned through blended learning?**

Data Analysis

Qualitative data from the open-ended questions were analysed using a content analysis method. Overall, 590 statements were identified within those responses. Each student's answers were read several times until all statements had been assigned to one of the following categories;

- **learner,**
- **facilitator's role,**
- **interface design,**
- **content,**
- **teaching process,**
- **technology, and**
- **communication.**

The data were independently coded by both authors using the identified categories to increase inter-coder reliability. A matrix was developed to reveal the interactions among the categories. Each vertical category in the blended learning components matrix explains the needs and concerns of the horizontal category.

The matrix was developed through the following steps:

- **Both authors proposed an initial matrix independently based on the categories of the participants' responses;**
- **the Cohen Kappa inter-rater agreement coefficient was calculated as 0.74, which is accepted as "good agreement";**
- **discrepancies were resolved iteratively;**
- **a senior e-learning expert examined the created matrix and then made additional suggestions, and**
- **the last version of the matrix was created.**

RESULTS

For the first research question content analysis method was used to determine learners' recommendations regarding the chemistry topics for which a blended chemistry course might be most useful.

The second research question determined the pre-service science teachers' perceptions of the most important design characteristics of a blended chemistry course, in particular what should be taken into account while designing instruction.

Pre-service Science Teachers' Recommendations for The Most Suitable Chemistry Topics for Blended Learning

Pre-service science teachers suggested that certain topics in the chemistry courses could be offered as blended learning. The most prominent findings were associated with the *Chemistry I* course (f=123, 44.24%); in particular, lessons related to the atom (f=29, 10.43%) and structure of matter (f=21, 7.55%), were suggested for blended learning.

The second highest frequency (f=83, 29.86%) of topics suggested as being amenable to blended learning was for the *Chemistry IV* course, which includes organic chemistry topics.

A total of 58 (20.86%) comments focused on the *Chemistry II* course. Acids and bases (f=30, 20.86%), was considered the most useful chemistry topic to be taught through blended learning.

The results showed that the least frequently referenced topics were associated with the *Chemistry III* course, which includes analytical chemistry topics.

Some of the science teachers made general comments regarding the most useful chemistry topics for blended learning, such as abstract chemistry topics (f=22), all chemistry topics (f=16), chemistry topics including experiments (f=13), theoretical chemistry topics (f=8), and chemistry topics requiring mathematical measurements (f=3).

Certain chemistry topics suggested by the pre-service science teachers as blended learning can be seen in Table 1.

Table: 1
Pre-service science teachers' suggestions for the most suitable chemistry topics for BL

Course	F	%	Topic	f	%
Chemistry I	123	44.24	Atom	29	10.43
			Structure of matter	21	7.55
			Periodic table	16	5.76
			Chemical bonds	11	3.96
			Gases	10	3.60
			Chemical reactions	10	3.60
			Elements and compounds	9	3.24
			Solutions and mixtures	8	2.88
			radioactivity	7	2.52
Chemistry II	58	20.86	Acids and bases	30	10.79
			Chemical equilibrium	9	3.24
			Chemical kinetics	6	2.15
			electrochemistry	6	2.15
			Solubility equilibrium	6	2.15
			Metals and non-metals	1	0.40
Chemistry III	16	5.76	Analytical chemistry topics	16	5.76
Chemistry IV	83	29.86	Organic chemistry topics	83	29.86
Total	278	100		278	100

Perceptions of Learners About The Design of An Effective Blended Learning

The pre-service teachers reported several important suggestions with regard to blended learning in chemistry courses.

The second open-ended question and interview responses were coded according to seven categories. The themes, sub-themes and frequencies are presented in Table: 2.

Learner

Some of the learners mentioned that a blended chemistry course should be designed according to learner characteristics and needs, and directed according to learner satisfaction by the course instructor.

The following comments were typical responses with respect to this sub-theme:

- **The characteristics of the intended audience that is learning the subject must be taken into consideration so that unnecessary information can be avoided. (Learner characteristics)**
- **The topics that the students need to learn should be presented in a fun and understandable way during the instruction. (Learner satisfaction)**

Facilitator Role

Most of the learners indicated that the facilitator's role is very important for designing a blended chemistry course.

Pre-service science teachers' common views in this category were as follows:

- **The course instructor should prepare the content of the blended chemistry courses.**
- **Students should be able to ask questions through a forum or by e-mail and should get a prompt response.**
- **Support can be provided by more than one instructor.**
- **The instructor should update the online piece of the course regularly.**

Interface Design

A high number of statements were made regarding the interface design. According to the learners, there should be a search engine for locating relevant information.

In additionally, the course should be arranged taking into account usability and design principles such as font style, font size, and colours.

One of the learners stated the following representative response:

A search engine will help students to reach the necessary information without wasting time.

Students should be able to obtain information easily. Page layout, colour tones, font size, and format should be considered when designing the blended course.

Teaching Process

The most frequent response from the open-ended question was consideration of the teaching process (f=164). Learners noted:

The sequence of the topics on the online piece should be compatible with the face-to-face piece. Topics should be explained in an understandable way.

Students shouldn't have any question at the end of the instruction. The duration of the online piece should be short since the online environment has a lot of distracting pieces. After a while students may not give enough attention to the course.

The online piece should be designed to help learning. The teaching process should be designed very carefully and students should be guided in every stage.

Content

A high number of statements (f=131) about the pre-service science teachers' views on the major factors related to the design of the blended chemistry courses were classified under the content category.

Within this category consideration of visual elements (f=59) and use of media (f=53) such as animations and simulations were more prevalent than other types of statements.

Additionally, it was noted that there should be evaluation questions at the end of each topic and that the chemistry information should be valid and reliable. Several of the learners made similar comments about each of the sub-categories:

The instruction should be supported by videos, animations, visual elements, and any related media pieces when needed. (Visual elements and media)

The accuracy and reliability of the content is really important. (Accuracy)

The instructor/facilitator should prepare well-structured questions to make students think and reflect. (Evaluation)

Technology

Some of the learners mentioned that the technology used for blended chemistry courses should take into consideration update regularity, infrastructure, and easy access. Illustrative responses were as follows:

The website should be updated as needed by the instructors. (Update regularity)

The online piece of the blended course should be open to the public. Everybody should be able to get information from the online piece. (Easy access)

It is essential to have a computer lab accessible by the department to use the technology effectively and to communicate easily. (Infrastructure)

One of the learners gave a particularly insightful comment regarding infrastructure:

I believe that it is very important to consider equality of opportunity. I don't believe that the blended instruction will be effective until every student has equal circumstances regarding Internet and computer access. I also believe that blended instruction will be more effective when students have similar computing education.

After establishing a solid background and infrastructure, we can then integrate cutting edge technology and scientific innovation.

Communication

A number of students stated that communication with peers and the instructor of the course is very important in terms of the quality of a blended chemistry course. One of the students said:

It should be easy to communicate not only with other students but also with instructors to get prompt feedback and answers to all questions.

The categories and sub-categories, frequencies, and illustrative quotations are also presented in Table: 2.

Table: 2
Pre-service science teachers' expectations for designing a blended chemistry course

Category	F	Sub-Category	F	Illustrative quote
Learner	32	Characteristics	17	It should be appropriate for the target group's needs and characteristics.
		Satisfaction	15	The web page should be fun. Even prejudiced students should take a look at it.
Facilitator Role	64			The facilitator should answer students' questions promptly
Interface Design	125	Search Engine	5	There should be a search engine on the web site.
		Usability	60	It should be easy to access to major chemistry topics on the web site.
		Design techniques	60	Font style, font size, and the colors should be chosen according to design principles.
Teaching Process	164			It should be used various teaching methods during the instruction process.
Content	131	Visual Elements	59	There should be videos about chemistry experiences.
		Media	53	Abstract concepts should be made more concrete by using animations.
		Accuracy	9	Information should be valid and reliable.
		Evaluation	10	There should be evaluation questions to test our knowledge.
Technology	45	Update Regularity	23	Information on the web site should be updated.
		Infrastructure	9	Each student should own a personal computer and computer laboratory should be used effectively.
		Easy Access	13	There should be no membership or password requirement.
Communication	29			Students should be able to in contact with each other

The interactions between the categories can also be seen in the blended learning components matrix (Table: 3).

Table: 3
Blended Learning Components Matrix

	Learner	Facilitator Role	Interface Design	Content	Teaching Process	Technology
Learner	Interact and share experiences with peers.	Interaction with facilitators and other instructors.	Provide feedback to facilitator about the page design.	Provide feedback to facilitator about the content design.	Learners should do research and homework at home.	Sufficient infrastructure needed to use blended learning. Adequate skill and knowledge to use BL
Facilitator Role	Provide effective and direct feedback to learners. Provide multiple instructor supports.	Interaction with other instructors.	Design synchronous and asynchronous tools to ensure effective communication.	Provide appropriate content to meet learner needs, Ensure validity and accuracy of the content, Ensure security of online tools,	To ensure knowledge transfer as effective as face-to-face learning. A good plan for the learning process.	Ensure the proper to use of technology. Be aware of the technological problems faced by the students
Content	Appropriate to learner expectations and needs. Useful resources for students' present and future use.	Content should be prepared by experts in the chemistry field. The website should be designed for facilitators to be able to give prompt feedback to students.	Content and interface design should be consistent	Content should be consistent. Examples from daily life. Animations, visualisations and videos of experiments, pictures, figures, and graphics should be included to ensure more concrete content.	Content should be designed to promote learning process. Various materials should be used to support learning.	Appropriate media should be chosen for content.
Interface Design	Appropriate to learner satisfaction.	Additional resources and facilitator's contact information should be available.	Navigation should be user-friendly.	Design to find chemistry topics easily. Material and interface design should be consistent.	Concept maps should guide the learners through the learning process.	Cutting edge technology should be used in the interface design

Teaching Process	**Learner should be informed about the duration of the teaching process.**	**A good plan for the teaching process.**	**Interface should be designed to promote learning process.**	**Teaching process should be consistent with content. Teaching process should be consistent with content**	**Various instructional methods should be used.**	**Various technological tools should be used during the teaching process**
Technology	**Synchronous and asynchronous tools should be used for learner to learner communication.**	**The facilitator should be well equipped in terms of technology.**	**Update regularity in terms of page design.**	**Update regularity in terms of knowledge and innovation in the field. There should be no membership or password requirement.**	**Abstract concepts should be made more concrete by using technological tools.**	**Technological problems should be eliminated as much as possible.**

CONCLUSIONS AND DISCUSSION

Previous studies demonstrated that blended learning applications are useful in many ways for teachers and for science education. A content analysis was conducted to determine pre-service science teachers' perceptions about how such a course could be designed according to perceptions and priorities of learners. In addition, this study examined the learners' perceptions of the essential factors necessary to design an effective blended chemistry course.

The qualitative data showed that a majority of the learners stated that the teaching process is a priority, with the over-arching theme being that the instruction should be carefully planned and responsive to student needs. Commonly, learners expressed that the process of teaching the content should not be too long or complicated. If the material is too lengthy or when students learn the material at their own pace, a negative effect can readily occur with dual mode presentation (Guan, 2009).
Moreover, learners stated that various teaching methods should be used and that instructions should be given step by step. Instructors need to consider effective teaching methods to ensure the quality of the instruction (Zheng & Smaldino, 2003).

Another important observation from the study is that the learners agreed that their needs and characteristics and their satisfaction about the course content should be taken into account when designing a course. Along these lines, many researchers stated that the achievement of blended learning is dependent upon the organisation of the course based on student needs, the nature of course content, and the course objectives (Zheng & Smaldino, 2003; Burewicz & Miranowicz, 2005; Pereira et al., 2007; Yukselturk & Bulut, 2007). It is necessary to determine the pre-service science teachers' motivations for using blended learning since designing a blended chemistry course requires a large amount of time and effort. Learners who have motivation and adaptation problems within the online environment may not be successful with the blended instruction (Yükseltürk & Bulut, 2007). However, students who consider themselves well informed regarding the use of technology indicated less anxiety and more confident about using computers (Lambert, Gong, & Cuper, 2008).

In addition, learners are more motivated to use new technology when they believe it is a necessary and useful tool (Lan, 2001).

Content organisation has a great impact on learning outcomes (Zheng & Smaldino, 2003). According to the learners in the study, content should be prepared by experts in chemistry, should include reliable and valid information, and should be designed to promote the learning process by choosing appropriate visual elements and media. Previous research reported similar results. Instructional designers need to be aware of the effects of visual elements and media on learning efficiency (Guan, 2009). In addition, blended learning helps students to perform difficult laboratory exercises through visual media such as simulations, virtual laboratories, and other digital resources (Sancho et. al, 2006). More specifically, the application of simulations and media allows for effective and individualised learning in teaching chemistry (Burewicz & Miranowicz, 2005). A resource that allowed learners to become familiar with the laboratory could have a major impact on their learning experience (Dalgarno et. al, 2009).

Moreover, learners stated that content should be consistent with the learning outcomes to motivate them to participate in their classes. As long as the learners do not see a connection between the course content and the learning outcomes, they will not be willing to take a blended course (Gerber, Grunt, Grote, 2008). Learners also stated that course content should include evaluation questions to assess the knowledge they acquired through blended learning. This assessment should include clear, constructive, and prompt feedback (Palmer & Holt, 2008).

The next most popular statements were related to the facilitator's role. This result is consistent with research demonstrating the importance of the facilitator's role in ensuring a high quality of blended learning (Wang, 2006; Mouzakis, 2008; Palmer & Holt, 2009; Goktas, Yildirim, & Yildirim, 2009).

The learners specifically stated that they needed effective and direct feedback about their problems and questions via forum or e-mail by the facilitator of the course. Timely feedback greatly increases the student's learning in online instruction (Wang, Wu, & Wang, 2009) as well as student satisfaction with the course (Palmer and Holt, 2009) Communication and interaction are other important issues in designing a blended chemistry course. Learners can affect the quality of online learning through communication with their peers and the course instructors (Yukselturk & Bulut, 2007). Various synchronous or asynchronous communication tools such as e-mails, blogs, chats, and forums provide a convenient place for learners to discuss the course topics (Ng, 2008). Learners should be encouraged to use these tools with each other and their instructors (Palmer & Holt, 2009). Learners also made many statements that fell into the interface design category. It was clear that usability and design technique were equal priorities for the participants. The quality of material can be improved by considering design principles. (Ozdilek & Ozkan, 2009). Stein, et.al. (2001) proposed that students' performances may be impacted by well-designed instructional materials.

The results affirm that blended instruction should include various technological resources and tools to facilitate learning. These technological tools should be updated regularly and should be easily accessible to design a high-quality learning environment (Yükseltürk & Bulut, 2007). The administration should also provide an adequate technology infrastructure, including a well-equipped computer laboratory.

In conclusion, content analysis showed that a blended chemistry course is an effective means of educating pre-service science teachers to ensure higher quality chemistry instruction. The results revealed that the content of online instruction, the teaching methods, interface design, use of media and other visual elements, usability, design techniques, and facilitator role should be taken into consideration when designing the blended learning. The results of the study also suggested that designing a blended learning environment is most suitable for specific topics such as organic chemistry, acids and bases, the structure of an atom, and the structure of matter. When blended chemistry courses are designed according to learner expectations, it can be concluded that the majority of the learners will benefit. Likewise, the results of the study have important implications for instructors designing effective blended chemistry courses for pre-service science teachers.

RECOMMENDATIONS

- **This study provides important suggestions for designing a blended chemistry course for pre-service science teachers. Several main and sub-categories arose from open-ended responses and interviews of learners.**
- **The interaction between these categories is shown in Table: 3. Based on our results, major recommendations for blended chemistry course design are as follows.**
- **Facilitators should ensure that the knowledge transfer in the online environment is as effective as face-to-face learning, which can be done through adequate planning. Instructors should provide constructive and timely feedback to learners' problems and questions. To sustain effective communication, either synchronous or asynchronous tools should be included in the online learning environment.**
- **Facilitators are also responsible for the validity and accuracy of the chemistry content, which should appropriately meet the learner expectations. Concrete content, examples from daily life, animation, visualisations and videos of experiments, pictures, figures, and graphics should be included in instructional materials.**
- **A search engine should be included to provide easy access to specific chemistry topics. Facilitators should be aware of the importance of update regularity, particularly page design and content.**
- **Learners should interact with their peers and the instructor of the course regularly, provide feedback to the facilitator about the page and content design, and do their research and homework about the topics.**
- **In addition, they should have the adequate skills and knowledge necessary to use blended learning.**

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