

Original Research

Evaluating the impact of video-only and video-assignment approaches on student learning in the computer-aided drug design course

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Abstract

Background: Asynchronous learning is now an established part of contemporary pharmacy education, affording students flexibility and fostering self-directed study. Nonetheless, the difference in effectiveness between modalities using assignments for formative assessment and ones that do not is unknown. **Objectives:** The current study aimed to explore two asynchronous learning approaches: a video-assignment approach, which included formative assignments as part of the instructional experience, and a video-only approach which did not have assignments associated with engaging with the asynchronous instructional material. This study sought to learn more about students' (1) knowledge acquisition, (2) perceptions of their learning experience, and (3) barriers that they faced during these modalities. **Methods:** A quasi-experimental cross-over educational design was developed using 44 pharmacy students enrolled in a summer course in computer-aided drug design, and two asynchronous topics were delivered: "Homology modeling and drug-receptor interactions" (video-assignment) and "Pharmacophore modeling and virtual screening" (video-only). After each asynchronous modality, students completed a brief knowledge assessment, and a survey regarding their learning experience and challenges. The data was analyzed by the Wilcoxon signed-rank test and McNemar test. **Outcomes:** Regarding knowledge acquisition, students in the video-only group had significantly higher scores (median = 6.0/10, IQR = 2.8) than their peers in the video-assignment group (median = 5.0/10, IQR = 3.0) ($P = 0.001$). Perceptions of the student learning experience were similar between groups, with 93.2% percent ($n = 41$) of learners agreeing that the video-assignment approach positively contributed to their skill development and 95.5% ($n = 42$) felt the same way in the video-only approach. The two most frequently identified barriers were lack of teamwork (40.9%, $n = 18$ in video-assignment, and 34.1%, $n = 15$ in video-only) and technical difficulties. **Conclusions:** Knowledge acquisition was greater in the video-only method compared to video-assignment. However, there was sustained positive engagement in both the video-only and video-assignment approaches and perceived learning outcomes were comparable. The results from the current study suggest that assignments may not be required for effective learning in this context and further studies are warranted to better understand effective asynchronous teaching methods in pharmacy education in the future.

Keywords: Pharmacy Education, Asynchronous Learning, Online Learning, Drug Discovery, Drug Design, Jordan.

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INTRODUCTION

Pharmacy education is currently undergoing a transformative shift towards innovative, student-centered approaches¹, which has allowed the emergence of asynchronous learning as a viable and widely recognized methodology due to its inherent flexibility and adaptability^{2,3}. This progression indicates that there is a need for updating our educational skills to prepare for the changing needs of pharmacy

education, and we must take a closer look at how effective some asynchronous teaching types². The need to explore asynchronous learning is made even more relevant due to the impact of COVID-19 on the teaching landscape, which promoted online learning pedagogy⁴. Nevertheless, with reported negative attitudes of pharmacy students and knowledge gaps, there is a desire to ascertain a more thorough understanding of the ways asynchronous learning, as it relates to pharmacy education⁵.

Online learning contains other types of teaching methods. Online teaches students via the internet. There are two forms of online teaching: fully online and blended learning. Blended learning combines online teaching with opportunity for students to engage with educators in the presence of each other (face-to-face). Both types of online teaching can also feature asynchronous learning^{3,6}. The interest in asynchronous learning is due in large part to some potential benefits for educators and students^{3,7}. Asynchronous learning happens via communication between educators and students, even when not together, either in time or space. Asynchronous learning provides opportunities for students to work on materials whenever is most convenient for that student; it is also easy to access learning materials^{3,6-8}. Students can work at their own pace, use critical thinking skills, and create their own answers, which can motivate them to become self-directed, life-long learners^{7,9,10}. Asynchronous online learning aligns education and technology and offers



highly effective pedagogical strategies that are challenging in traditional classroom settings. However, some instructors still prioritize in-person, real-time engagement over asynchronous learning. Furthermore, concerns have been raised about academic integrity in asynchronous settings^{3,7}. Thus, the use of asynchronous videos has been associated with assignments to ensure active student participation and learning, which has been found to relate significantly and positively to students' academic outcomes^{11,12}. However not all types of assignments contribute to the same level of engagement and learning¹³.

In our school of pharmacy, several courses are "blended". One of which is the "computer-aided drug design" course assigned for fourth year level students. In the blended courses one third of the material should be conducted in asynchronous mode. The most common design for the asynchronous part is for the educator to send short video segments with an embedded quiz or an assignment to ensure the students' learning and engagement.

Drug design aims to equip students with knowledge and skills essential for actively contributing to pharmaceutical innovation and development. It explores drug discovery and development, delving into the molecular intricacies that underpin pharmacological actions. Students engage with concepts such as structure-activity relationships, pharmacokinetics, and pharmacodynamics, gaining a deep understanding of how chemical structures impact therapeutic outcomes. An integral component of this course is the incorporation of computational methods in drug design, reflecting the contemporary tools and techniques employed in the pharmaceutical industry. From molecular modeling to virtual screening, students are exposed to cutting-edge technologies that amplify their capacity to design and optimize pharmaceutical agents. This interdisciplinary foundation ensures that students acquire a holistic perspective on drug design, recognizing its multifaceted nature and the collaborative efforts required in the field. The flexible nature of asynchronous learning accommodates the diverse needs of "Drug Design" pharmacy students, offering accessibility to course materials and facilitating engagement with complex subject matter at their own pace.

In this study, we aim to compare two distinct asynchronous teaching modalities within the "computer-aided drug design" course: one integrating assignments and the other without. In this comparison we explore pharmacy students' perspectives and evaluate the impact of these modalities on their knowledge acquisition and overall learning outcomes. By examining the student experience in both scenarios, we aim to uncover insights that will inform educators on the most effective ways to implement asynchronous teaching methods in pharmacy education.

METHODS

Study design, setting, and participants

This study adopted a quasi-experimental cross-over educational

design to gather feedback on students' perspectives regarding asynchronous learning through two distinct modalities. A total of 45 students, enrolled in the summer course for the academic year 2022-2023, specializing in computer-aided drug design, were invited to participate. The study involved the introduction of two new topics: "Homology modeling and drug-receptor interactions" and "Pharmacophore modeling and Virtual screening." Both topics were delivered via asynchronous videos. The first topic required the students to submit an assignment with a ten-point evaluation on a preset deadline. The second topic did not include a graded assignment. Instead, the students were informed that there will be a survey distributed at the end of the course to assess their knowledge and perspectives about both topics and the delivery methods. In addition, they were informed that the survey was not obligatory.

Videos development and data collection

Comprehensive videos were developed to enhance understanding, featuring various computational modeling tools, databases, and servers accessible online. The effectiveness of these videos was evaluated through feedback obtained via a survey. The videos covered the use of freely available online resources, such as the Uniprot database, RCSB protein databank, PDBsum, and Swiss model ExPASy for Topic 1. Topic 1 assignments were uniquely designed to prevent plagiarism and required students to build homology models for different proteins. Topic 2 introduced DS BIOVIA Discovery Studio software 2016 v16.1.0 x64 and ZincPharmer online server tool. After exposure to each learning modality, students were prompted to complete a survey using the Google Forms platform, distributed through Microsoft Teams.

The reliability of the questionnaire sections was assessed using Cronbach's alpha. The perception scale demonstrated acceptable reliability for both the video-assignment ($\alpha = 0.751$) and video-only ($\alpha = 0.843$) conditions. For the barriers scale, reliability ranged from good to excellent (video-assignment: $\alpha = 0.815$; video-only: $\alpha = 0.913$).

Survey development

Two meticulously crafted surveys were created, tested for validity, and subsequently distributed online. To ensure the reliability and validity of the questionnaires, two academics participated in evaluating the initial draft for content and face validity. Adjustments were made based on the insightful comments and feedback provided. Each survey consisted of four primary domains. The first section assessed students' demography including their gender, age, and GPA. The second section evaluated students' knowledge of the tools presented in every topic; where ten true or false questions were used. Each correct answer was scored as 1, while incorrect answer was scored as zero. The third section assessed students' perceptions of their learning experiences, which were expressed in 11 survey items. The last section evaluated students' perceptions of challenges encountered in their learning experiences, were



Table1. Demographic characteristics of the pharmacy students (n= 44)		
Parameters	n (%)	Median (IQR)
Age (years)		22.0 (1.0)
Gender		
o Male	17 (38.6)	
o Female	27 (61.4)	
GPA		
o Excellent	4 (9.1)	
o Very good	11 (25.0)	
o Good	17 (38.6)	
o Satisfactory	12 (27.3)	

IQR: Interquartile range

expressed by nine survey items. The first page of the survey was about the study objective, followed by an electronic consent where students were given the option of completing or halting their responses.

Ethics statement

Prior ethics approval was obtained from the Applied Science Private University ethics committee (IRB Approval Number: 2024-PHA-35), and the study meticulously adhered to ethical standards outlined in the World Medical Association Declaration of Helsinki guideline¹⁴. Clear communication was maintained with all participating pharmacy students, assuring them of the voluntary nature of their involvement and the confidentiality of their responses. An electronic informed consent was obtained after informing the participants about the study purpose, risks, and benefits.

Statistical methods

Students’ responses were coded and entered into a customized database using the Statistical Package for the Social Sciences (SPSS), Version 26.0 (IBM Corp., Armonk, New York, USA). Descriptive results were presented as median and interquartile range (IQR) for ordinal Likert scale variables, and percentages for nominal variables. Wilcoxon sign rank test and McNemar test were used to compare between knowledge scores and perceptions respectively, of the “Video-Only” and “Video-Assignment” Methods. For all statistical analysis, a P-value of less than 0.05 was considered statistically significant and all tests were two tailed.

RESULTS

During the study period, 44 pharmacy students (response rate 97.8%) participated and received two learning methods: the video-assignment method and the video-only method. The students had a median age of 22 years (interquartile range [IQR] = 1.0). Of the participants, 61.4% were female (n = 27) and 38.6% were male (n = 17). Regarding their Grade

Point Average (GPA), more than one-third of the students had either an excellent or very good GPA (34.1%, n = 15), while the remaining 65.9% had a good or satisfactory GPA (Demographics are presented in Table 1).

Students were presented with 20 statements to assess their knowledge of specific drug design techniques, with 10 statements covering topics delivered using the video-assignment approach and another 10 covering topics delivered using the video-only approach (Table 2).

Under the video-assignment approach, only 4.5% of the students (n = 2) were aware that PDBsum could be used to download their protein. Furthermore, just 15.9% of them (n = 7) knew that when using Biovia to identify drug-receptor interactions, there was no need to add all hydrogens to the ligand and protein. Additionally, around one-fourth of them (n = 12, 27.3%) recognized that Biovia Discovery Studio could not be used to visualize drug-receptor interactions online. In summary, the median knowledge score for students following the video-assignment approach was 5.0 out of 10 (IQR = 3.0).

In contrast, students following the video-only approach achieved better results, with more than 50% of the students correctly answering most of the statements. The least correctly answered statement, which indicated that conformation generation cannot be used in virtual screening, was answered correctly by only 13.6% of the students (n= 6). Overall, the median knowledge score for students following the video-only approach was 6.0 out of 10 (IQR = 2.8).

The Wilcoxon signed-rank test showed a significant difference in knowledge scores between the two learning approaches (Z = -3.429, p = 0.001), with a large effect size (r = 0.52), indicating a substantial improvement in the video-only condition.

In terms of students’ perceptions of the two learning approaches used in the drug design course (as shown in Table 2), the results revealed no significant differences between the two approaches (P > 0.05 using the McNemar test). The majority of students believed that both experiences positively contributed to their skills in computer-aided drug design (n = 41, 93.2% for the video-assignment approach and n = 42, 95.5% for the video-only approach). Furthermore, the majority of students felt that both experiences positively contributed to their knowledge in computer-aided drug design (n = 40, 90.9% for the video-assignment approach and n = 39, 88.6% for the video-only approach). For more details on students’ perceptions of the two learning approaches, please refer to Table 3.

Figure 1 illustrates the barriers perceived by students regarding the two drug design learning approaches, and the results indicated no significant differences between the two approaches (P > 0.05 using the McNemar test). The most commonly perceived barriers chosen by students for the video-assignment approach were the lack of teamwork (n = 18, 40.9%), followed by the non-availability of well-functioning devices (n =



Table 2. Assessment of students' knowledge about drug design technique using two different learning approaches (n= 44)

Study method	P value#	Correct answer	Number of students answered correctly	Knowledge score out of 10
			n (%)	Median (IQR)
Video-assignment method	I can use PDBsum to download my protein	FALSE	2 (4.5)	5.0 (3.0)
	I can use RCSB Protein databank to visualize drug-receptor interactions online	TRUE	30 (68.2)	
	I can use PDBsum to visualize drug-receptor interactions online	TRUE	27 (61.4)	
	I can use Biovia discovery studio to visualize drug-receptor interactions online	FALSE	12 (27.3)	
	When using Biovia to identify drug-receptor interactions, I need to add all hydrogens to ligand and protein	FALSE	7 (15.9)	
	I used Uniprot database, to get the fasta sequence of my template and target	FALSE	14 (31.8)	
	I used Uniprot database, to get the fasta sequence of my target	TRUE	39 (88.6)	
	Ramachandran plot is a method to optimize the 3D structure of the protein	FALSE	14 (31.8)	
	Ramachandran plot is a method to validate the quality of a protein	TRUE	26 (59.1)	
	An excellent homology model has a Z-score of less than 1	TRUE	29 (65.9)	
Video only method	I can use Biovia discovery studio for ligand-based pharmacophore generation	TRUE	40 (90.9)	6.0 (2.8)
	I can use Biovia discovery studio for conformation generation	TRUE	37 (84.1)	
	I can use Biovia discovery studio for virtual screening	TRUE	34 (77.3)	
	ZINCPharmer tool is used for pharmacophore generation	FALSE	11 (25.0)	
	ZINCPharmer tool is used for conformation generation	FALSE	11 (25.0)	
	ZINCPharmer tool is used for virtual screening	TRUE	25 (56.8)	
	Pharmacophore features are visualized in the same way in different software or tools	FALSE	13 (29.5)	
	Pharmacophore model is composed of pharmacophore features	TRUE	38 (86.4)	
	Pharmacophore models can be used in virtual screening	TRUE	37 (84.1)	
	Conformation generation can be used in virtual screening	FALSE	6 (13.6)	
Difference in knowledge score between the two methods using Wilcoxon sign rank test				P= 0.001

13, 29.6%). On the other hand, the most commonly perceived barriers chosen by students for the video-only approach were the lack of teamwork (n = 15, 34.1%), followed by the lack of enough time (n = 13, 29.5%).

DISCUSSION

After COVID-19, educational trends have shifted in an effort to address growing issues that significantly affect the learning environment. Asynchronous learning has emerged as a substitute for conventional methods¹⁵. Computer-based, asynchronous learning was found to be affordable, in addition to permitting self-directed learning and revision¹⁶. In Jordan, the use of e-learning in universities is not optional anymore, as it became a mandatory requirement by the ministry of higher

education and scientific research in 2021¹⁷. Thus, this study was conducted to test the effectiveness of two asynchronous teaching methods: the video-assignment method and the video-only method on delivering knowledge to pharmacy students regarding computer-aided drug design.

The obtained results in this study revealed that students felt that both approaches positively contributed to their knowledge in computer-aided drug design. However, the students were found to have better knowledge with the video-only approach, as reflected by their answers to questions related to the topics discussed in the videos. It was easier for the students to receive and understand the information when the whole lecture's topic was discussed by the lecturer in the pre-recorded video rather than letting them get the information through solving



Statement	Video-assignment	Video alone	P value#
	Strongly agreed/Agreed (%)		
I enjoyed this experience.	34 (77.3)	35 (79.5)	1
This experience positively contributed to my knowledge in computer aided drug design	40 (90.9)	39 (88.6)	1
This experience positively contributed to my skills in computer aided drug design	41 (93.2)	42 (95.5)	1
After this experience, I feel more confident dealing with computer software and tools used in drug design	38 (86.4)	35 (79.5)	0.453
After this experience, I feel more confident approaching “drug design” final exam.	29 (65.9)	25 (56.8)	0.289
This experience positively changed my opinion about chemistry-related courses (e.g. medicinal chemists)	33 (75.0)	28 (63.6)	0.227
This experience encouraged me to learn more about computer-aided drug design	37 (84.1)	35 (79.5)	0.625
This experience helped me to be me more independent in learning	34 (77.3)	33 (75.0)	1
This experience helped me increase my self-confidence	33 (75.0)	29 (65.9)	0.344
This experience helped me in time-management	31 (70.5)	31 (70.5)	1
My university provides the resources necessary for students for such an experience	33 (75.0)	32 (72.7)	1

#McNemar test

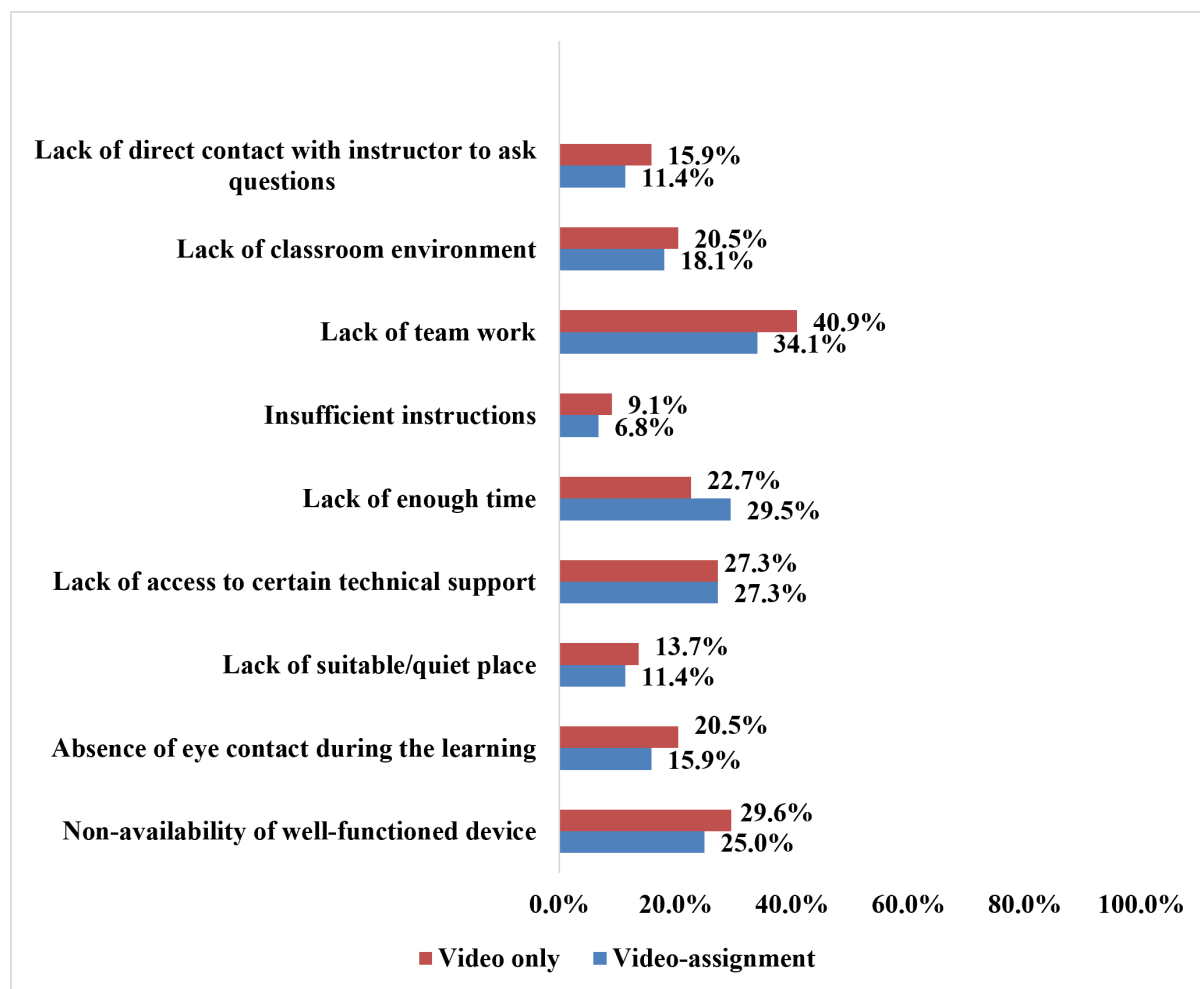


Figure 1. Barriers perceived by the students against the two drug design learning approaches (n= 44)

problems in assignments designed in relation to the lecture's topic. This indicates that the students participating in this study do not have the required skills to be self-learners, thus the didactic education method, even if it was not face-to-face with the lecturer, allowed them to gain better overall knowledge including better use of the databases used in drug design. Similar findings were observed in a prospective observational quasi-experimental study of the fourth year medical students at the David Geffen School of Medicine at UCLA in the United States of America (USA), where asynchronous, computer-based instruction were found to be inequivalent to traditional didactic teaching methods¹⁶. In addition, a study conducted in New York, including 2,036 students, revealed that the students had higher levels of learning community when they sensed stronger "teaching presence" by their instructors¹⁸. In this study, although both teaching methods are asynchronous, but in the video-only approach, the lecturer explained all the information related to the delivered topic in the pre-recorded video rather than leaving some for the students to self-learn during the assignment, which can make the students feel a stronger teaching presence, thus achieve better.

On the other hand, many published research in the literature found that asynchronous teaching allows students to learn at a time, place, and setting convenient for them^{16,19}, but in many cases it was found that the results obtained from online-learning and lecture-learning were quite similar²⁰⁻²³. In this study, the video-only approach mixes asynchronous learning, and the presence of the lecturer during the whole teaching process delivering the information in a didactic mode similar to the face-to-face teaching.

When it comes to the barriers that the students felt in the asynchronous teaching approaches, the lack of teamwork was identified in both the video-only and video-assignment approaches. In addition, unavailability of well-functioning devices was mentioned as a barrier in the video-assignment approach, and the lack of enough time was identified as a barrier for the video-only approach. Asynchronous teaching raised a concern for isolation before, due to the lack of teamwork in this approach of teaching¹⁹. The lack of enough time mentioned by the students for the video-only approach can be explained due to the need of the students to watch a whole pre-recorded lecture for 40-45 minutes.

Limitations of this study

There were several limitations to this study, related to the nature of the quasi-experimental cross-over design and the possible influence of topic and sequence effects. The two instructional topics may have varied in inherent difficulty or simplicity, as well as the students' background knowledge on the material presented in each. If they varied in such ways, apparent differences in knowledge could reflect not only variations in instruction, but also in the difficulty/simplicity or prior knowledge pertaining to the topics. Moreover, sequence effect (or order effect) may have also been present, given that students learned using the video-assignment methodology

before learning using the video-only methodology. As they proceeded through the course, they became more accustomed to the format, assessment procedures, and expectations of the course, potentially biasing the results toward the video-only methodology. Carryover effects are another possibility, in that the skills and knowledge obtained during the first instructional session may have supported performance in the subsequent topic. Without a washout period, and without counterbalancing topic order, these effects cannot be ruled out.

Additional limitations of this study may stem from the true/false knowledge assessment, which may have been prone to guess-based scoring inflation. The fact that students in the assignment-based condition engaged with little instructional scaffolding and feedback, given the nature and difficulty of the computational tools being employed, may have impacted their results. Cognitive load from simultaneously learning the material and maneuvering a complex computational tool may also have become an issue, along with time pressures imposed by learning the tool along with the material. Training students on how to approach self-directed learning and providing some feedback on assignments are further improvements for future studies, as there was no explicit instruction on self-directed learning and the provision of feedback was minimal in this study.

Randomizing or counterbalancing order effects and using equivalent instructional topics will be addressed in future studies; along with incorporating structured instructional scaffolding, evaluating feedback, and investigating the learning outcomes in asynchronously taught topics among novice self-directed learners.

CONCLUSION

Knowledge acquisition was greater in the video-only method compared to video-assignment. However, there was sustained positive engagement in both the video-only and video-assignment approaches and perceived learning outcomes were comparable. The results from the current study suggest that assignments may not be required for effective learning in this context and further studies are warranted to better understand effective asynchronous teaching methods in pharmacy education in the future.

AUTHORS' CONTRIBUTIONS

The authors confirm their contribution to the paper as follows: study conception and design: All authors; data curation: HRM and MA; analysis and interpretation of results: RAF; draft manuscript preparation: All authors; manuscript copy-editing: All authors.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.



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