



Impact Of Collaborative Self-Study On Medical Students' Learning In An E-Learning Inverted Classroom: A Biochemistry Seminar Study

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Abstract:

First, the students study by them and after that, the teacher leads a group session to consolidate and extend their knowledge. Following this method, students are supposed to prepare well ahead of the face-to-face meetings, so good materials and clear instructions for preparation are necessary. The focus of this study was to discover how various types of self-study material and instructions affect medical students' learning of biochemistry in an inverted e-learning classroom. Moreover, the study asked if students learning together in pairs during self-learning achieved higher gains than those who studied alone. Using an e-learning method and inverted classroom setup, the research was carried out in a biochemistry second-year medical seminar. The study team divided 196 students among three even groups, each of which received unique materials and instructions for the self-study period. I asked students to complete tests at the beginning of the face-to-face sessions to check what they knew. During the study, students filled in questionnaires assessing their motivation, how interested they were and how much they did self-study. Prior to on-site sessions, those who had collaborated during self-study achieved much better results on formative tests than those who studied solo. The role played by the actual materials used was small, since almost every student completed their preparation tasks. Both participants benefited from the dyadic learning approach and they both reported more motivation, greater interest in what they were studying and spent longer studying. According to the study, the help given during the self-study phase is much more valuable than the study materials themselves when it comes to learning in an e-learning inverted classroom. Teamwork led to the greatest achievements among the groups studied.

Keywords: flipped learning, preparing before class, teaching in medicine, an introduction to biochemistry and cooperative learning

Introduction:

A blended learning framework supports the inverted classroom (ic) which is structured into two key phases. Initially, students work on their own with the topic and then have sessions with others, where a guide supervises them as they apply their new information. Because the basics are learned in advance, there is more time for practical work when you meet in person. You can spend this extra time working on and exploring the lesson more confidently. So, passive learning is followed by more active learning which boosts the use of higher thinking abilities. Students



can pick up new skills during the part of the course taught in person. Previous research pointed out that the ic approach helps students learn more effectively. The technique has also been used effectively in medical education, dentistry, pharmacy and nursing and is regarded as a useful approach. Studies, as well as our own research, demonstrate that students are more motivated and satisfied when given instruction with the ic approach than when it's done just through lectures. Ic's success rests on students sufficiently studying while preparing on their own. Students need to be prepared for the in-person classes or they cannot work with the content effectively. Because of this, it is very important to give students slides and instructions in how to go about learning by themselves. Using an e-learning platform in students' self-study time after the lessons is being suggested because digital learning tools are now well known and accepted by students. This view is supported by the fact that students prefer digital content, according to a number of studies, in courses taught on these subjects. for many years, educators have praised the benefits of learning in groups. Doing group work can strengthen a learner's thinking abilities as well as help them develop effective social skills. In addition, people seem to be more motivated and have a more positive view of learning particular subjects when they are in smaller groups. Although methods exist for designing peer-based computer learning, there is not a lot of research on how collaborative technology-aided learning influences students during self-study periods in an inverted classroom. Additionally, how instructional resources and advice affect learning success is not fully understood in this context. The purpose of this study was to see if medical students learned more biochemistry when they used different study materials and methods during e-learning self-study in an inverted classroom. Specifically, the aim was to see if working in a pair during self-study improved both conceptual and practical knowledge when compared to studying alone.

Methodology:

The research happened as part of a biochemistry seminar called "from gene to protein," which medical students take as part of their initial, non-clinical training. The second term of the academic year usually sees this seminar run, with students present for two days, each for four hours. It is necessary for students to finish two self-study sessions which correspond to these scheduled sessions, during preparation. The students are sorted into groups ahead of the training and on average, 20 students belong to every group. In all, 196 medical students in their second year volunteered for the study. No one was forced to take part, so some students didn't do each task. In the descriptions for the accompanying figures or tables, the number of respondents for each item is provided. To form groups for the seminar, students were chosen through a centralized, computerized system that threw out random combinations. Now and then, students would change their group to fit their upcoming schedule. Guidelines for creating study designs and tips for individuals studying alone

In order to find out how various types of guidance affected learning in self-study, we randomly created three groups of participants (shown in fig. 1). Such groups differed according to what was given to work with and how much guidance they got during the preparation phase, including that first face-to-face meeting. Forty-two students were placed in the basic group, 76 students were put in the individual learning group and 78 students were divided into pairs for the collaborative dyad group. Participants all completed a form that asked about their age, gender, term in college and their secondary school and college grades. Another set of questions was used to learn about student motivation. All the learners watched the same educational videos before attending the next part of the training. Students in the basic group were instructed by email to



watch three educational videos before starting the first on-site phase. No special resources or questions to boost understanding were utilised with this group. Instead, in the first face-to-face session (known as phase 0), both the organizations and individual learning groups were given handouts to guide their study on their own. The materials were planned with instruction and meant for use on your own or together with another student. Each group got worksheets that explained step-by-step how to prepare for the site's on-site phases 1 and 2. Individually, the individual group was told to complete comprehension questions, but the collaborative group was offered the opportunity to work with a partner to do the same thing. These teams were created at the start of the onsite program when everyone was there. The teaching team had one member make the worksheets and two unrelated experts conducted a review of them. The effectiveness of the preparation was tested by carrying out knowledge assessments at the start of each on-site session. An additional visual timeline has been added (see additional file 1: figure s1 and additional file 2) which summarizes the schedule of all study activities, covering the order and timing of instructions, questionnaires and measurements. While three instructors ran the in-person sessions for each group, one lead educator made sure everyone got the same guidance. You can use videos and worksheets to learn on your own. We began self-study with three educational videos used in a previous study. I included different aspects in these videos. In the second part of self-study, two short videos showed how to use SDS-PAGE and DNA sequencing in biochemistry. Students in both small groups and alone were given work sheets with eleven comprehension questions for the initial phase and four for the second. These questions required both a theoretical and a practical understanding. At the outset, the course focused on biochemical fundamentals, followed by a single case study and a relevant question. About half of the questions had been used in a previous edition of the seminar. All the content was created by the main instructor and examined by a group including biochemical specialists and a psychologist. Even though it was unnecessary since the participants were anonymous and signed up on their own, the instructional team still managed ethical practices. All students were made aware at the start of the first real group session that taking part was optional and identity would be kept secret. Submitted questionnaires were taken as proof of informed consent. There was no reward or payment for anyone in the study. No one was required to join the surveys or assessments and all identities stayed completely anonymous during the process. One person decided not to participate and their data was not part of the analysis. When we noticed that questions had inconsistent or opposing answers, those cases were flagged, checked again and were removed from analysis when there was no way to clarify them. Not all of the studies had exactly the same number of participants, as illustrated in the accompanying tables and charts.

Result:

The demographic data presented in table 1 indicate that the three groups—basic, individual, and collaborative—were largely comparable across several key variables. The proportion of female participants ranged from 63.2% to 70.5%, with no statistically significant difference observed among the groups ($\chi^2(2, n = 193) = 1.87, p = 0.39$). The average age of participants was also similar across groups, ranging from 21.6 to 22.0 years ($f(2,190) = 0.31, p = 0.74$). Likewise, the mean semester level, final secondary-school exam grades, and first semester grades did not differ significantly between groups, suggesting that the students were relatively homogeneous in terms of their academic background and demographic composition. Presents group comparisons on basic motivation and interest related to their studies and specifically to biochemistry. Across all six motivational items, no statistically significant differences were found between the groups.



Students generally reported high levels of personal importance placed on studying human medicine, with mean scores ranging from 5.35 to 5.48 out of 6 ($f(2,190) = 0.37$, $p = 0.69$). The tendency to engage in academic discussion about their study subject also did not significantly vary ($f(2,190) = 0.42$, $p = 0.66$). Interest and motivation specifically related to biochemistry were moderate, with mean scores between 3.30 and 3.60, and again no significant group differences were detected (interest: $f(2,190) = 0.31$, $p = 0.73$; motivation: $f(2,190) = 0.62$, $p = 0.54$). These findings indicate that prior to the intervention, all groups were statistically comparable in terms of their demographics, academic performance, and motivational baseline. This homogeneity strengthens the internal validity of the subsequent comparisons related to the impact of instructional design and collaborative learning during the self-study phases.

Table 1: overview of the ages, genders, languages and ethnicities of participants

Variable	Basic group	Individual group	Collaborative group	Total	Group comparison
N	40	78	75	193	
Sex (female %)	68.0%	70.5%	63.2%	67.3%	N.s. ($\chi^2(2, n = 193) = 1.87$, $p = 0.39$)
Age (mean $\pm$ sd)	21.9 (± 3.25)	21.6 (± 3.18)	22.0 (± 4.05)	21.8 (± 3.50)	N.s. ($f(2,190) = 0.31$, $p = 0.74$)
Semester (mean $\pm$ sd)	2.01 (± 0.30)	2.00 (± 0.12)	2.03 (± 0.21)	2.01 (± 0.22)	N.s. ($f(2,190) = 0.65$, $p = 0.52$)
Final exam grade (mean $\pm$ sd)	1.52 (± 0.45)	1.49 (± 0.48)	1.54 (± 0.51)	1.52 (± 0.48)	N.s. ($f(2,187) = 0.47$, $p = 0.63$)
1st semester grades (mean $\pm$ sd)	2.35 (± 0.75)	2.29 (± 0.60)	2.28 (± 0.62)	2.30 (± 0.64)	N.s. ($f(2,187) = 0.28$, $p = 0.76$)

Table 2: items on basic motivation and interest – group comparison

Item	Basic group	Individual group	Collaborative group	Total	Group comparison
N	40	78	75	193	
It is of great personal importance to study human medicine	5.40 (± 0.92)	5.48 (± 0.79)	5.35 (± 0.95)	5.41 (± 0.89)	N.s. ($f(2,190) = 0.37$, $p = 0.69$)
I prefer to talk about the content of my study subject rather than other subjects	3.28 (± 0.88)	3.35 (± 1.18)	3.25 (± 1.05)	3.29 (± 1.07)	N.s. ($f(2,190) = 0.42$, $p = 0.66$)
I engage deeply with study questions beyond exam requirements	3.85 (± 1.00)	3.95 (± 0.95)	3.70 (± 1.25)	3.83 (± 1.07)	N.s. ($f(2,190) = 1.72$, $p = 0.18$)
I chose my current study	5.08	5.15 (± 0.98)	4.80 (± 1.20)	5.01	N.s. ($f(2,190) =$



path due to interest in the subject	(±1.02)			(±1.07)	2.09, p = 0.13)
My interest in biochemistry is very high	3.60 (±1.07)	3.55 (±1.19)	3.40 (±1.22)	3.52 (±1.16)	N.s. (f(2,190) = 0.31, p = 0.73)
My motivation to learn biochemistry is very high	3.45 (±1.02)	3.52 (±1.20)	3.30 (±1.27)	3.43 (±1.17)	N.s. (f(2,190) = 0.62, p = 0.54)

Figure 1: participant overview, study group comparison - ages, genders, and academic performance (n = 193)

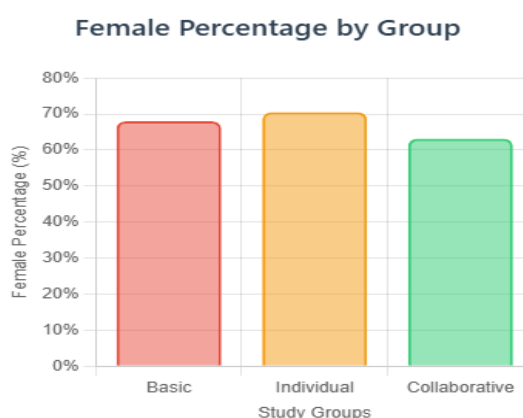
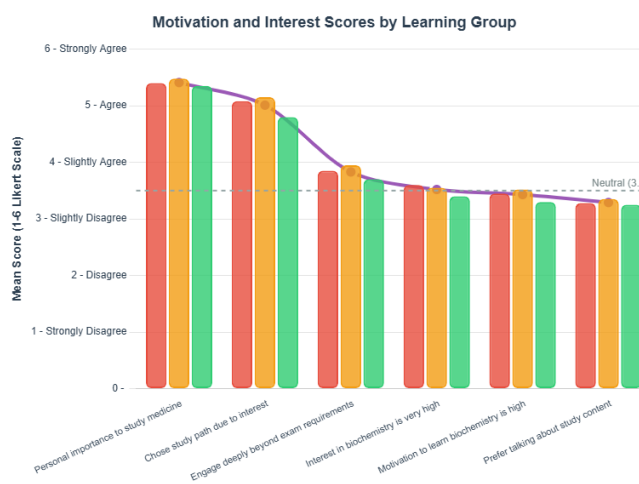


Figure 2: basic motivation and interest, group comparison across learning approaches (n = 193)





Discussion:

The researchers divided participants into the basic group, who viewed the videos alone and the individual group, who also answered questions related to what they saw in the videos. The examination revealed that the addition of comprehension questions to explanations did not greatly improve learning compared to those who did not use them. Such an effect may happen because the videos are detailed, meaning they may have explained everything well enough that the extra materials felt unnecessary. In comparison, the collaborative group which collaborated in pairs, achieved much better results than the active recall group on all knowledge tests. It demonstrates how group learning can raise student achievement in ic classes. Research has consistently shown that students involved in collaborative work usually perform better than their classmates who work on their own, mainly when solving problems or using what they have learned. The collaborative group noticed students having increased motivation, staying interested longer and better realizing the importance of the subject they were studying. They spent more time on their learning tasks than students in the basic and individual groups. These results agree with other studies that prove collaborative learning settings encourage students to be more engaged and persistent in their learning according to the study, strategies that involve group learning work better for student achievement in online ic approaches than just handing out extra study materials. The investigation points out that incorporating collaborative research assignments improves pupil learning no matter what methods are used. Future studies may look into adding small learning groups and using detailed collaboration scripts to increase student learning.

Conclusion:

The impact of instructional methods and study materials on how medical students learned biochemistry in an online ic system was analyzed in this study. Simply put, the way a self-study program is delivered is far more significant for learning results than the amount or subjects of the material. Collaborating in pairs led to better performance than studying alone, even if everyone had additional comprehension resources. Peer interaction clearly supports strong performance in the self-directed learning stage as shown by the collaborative group. Teamwork in schoolwork improved both students' conceptual and conditional test scores and encouraged them to work harder, enjoy learning, care more about the subject and spend more time learning. What we found matches what other researchers have described: being engaged in group learning helps people grasp content better, solve problems more efficiently and keep interest in the subject. While extra materials, like comprehension questions, had some theory value, they were not used much in this study. Perhaps the high standard of the videos led people to believe they didn't need more information. The basic facts suggest that improving individual study results depends more on how the material is presented than on the amount studied according to the study, sound instructional design forms a key part of the ic model. Getting students to study partnered—even just in small informal pairs—has been found to improve education outcomes and inspire better study habits. Because of these results, teachers creating ic-based courses should build structures for group learning and clearly direct students to use peer support as they study. Further investigations could study innovative ways to team up students to bring better outcomes to the approach.



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