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EVALUATING FULLY AND PARTIALLY ONLINE PROBLEM-ASED LEARNING IN LARGE BIOCHEMISTRY CLASSES: TUDENT ACCEPTANCE AND LEARNING OUTCOMES DURING THE COVID-19 PANDEMIC

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ABSTRACT
Sunieri and his team found that conventional problem-based learning (PBL) requires substantial resources since learning is guided in small groups. It is not well known what the advantages are of using PBL in a large lecture class. The study included a PBL case in a large biochemistry class delivered in a traditional lecture format and investigated whether students would accept a totally online or hybrid online PBL course. The students were put into three groups: those learning completely online in Group 1, those learning some online in Group 2 and those learning some online with lower grades in Group 3. Eight closed-ended questions and two open-ended questions, plus the results of a final exam, were used to evaluate whether students accepted fully online or hybrid Project-Based Learning in a large class. Using Kruskal–Wallis and chi- square tests, the closed-ended responses were interpreted. Data from open-ended responses was analyzed by making a word cloud using Wenjuanxing. Using one-way ANOVA, the final scores from each cohort were analyzed. All students rated both fully online and hybrid PBL highly. There were no meaningful differences in how effective PBL was perceived by Group 2 and Group 3. Final exam scores were not much different for Group 1 than Group 2. However, those in Group 1 said they liked PBL much more than those in Groups 2 and 3. When the open-ended questions were analyzed with a word cloud, the main feeling from the students was that they liked PBL. When students are involved, two well-chosen PBL cases seem to be the best way to learn biochemistry. Both online and combination PBL options in large classrooms were generally supported to go well with standard biochemistry lectures.

Key words: Problem-Based Learning (PBL), Online Education, Large Classroom, Biochemistry Teaching, Student Acceptability

INTRODUCTION
In 1969, a medical school started using PBL with the idea that students work through problems to guide their learning [1]. Most of the time, learners are assigned to groups where they discuss real

clinical problems with instructors present [2]. It is commonly accepted that group work within PBL encourages students and helps them build the important abilities they will need in their work. Educational institutions use many different ways to design and carry out PBL. Teachers sometimes use just one or more PBL cases with the regular curriculum, but some have revamped their whole curriculum to use PBL [5–8]. Because of these differences, the key part of PBL is introducing contextual problems to students who typically know very little about the topic [5]. Biochemistry forms the basis for medical education. Still, studying the underlying biomedical concepts in this area can be hard for many learners [9]. Biochemistry is typically recognized by undergraduates as possessing relatively little clinical significance [10]. Consequently, teachers in medical biochemistry need to link biochemical concepts to healthcare, including diseases, their causes, how they are treated, their outcomes, preventative measures and patient instruction. Additionally, educators strive to develop students' abilities to keep learning, so that they can give the best and latest care in their work after graduating [11]. Understanding the different metabolic pathways is important but can be very hard in biochemistry. Medical students should know how the many elements of metabolic networks function and depend on one another to describe different functions and diseases [12]. It is widely recognized by professional organizations that many college students studying biochemistry only learn the main concepts about metabolism [13]. Carbohydrate, lipid, amino acid and nucleic acid metabolism are main parts of the curriculum. Liver biochemistry such as its metabolism, transformation, bile acid functions and bilirubin processing, is also presented in the course. To support teaching and learning for metabolic biochemistry, a mixed approach with PBL activities and lectures was introduced to help future physicians. Presently, there is a lack of research on how fully online and partially online hybrid-PBL work in large classroom situations. This work highlights and investigates the outcomes of both fully remote and combined in-person and online large-class PBL programs centered on amino acid metabolism and liver biochemistry during the recent time of the pandemic.

MATERIALS AND METHODS

Participants and study setting

In the first semester of their second year, 689 undergraduate students taking regular biochemistry participated in this study. All the students were new to the concept of problem-based learning in their medical learning. In response to the global COVID-19 pandemic, classes were given partly or exclusively online. For this study, all participants were sorted into three groups: Group 1 were those who learned online completely and Groups 2 and 3 were partial cohorts (the first session was on campus and the second online), with 327, 163 and 199 students in those groups respectively. Age or gender were not significantly different among the groups. The academic performance of Groups 1 and 2 in the time before the course was the same. A group of students in Group 3 earn public support and, generally, go to community healthcare centers after finishing their education. Grades 1 and 2 had much greater learning ability and motivation than Group 3. Furthermore, each of these groups was randomly split into several smaller sections. Every subgroup had ten to eleven students and elected a chairperson and a recorder who helped lead the case discussions and recorded what happened. PBL groups in biochemistry were supported and coordinated by their instructors. Each large classroom was used for PBL case scenario sessions, with five subgroups in every room. Project-Based Learning sessions were led using video conferencing for online groups and direct support for face-to-face classes. In both methods, a facilitator supervised five separate subgroups.

PBL arrangements

When they had learned about carbohydrate and lipid metabolism using traditional lectures, students used online materials like objectives, slideshows and short videos to explore amino acid metabolism and liver chemistry without guidance from their instructor. Next, a problem-based learning (PBL) case that followed the progression from alcoholic fatty liver through alcoholic hepatitis to hepatic encephalopathy was presented. The case was based on actual patient stories developed by an experienced team of biochemistry instructors and clinicians to follow the curriculum's aims. While putting together the course, the team created an extensive guide for tutors. The PBL case review committee at the institution gave the case their approval. It dealt with main subjects in amino acid metabolism and liver biochemistry, together with metabolic aspects of carbohydrates and lipids and their mutual connections. The case was designed as two sessions, each session was 2.5 hours long. Before carrying out the study, the training of faculty and the method for using the questionnaire were the same for all participants. Since PBL was new to the students, we organized an introductory session about the approach and process before the first meeting. The senior students had conversations with the newcomers to guide them. During later sessions, students were taught to use the concepts of evidence-based medicine which point out that high-quality research supports better patient care. Moreover, for better learning, a learning contract was made to outline what was expected from tutors, chairs, recorders and all group participants. Students were expected to search for main questions with possible answers, suggest ideas for answers, collect evidence, discuss important learning points and explore these topics from a biochemical standpoint as well as a general medical standpoint. Students were told to use the Internet and reference books in biochemistry, diagnostics, internal medicine, as well as similar areas. The sessions were documented so that the results of each participant could be checked. After finishing each session, subgroups gave reports covering the four main aspects to their facilitators. Comments and suggestions from facilitators were added to the reports both before and after the second round which pointed out the project's strengths, areas that needed work and useful recommendations. In conclusion, the facilitators explained the main aims of the learning activity and the related biochemical topics.

Survey of students

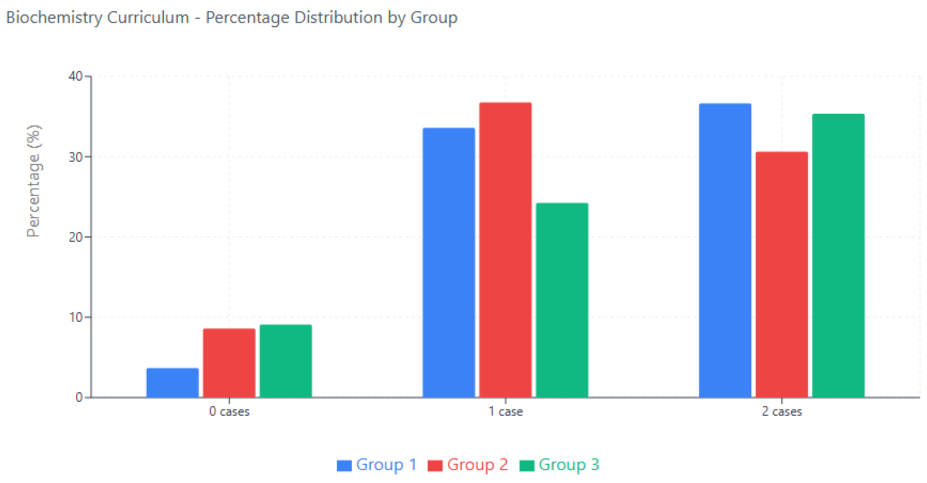
Drawing on previous research [6, 14–16], an online survey tool named Wenjuanxing (www.wjx.cn) was utilized to design a questionnaire consisting of eight closed-ended questions and two open-ended questions to assess students' views on the effectiveness of the PBL case scenario sessions. The survey included two open-response sections prompting students to answer: (a) What did you learn most from the PBL experience? (b) What are the advantages and disadvantages of the PBL sessions compared to traditional teaching methods? Additionally, what improvements do you suggest for the current PBL sessions?The evaluations were conducted immediately following the case scenario sessions. Participants rated six survey items (listed in Table A 2, Additional file 1) using a four-point Likert scale, where 0 represented strongly disagree or disagree, 1 indicated neutral, 2 corresponded to agree, and 3 signified strongly agree. Student participation in the survey was voluntary, and confidentiality and anonymity of responses were maintained.

RESULTS

Table 1. Students' expectations for the number of perceived useful PBL cases in biochemistry curriculum

Group	Students' expectation number	χ^2	P-value
	0	1	2
Group 1, n (%)	12 (3.67)	110 (33.59)	120 (36.63)
Group 2, n (%)	14 (8.59)	60 (36.75)	50 (30.62)
Group 3, n (%)	18 (9.09)	48 (24.24)	70 (35.35)

Figure.1Students' Expectations for Number of Perceived Useful PBL CasesBiochemistry Curriculum - Percentage Distribution by Group



Students from all three groups showed some interesting trends with regards to the usefulness of PBL cases in biochemistry. Most of the students in Group 1 thought that two examples of PBL would best support them, with 36.63% agreeing, just behind the 33.59% who felt one case would be best. Less than 4% of voters said that having zero COVID cases was enough for restrictions to be lifted. It appears that Group 1 learners realize the advantage of doing additional project-based work. The findings for Group 2 were close to Group 1 as 36.75% wanted only one PBL case, while 30.62% wanted two, though slightly more students (8.59%) chose no experiments compared to Group 1. It might be a result of small differences in the ways people in these groups learn or have experience. Verdicts from the third group were very interesting, since while the most popular answer (35.35%) picked two cases, 24.24% wanted only one and another 9.09% expected no cases at all. Such results may mean that everyone in the group is not equally involved or motivated. When statistical significance is measured by p-value, the results did not show much difference among the groups' expectations since the p-value was greater than 0.05. Students, in general, believe that making PBL cases a regular part of biochemistry instruction is the best way to help them improve their learning. In general, the data demonstrates that using the right amount of PBL cases supports different students and leads to effective results.

DISCUSSION

PBL relies mainly on its basic concepts and principles such as contextualized learning, constructive learning, working together and independent study. This is what gives PBL a clear advantage over simple lectures. Even so, the traditional approach of small group learning makes PBL very resource-heavy. This reason has greatly reduced the rate of using PBL in medical schools around the world. As a result, we need to learn more about using PBL in classrooms with many students. To our understanding, it is the initial study to examine how online or hybrid online PBL might work in a large biochemistry course. We found through our analysis that both the fully online and hybrid online versions of PBL offered valuable additional support to the standard biochemistry instruction in large groups. Achieving significant improvement in students' skills and competencies requires time, so relying only on a short sequence of PBL cases isn't reasonable. Yet, PBL clearly offers students a different learning experience to what they are used to in regular classrooms. There has been proof that face-to-face large-class PBL can be run in several different ways. One research example includes a hybrid-PBL biochemistry lesson for a big class, but their participants had different backgrounds, topics started with lectures, special attention was given to application in solutions and their cases were close to those of case-based learning. Another group evaluated using integrated learning activities in a large-class setting for PBL and the outcomes were just as good as those using small groups. An additional analysis proved that large-class PBL could be done well in a stomatology class. Even so, because of pandemics and people needing to collaborate globally rather than locally, large-class PBL is not always possible. What stands out from our research is that the majority of students have truly understood and practiced PBL. Consequently, online or hybrid online PBL offers a strong alternative to large-class PBL when it cannot be held in person. Many students think that traditional lectures are the most effective way to pick up short-term knowledge, according to the survey and the word cloud analysis. Therefore, having many PBL sessions could cause students to feel overwhelmed and unproductive because daily classroom tasks are very demanding now. According to former research, PBL implementation is sometimes blocked in certain areas because students are used to traditional classes, the nature of the subject and the sample group from smaller studies. They may be reasons for the results we got in our large-sample study. Three important factors affecting the success of PBL are tutor capability, student drive and the case scenarios. The design process for this study involved creating a case modeled on real medical scenarios, by a group of biochemistry instructors and medical practitioners highly experienced in writing PBL cases. Because our students join us from an area with deep cultural ties to alcohol use, the case closely follows real life. Life sciences were the main subject and through them, biochemistry was introduced as part of broader medicine topics. A detailed tutorial was made available to all tutors and experienced experts carried out their training. Even so, differences in student motivation could have impacted the perceptions of all groups. Those who took part in longer online courses in Group 1 were more likely to enjoy their experience than either of the remaining groups. As a result of the lockdowns because of COVID-19, real-life classes were quickly replaced by online courses everywhere. Thousands of medical students who took part in surveys across many schools found that, although online classes have their positives, learners still prefer in-person classes. People claimed that studying online helped them avoid traffic, improved their comfort, meant saving money and let them learn whenever they were ready. The disadvantages found in online learning were shaky internet, feelings of stress, a drop in interacting with people, less willing to study, difficulties in focusing and troubles with asking questions. In addition, spending more time at home increased people’s feelings of loneliness. Many participants experienced “Zoom fatigue” after dealing with too many video meetings, according to the poll. According to Attention Restoration Theory, people tend to feel less tired during meetings if they notice a sense of belonging to their group and positive social interaction. PBL helps tackles the fatigue medical students may experience when learning online. According to our results, there was no significant distinction in final exam marks between the two groups which may explain why Group 1 participants rated their program higher.

CONCLUSION

In this study, we effectively integrated fully online and hybrid online PBL approaches within a large classroom environment alongside traditional biochemistry lectures. Our medical undergraduate students positively received both fully online and hybrid PBL as valuable enhancements to conventional teaching. This study represents a novel attempt to implement fully or partially online PBL in a large-class setting within a specific academic discipline, potentially offering insights for broader adoption of PBL across various fields. Looking beyond the pandemic, to enhance the effectiveness of medical biochemistry education—particularly in the context of online delivery during future public health crises or inter-institutional collaborations—we recommend that medical schools incorporate fully online or hybrid online PBL components into the biochemistry curriculum.

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