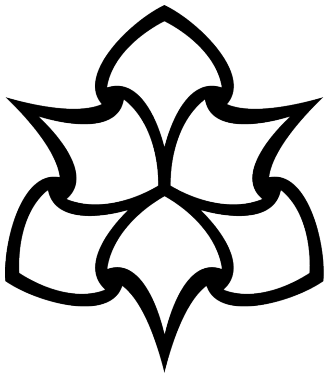

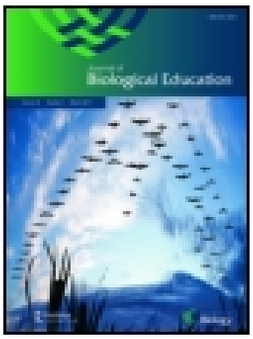

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Exploring the use of problem-based learning in clinical embryology training

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ABSTRACT

Problem-Based Learning (PBL) is an effective teaching method in many fields, in particular the medical disciplines. Clinical embryology deals with all aspects of assisted conception including insemination and embryo transfer. Clinical embryologists deal with daily issues that require troubleshooting and problem solving. The aim of this study was to explore and share the use of PBL teaching in a clinical embryology training programme. Students were given real-case scenarios and tasked with formulating a solution. A survey of questions to evaluate the PBL session was developed using a 5-point Likert scale. The scores obtained from these tests were assessed and analysed using Mann-Whitney *U*-tests ($p = 0.05$). The PBL teaching offered a format for students to develop critical problem-solving skills in a safe environment, which encourages learning through problem solving by creating a usable body of knowledge and clinical skill, which are imperative for clinical practice.

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Problem based learning; teaching; clinical science; embryology; education

Introduction

Clinical embryologists are clinical scientists who perform diagnostic services and assisted reproductive technology procedures, such as in vitro fertilisation (IVF), embryo culture and embryo transfers at hospitals and Assisted Reproductive Technology (ART) clinics. They are also involved in laboratory management, patient consultation and carry out research in reproductive science. They work with a multidisciplinary group consisting of clinical and biomedical scientists, nurses, and clinicians. Furthermore, in the clinic, the embryologists have to deal with daily issues that require critical thinking, troubleshooting and problem solving (Kovačič et al. 2015; Carroll 2019).

PBL is an established teaching practice in medical training, where medical students are encouraged to develop self-learning and clinical practice skills (Hung, Jonassen, and Liu 2008). The incorporation of PBL training in other healthcare science disciplines has grown in recent years and has been integrated into Clinical Science MSc programmes such as Clinical Bioinformatics (Davies et al. 2019). However, there are no studies to date describing the use of PBL in the training of clinical embryologists. Therefore, given the nature of the role of clinical embryologists, it was decided to incorporate PBL into the MSc with real case scenarios based on the practice of ART. These PBL sessions would enable the student to acquire problem-solving skills that would benefit them in both their clinical training and subsequent role as clinical embryologists in the ART clinic.

The concept of PBL as an alternative to traditional or teacher-led education was introduced in the Faculty of Medicine at McMaster University in Canada in the late 1970s (Neufeld and Barrows

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1974). Since then it has been implemented in universities all over the world including medical and dental schools, pharmacy, veterinary medicine and nursing programmes (Barrows 2000). The PBL approach is student-centred, where students are presented with a problem or scenario in a tutor-led small group. Students learn about a subject through the experience of problem solving and group discussions (Fatemeh et al. 2008; Wood 2003). Furthermore, PBL encourages active learning and is considered the most effective technique for students to learn. Wang et al. (2016) demonstrated using a meta-analysis that PBL was more effective than traditional teaching methods in improving knowledge and skills (Wang et al. 2016).

The aim of this study was to incorporate PBL teaching on the MSc as part of the clinical embryology training and to share and promote this teaching practice to other educational programmes allied to medicine such as clinical, healthcare and biomedical science, and particularly other programmes teaching clinical embryology.

Methods

Study population

Students undertaking the MSc in clinical science, specialising in clinical embryology, took part in a PBL session as part of their course. These students are also employed as trainee clinical embryologists in IVF clinics throughout the UK, where they carry out their clinical training – as part of The Scientist Training Programme (STP), which is a three-year programme of work-based learning, supported by a University accredited master's degree (Nshcs.Hee.Nhs). The students do this PBL session in the final year of the (part-time) MSc. Additionally, graduates of the MSc (who had taken the PBL sessions as students) working as qualified (practicing) clinical embryologists were also recruited for the study to evaluate how the PBL exercise was beneficial in clinical practice post training.

The total number of students who undertook the PBL session was 47 over three different cohorts, with 31 responding to the survey, including 15 student trainees (student) and 16 practising clinical embryologists (ClinEmb).

Study design

The students were presented with the principles of PBL teaching, and given instructions and guidance to perform the task. Each student was assigned a scenario where they had to research the case further, carry out root cause analysis (where applicable) and formulate a solution. A survey to gather feedback and garner the usefulness of PBL in clinical embryology training and clinical work was carried out with current students and with clinical embryologists (former students) (see Figure 1 for study design overview).

Each scenario consisted of a background to the case and instructions to guide them through the process. The scenarios presented were chosen based on real-life working cases that clinical embryologists experience in ART clinics. The clinical scenarios included cases of laboratory equipment breakdown, failed fertilisations, patient communication and adverse incidences in the clinic as recorded by the Human Fertilization and Embryology Authority ('Human Fertilisation and Embryology Authority'). For examples of scenarios used in this session, see Table 1.

The students were given two days of independent study and were encouraged to work in groups and confer – and to speak with their host clinic where necessary. This activity was not facilitated by the tutors and encouraged independent and group work outside scheduled class time.

After allowing a period of two days to research their case scenario, each student presented their PBL solutions in class – detailing the case they were assigned and providing the root-cause analysis and problem-solving activities they utilised, stimulating discussion and feedback, which was facilitated by a principle clinical embryologist and the course director. This activity was not part

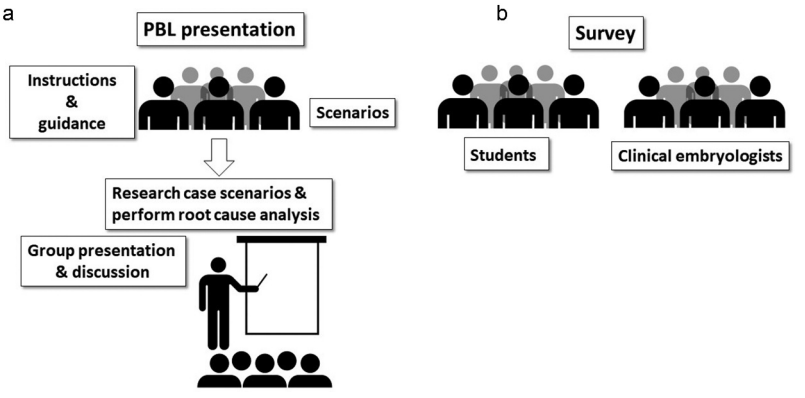

Figure 1. Study design .

of any summative assessment. However, verbal feedback was given to each student after their presentation.

A short feedback survey of questions to evaluate the PBL session was developed (Table 2) using a 5-point Likert scale (strongly agree – 5; agree – 4; neither agree nor disagree – 3; disagree – 2; strongly disagree – 1). The survey questioned the employment status of the respondents to decern which respondents were students or clinical embryologists (Q8). The survey also contained free-text response option so respondents could add further feedback on their experience of PBL and its efficacy (Q9).

The online survey platform Survey Monkey Surveymonkey.com was utilised. Students and practising clinical scientists (graduates) were contacted via email with a link to the survey to complete.

Ethical approval

This study was reviewed and approved by the Science and Engineering Research Ethics and Governance Committee (Ref: 1422). There was no potential harm to participants; anonymity of participants was guaranteed; informed consent of participants was obtained for publication.

Data analysis

Scores obtained from these tests were assessed and analysed in the statistical software SPSS 28 and statistical tests undertaken using the Mann-Whitney *U*-test ($p = 0.05$).

Results

Participants were asked to complete a short survey to gauge their understanding of PBL and reflect on their experience, based on a series of questions (Table 2). A comparison of the responses from the student trainees and the practicsng embryologist was analysed using the Mann-Whitney *U*-test (Table 3). There was no significant difference between both students and clinical embryologist. Both students and working clinical embryologists found the PBL sessions helpful to their training and applicable in practice. Both the student and clinical embryologists understood the PBL exercise (Q1) and agreed that the scenario simulated a real clinical situation (Q2). They agreed that they could develop self-directed learning (Q4) and felt they could deal with real clinical situations (Q5). There was also high agreement that the teaching enhanced their training as a clinical embryologist, and PBL is an important part in clinical scientist training. The survey included a question to

Table 1. Clinical scenarios.

Clinical Scenario	Description	Instructions
Difficult egg collection	You are on egg collection duty and have 5 cases to handle in the morning. Each has 10+ follicles in their charts. One collection has more follicles than predicted and you are struggling to keep up with the tubes. You pour the tube into the dish and search for cumulous oocyte complexes (COC) and place them in the holding dish. However, the tubes are piling up in the heating block.	Work out what you would do in this case considering the following: Are there any clinical procedures to carry out initally? What are the consequences/risks of this case? What measures would you put in place to ensure this does not happen again? Research this, using what resources are available, including contacting your clinical colleagues if necessary. Present a short report to the group.
Patient Complaint	A patient calls the clerical office asking to speak to an embryologist. You are the embryologist who took the call. The patient, a man in his early 40s, has a complaint to make. He describes an incident when he was on the phone to an embryologist who was speaking to him about their fertilisation check. He explains that the embryologist speaking was rude and abrupt. The embryologist did not clearly explain the results and he felt he was being patronised. After the call he was very upset and felt this person was not being professional and demands a formal apology.	Work out the steps you would take to investigate this case, considering the following: What is the first thing you would do? What paperwork do you complete? e.g.in house, HFEA incident forms (if appropriate)? Who do you inform? What measures would you put in place to ensure this does not happen again? Research this, using what resources are available, including contacting your clinical colleagues if necessary. Present a short report to the group.
Failed fertilisation and arrested embryo development	You are the first embryologist in the lab on a Saturday. When you start to check for fertilisation you notice that there has been a failed fertilisation, a failed division from day 2 to day 3 and arrested embryos at the morula stage in one of the incubators.	Work out the steps you would take to investigate this incident considering the following: What is the first thing you would do? How is this classified in terms of the HFEA's risk metric? What paperwork do you complete (in house, HFEA incident forms)? Who do you inform? What information do you relay to patient(s)? What measures would you put in place to ensure this does not happen again? Research this, using what resources are available, including contacting your clinical colleagues if necessary. Present a short report to the group.
Embryo storage incident	You take a call from a patient who has been living overseas. They have returned to the UK and call to ask about using their frozen embryos they left with you 12 years ago. Scenario 1 is that the embryos have been destroyed as the couple did not respond to letters sent to their old address and had not given us a new address. Scenario2 is that the audit system had failed, and the embryos were still in storage in breach of the HFEA regulations(!).	Work out the steps you would take to investigate this incident considering the following: What is the first thing you would do? How is this classified in terms of the HFEA's risk metric? What paperwork do you complete (in house, HFEA incident forms)? Who do you inform? What information do you relay to patient(s)? What measures would you put in place to ensure this does not happen again? Research this, using what resources are available, including contacting your clinical colleagues if necessary. Present a short report to the group.

encourage free-text responses (Table 2, Question 9). For the analysis, the respondents were apportioned to students (Table 4) and Clinical Embryologists (Table 5). All the respondents were clear on the principle and purpose of the PBL with emphasis on the usefulness of PBL training to practical application in their workplace.

Discussion

Clinical embryologists face many difficult situations in their working days, which can include dealing with equipment failure, developmental errors in embryo culture, user errors, and difficult patient and colleague interactions. Being equipped with the ability to solve problems quickly and effectively is an imperative skill for a clinical embryologist.

Table 2. Problem bases learning survey questions.

Question	PBL evaluation survey questions
Q1	The principle of the PBL exercise was well presented and understood
Q2	The scenario I was assigned simulated a real clinical situation
Q3	PBL kept me engaged in my learning more than in a traditional class
Q4	I was able to develop self-directed learning skills
Q5	The PBL activity increased my confidence to deal with real clinical situations
Q6	The PBL activity enhanced my training as a clinical embryologist
Q7	PBL is an important part in clinical scientist training
Q8	What is your current employment status?
Q9	What are the most effective things about problem-based learning? *
	Likert scale: *strongly agree – 5; agree – 4; neither agree nor disagree – 3; disagree – 2; strongly disagree – 1*
	*Free-Text Response

Table 3. Analysis of likert scale.

Student or Clinical Embryologist (ClinEmb)	N	Mean	Median	Std Dev	Std Err	Variance	Min	Max	U	Sig.
Q1 Student	15	4.7333	5	0.45774	0.11819	0.21	4	5	84.5	0.163
Q1 ClinEmb	16	4.4375	4	0.51235	0.12809	0.263	4	5		
Q2 Student	15	4.6	5	0.73679	0.19024	0.543	3	5	113	0.8
Q2 ClinEmb	16	4.625	5	0.5	0.125	0.25	4	5		
Q3 Student	15	4.8	5	0.41404	0.1069	0.171	4	5	90	0.247
Q3 ClinEmb	16	4.5	5	0.63246	0.15811	0.4	3	5		
Q4 Student	15	4.2667	4	0.59362	0.15327	0.352	3	5	115	0.861
Q4 ClinEmb	16	4.3125	4	0.60208	0.15052	0.363	3	5		
Q5 Student	15	4.5333	5	0.5164	0.13333	0.267	4	5	97.5	0.379
Q5ClinEmb	16	4.3125	4	0.60208	0.15052	0.363	3	5		
Q6 Student	15	4.8667	5	0.35187	0.09085	0.124	4	5	97.5	0.379
Q6 ClinEmb	16	4.625	5	0.61914	0.15478	0.383	3	5		
Q7 Student	15	5	5	0	0	0	5	5	82.5	0.14
Q7 ClinEmb	16	4.6875	5	0.47871	0.11968	0.229	4	5		

Test Statistics [spss 28] Mann-Whitney U. Exact Sig. [2(1-tailed Sig.)].*

This study set out to explore and share the use and the perception of PBL in the training of clinical embryologists. PBL has been used as an effective teaching tool in medical training for many decades and its efficiency has led this format of teaching to expand to other fields such as dental education (Fincham and Shuler 2001) and biomedical science (Jones et al. 2010). Moreover, Davies et al. (2019) investigated the use of PBL teaching in another Clinical Science MSc programme, Clinical Bioinformatics. This study demonstrated that this style of teaching was preferred by students to a more traditional lecture-based format and that the PBL approach enabled the formation of communities of practice within these cohorts, which encouraged individuals to engage in sharing new knowledge. This study emphasised the importance of group work and study through the formation of communities of practice and used PBL to encourage this (Davies et al. 2019). However, to date, the present study is the first to report the use and evaluation of PBL specifically for clinical embryology training.

The goals for this activity were embedded in the ethos of PBL teaching (Biggs J 2003) to encourage learning through problem solving by creating a usable body of knowledge and clinical skill, which are imperative for clinical practice.

The study design included collaboration with principle clinical embryologists in practice and researching the HFEA incident archive ('Human Fertilization and Embryology Authority') to construct real-case scenarios (for examples see Table 1). Each student was given a scenario and tasked with researching the background further and working out a solution using methods such as root-cause analysis (Iedema et al. 2006). After a period of self-directed learning, they presented their findings to the class where discussions ensued (Figure 1).

Table 4. Student free-text response.

Student	Free Text Response
STU_1	It was good to be given potential clinical scenarios that I may come across during my career and training. Seeing each student present their own PBL was a useful way of learning as individuals assess and respond to situations differently; the way some students presented their PBL and looked at the problem was different to how I would have done it, so it was a useful learning exercise
STU _2	Student led teaching, good presentation practice, good discussion stimulation
STU _3	It simulates real life problems that we could encounter as we become registered embryologists and allows us to gain a greater understanding of how to solve these problems.
STU _4	No response
STU _5	It addresses real clinical problems that we come across and allows us to find out how to solve these problems if they were to arise, which makes it easier to remember
STU _6	Real scenarios in embryology and the ability to research, present findings and discuss with colleagues. Learn a lot from colleagues about how different clinics perform or deal with a variety of scenarios
STU _7	As I had to go away and research the solution to the problem myself it meant that I thought about the problem more and I do feel I learned more this way than simply being presented the solution in a lecture or classroom format.
STU _8	No response
STU _9	It allows you to shape the direction of your learning and explore knowledge around a scenario/question.
STU _10	Enables students to think about how they would approach real life situations that they may have not previously found themselves involved in but could possibly do so in the future. Also helps with OSFA prep!
STU _11	Self-directed learning. Participation in discussion Not too large a group
STU _12	The nature of PBLs means having to work out how you are going to initially tackle the problem, working through a variety of possibilities before settling on the most appropriate action to take (if appropriate) and having to consider the entire clinical picture. Learning to work through these kinds of problems is extremely valuable, both in terms of the OSFA and for future clinical practice.
STU _13	Comparing between your solutions and how others would approach the problem; gain insight into another perspective
STU _14	It addresses real clinical problems that we come across and allows us to find out how to solve these problems if they were to arise, which makes it easier to remember
STU _15	No response

To evaluate the efficacy of the PBL teaching and the perceptions of the impact of PBL on training and clinical practice, participants were asked to complete a short survey. The participants of the survey included students on the MSc programme undergoing their training (STP trainee clinical embryologists) and graduates who were working as clinical embryologists (HCPC registered clinical scientists) who had done the PBL previously as students. The approach was to see if the PBL activity benefitted their training and prepared them for clinical work, reflecting on the PBL and its efficacy. As the students (STPs) were still in training when they took the survey, their experiences and approach would have been different due to the role they had in the clinic.

The Likert scale was used to gauge the level of engagement with the PBL sessions and how applicable is it to training and real-life cases in the IVF clinic. The Mann-Whitney *U*-test was used to investigate if there was a significant difference in response to the surveyed questions (Table 2). In response to all the questions, there were no significant differences between the students and the clinical embryologists (Table 3).

Question 9 on the survey – "What are the most effective things about problem-based learning?" – encouraged a free-text response. The responses were separated between those from the students (Table 4) and those from the clinical embryologists (Table 5). The responses from the students mostly reflected on the learning experience the PBL activity offered them. Some responded that the group discussion, learning how their fellow students dealt with their specific scenario, was a very useful learning experience (Table 4; STU-1, STU-2; STU_13). Other students mentioned how the scenarios may prepare them for workplace clinical cases (Table 4; STU-1, STU-3; STU-5; STU_10; STU_14). In addition to how useful the PBL teaching prepared students for clinical work and the learning experience – students were also pleased that the PBL teaching was and had the potential to assist with the final clinical assessment of their training (Independent Assessment of Clinical Competence (IACC). The IACC (formally Objective Structured Final Assessment (OSFA) assess your readiness to practice and can include case scenarios, which require some problem-solving.

Table 5. Clinical embryologist free-text response.

ClinEmb	Free Text Response
ClinEmb_1	They were real life scenarios and were useful for revising for the OSFA. Obscure issues with legislation and consent were covered which is exactly what you need to feel confident in this area of clinical embryology.
ClinEmb_2	Be prepared, understand and ready to deal with such events in real life.
ClinEmb_3	Simulating situations encountered in the real clinical setting. Small groups so not to feel intimidated by many people watching.
ClinEmb_4	It is easier to become engaged in real scenarios, and allows for learning from other people who work in different situations and will raise different ideas and perspectives
ClinEmb_5	No response
ClinEmb_6	Offers a potential real-life scenario in the confines of a supported environment which develops confidence and problem solving
ClinEmb_7	Working on real case examples one would encounter in a work setting.
ClinEmb_8	Relevancy and applicability in a real-life clinical setting. Being near-empirical, the newly acquired knowledge is more profound and 'durable'.
ClinEmb_9	Real life scenario learning in a supportive, low-pressure environment
ClinEmb_10	The various scenarios discussed during the PBL presentations helped to stimulate thought amongst the group about how we would perhaps approach certain real-life situations that could arise throughout our career. It gave an opportunity to problem-solve and has guided my experience since then to approach these problems in actual situations within my own clinic. It also was an essential part of preparing for/answering questions in the final OSFAs and during interview for a position as a clinical embryologist upon completion of the STP. I think the most effective aspect was to be able to learn in a way where we had to think for ourselves and solve issues, as we would troubleshoot in day-to-day life, rather than listening and taking in all the required knowledge through lectures. I would say that more PBL sessions during the MSc course could be beneficial to training as a clinical scientist.
ClinEmb_11	Working through an issue verbally with others
ClinEmb_12	Opportunity to become comfortable with talking to patient (actor) about treatment and explaining scientific concepts in an understandable way. Preparation for OSFA
ClinEmb_13	Thinking about a scenario from different perspectives. Rationally processing actions to potential situations
ClinEmb_14	It helps you to apply your knowledge and understanding. And helps to really consider how we work. Abstract ideas become real. One of the best methods to learn.
ClinEmb_15	No response
ClinEmb_16	Troubleshooting skills. Thinking outside the box. Sharing ideas and points of view. Thinking as a competent and trained scientist rather than a trainee (who may not normally be involved in troubleshooting issues).

When evaluating the free-text responses from the Clinical Embryologists there was more emphasis on how the exercise supported their role in the clinic. Respondents commented on how the scenarios simulated situations encountered in the clinics, and how the PLB prepared them for working as clinical scientists (Table 5 ClinEmb_2; ClinEmb_6; ClinEmb_7; ClinEmb_8; ClinEmb_9; ClinEmb_10; ClinEmb_13; ClinEmb_14; ClinEmb_16). There were comments on the usefulness of group discussion and learning from others (Table 5 ClinEmb_3; ClinEmb_4 ClinEmb_10; ClinEmb_16). Importantly, the teaching experience encouraged problem solving and applying their knowledge and understanding to the clinical workplace. Similarly, to the students' responses – the PBL activity and the learning experience gained were useful in their preparation for their final clinical assessment.

Furthermore, both students and clinical embryologists commented that PBL offered real-life scenario learning in a supportive, low-pressure environment. This approach is key for a successful PBL to meet the learning objectives and to foster self-directed learning, promoting collaborative working and developing clinical reasoning, judgement, and decision-making skills (Gibbon and Marcangelo 2012).

Although a brief study, the overall aim of this study was to introduce PBL to clinical embryology training and share this practice. However, no study goes without limitation. The number of participants was relatively low. This was due to the recruitment of small numbers of trainee clinical embryologists on the STP each year. The PBL was delivered over a three-year period and graduates working as clinical embryologists were asked to complete the survey in addition to studying students. This approach was to discern if the PBL bestowed some skills to working clinical embryologists. However, there was no significant difference between responses. This may be due to the nature of the training programme (STP), where trainees are employed on fixed-term

contracts to train as clinical embryologists – and undertake the MSc part-time. Throughout their training, they also provide clinical service and diagnostics once competent. Therefore, the perceptions of the students and clinical embryologists are similar due to being in similar working environments during study (training) and post training. Nevertheless, the importance of PBL in clinical embryology training was highlighted in the response.

Conclusions

The purpose of PBL is to promote students' self-directed learning and practical skills and prepare them for real case scenarios. This method of teaching is widespread in medicine, and it is an effective tool to equip students with applicable skills in their work setting and has been used successfully in biomedicine and clinical bioinformatics. This study explored the use of PBL in the training of clinical embryologists and it demonstrated that these clinical scientists value and benefit from this format of education in their training. It is therefore hoped that this study will encourage PBL to become embedded in other training programmes for clinical embryologists. Further work should include more case scenarios, the use of patient or clinical scenarios and some summative assessment to evaluate student learning at the end of the session.

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Disclosure statement

No potential conflict of interest was reported by the authors.

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Authors' contributions

MC conceived the study. MC and HRH developed the PBL scenarios and facilitated the PBL Sessions. MC wrote the manuscript. AM did the statistical methods. MC and AM analysed the data. All authors read and edited the manuscript.

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