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A comparison of face-to-face and fully online problem-based learning: Student results and staff experiences, 2014–2020

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[Correction added on 29 August 2022, after first online publication: Name of author Malena Della Bona has been corrected.]

Abstract

Issue addressed: Problem-based learning (PBL) is a student-directed pedagogy that promotes critical thinking, self-directed learning and communication skills essential for health promotion students and practitioners. This paper reports on student results, student evaluation and staff experience of PBL in the face-to-face and fully online environment in an undergraduate health sciences unit in an Australian university.

Methods: A single time-point study using quantitative and qualitative administrative student data (2014–2020) and narrative reflection from teaching academics (n = 5) was undertaken. Descriptive, independent t test and bivariate analyses for student results data were conducted; an inductive approach was used to analyse qualitative data and create codes.

Results: Student sample (n = 472) consisted face-to-face (n = 358, 75.8%) and online (n = 114, 24.2%) enrolments. Final Unit Mark was significantly higher for fully online students compared with face-to-face students in 2018 ($P = .007$) and 2019 ($P = .001$). Final Unit Achievement was significantly higher for fully online students compared with face-to-face students in 2018 ($P = .017$) and 2019 ($P = .043$). Three themes emerged: The PBL approach; Evolution of PBLs; Student skills and competencies.

Discussion: PBL allows students to learn through facilitated problem solving and strong collaborative skills. The face-to-face and fully online PBLs improved the student and academic staff experience, while supporting the development of critical thinking and self-directed research. Further, it supported students to develop their core health promotion competencies; and enhanced the online student learning experience.

So what?: Vital for contemporary, global graduates, the fully online PBL approach allows students to build critical academic and professional skills utilising current information technology relevant for collaborative professional practice.

KEYWORDS
communication skills, competencies, fully online, problem-based learning, technology

1 | INTRODUCTION

Problem-based learning (PBL) is a student-directed pedagogical approach in which students learn about an issue by attempting to find a solution to an open-ended real-world problem.[1–5] In contrast to traditional lecture-dominant teaching and passive learning approaches, PBL approaches prompt students to actively engage in knowledge construction and develop competencies across multiple contexts.[4,6,7] The problem-based approach is an active way for undergraduate students to work together in small groups, supported by a tutor to learn basic problem-solving skills to address a health issue scenario.[1,3] The PBL approach promotes critical thinking, reasoning and self-directed learning,[2,3,5,8,9] key skills demanded by every health promotion student, graduate and practitioner.[9]

In a traditional PBL approach, students take responsibility for their own learning under the guidance of a tutor, shifting the teaching-learning process from a passive to an active process.[4,8,9] The PBL approach is theoretically grounded in adult learning theory and constructivism and provides a better learning environment and improved outcomes in terms of graduate knowledge, skills and attitudes.[9,10] Briefly, the students define their learning objectives by using a set of prompts referred to as triggers from a pre-defined problem-based scenario. They learn within small, self-directed groups and carry out specific tasks, including self-directed study before returning to the group to discuss[4] and, then present their findings.[3,7,11] Learning in small groups provides students with an opportunity to develop group-based working and communication skills, and essential competencies in health promotion practice.[12] At the completion of the PBL process, it is anticipated students will have developed critical academic skills and communication competencies that will be utilised as a part of their health promotion accreditation and practice.[12,13]

Transitioning PBL delivery to online teaching has been met by challenges for both learning efficacy and use of technology.[6] Furthermore, issues with student confidence, preparedness and engagement with the learning materials and expectations, all impact the student experience of PBLs delivered fully online.[14] A 2014 systematic review of the use of technologies in PBL curricula described a range of technologies to both supplement and deliver PBL tutorials.[6] The review described a simple asynchronous online discussion board to supplement face-to-face tutorials through to an online three-dimensional community that enabled interactions with avatars to gather information.[6] In the past decade, there has been a rapid change in technology utilised in the tertiary education setting from mostly static to interactive platforms.[7,15,16] The benefit of these changes for online learning is the capacity to increase student engagement, enhance critical analysis and promote collaborative opportunities among students.[17,18]

There are many studies that suggest a positive impact of the PBL approach on health sciences' students learning.[4,6,10] We posit the PBL approach supports students in the development of core health promotion competencies[12] by providing a process for critically exploring health issues within a context.[6,9,10] Despite the well-established pedagogical advantages associated with face-to-face PBL in tertiary health education, there are associated logistic difficulties with moving to the fully online environment.[11] This paper reports on student results, student evaluation and the staff experience of PBL in the face-to-face and fully online environment in an undergraduate health sciences unit in an Australian university.

2 | PROBLEM-BASED LEARNING

The PBL approach was used as one component of a suite of assessments in an undergraduate unit titled "Physical Activity Promotion and Injury Prevention" delivered from 2011 to 2020. Originally, the PBL approach was developed for face-to-face delivery and individual assessment, aligning with the face-to-face mode of enrolment. Briefly, the PBL scenario introduced a set of triggers, followed by a tutor-led peer discussion, objectives were formalised; and the PBL process was facilitated by the tutor in real-time. Students undertook individual research and an individual oral presentation formed part of the assessment (Figure 1). In an attempt to duplicate the face-to-face experience for the fully online student (including delivery and assessment), the PBL approach was modified five times over the period 2014–2020 (Figure 1). Action research is a recognised pedagogical approach using reflection to build and refine teaching approaches for improved student outcomes.[19] The academic teaching team utilised reflection and observation[19] as part of an action research process to inform the refinement of the PBL approach over 7 years.[20,21] The fully online PBL format evolved from the traditional PBL delivery[9] using the student Learning Management System (LMS) Blackboard[22] delivering static "text only" triggers with no peer-to-peer interaction (Version 1 [V1]), to a fully integrated virtual learning environment using the LMS and collaborative peer-tutor option (V5) (see Figure 1). The changes for fully online students included: how content was delivered; the development of clear online protocols to support student expectations and critical discussion[23]; provision of a virtual learning environment[1]; and a shift to a group assessment (Figure 1).

3 | METHODS

A single time-point study, including evaluation of quantitative and qualitative student data and qualitative narrative reflection from teaching academics, was undertaken. Ethics approval for the research was granted by Curtin University's Human Research Ethics Committee (approval HRE 2022-0031). As only de-identified administrative data were used, consent from students was not required; however, consent was obtained from the data custodians (Faculty of Health Sciences, School of Population Health) to access student results data retrospectively and from academic staff involved in the PBL approach.

3.1 | Participants

Existing administrative data for a public health first-year unit at an Australian university from semester 2, 2014 through semester 2, 2020 were used in this research. Participants were undergraduate

PBL Component	Version 1 (V1)	Version 2 (V2)	Version 3 (V3)	Version 4 (V4)	Version 5 (V5)
	2014	**2015**	**2016-17**	**2018**	**2019-20**
Trigger Presentation	Static (text)	Static	Static	Static	**Triggers provided as podcasts**
Trigger Discussion	Student ↔ tutor email	**Asynchronous discussion board**	Asynchronous discussion board	Asynchronous discussion board	Asynchronous discussion board
Critical thinking Online protocol	Not used	**Protocol introduced**	Protocol for critical thinking	Protocol for critical thinking	Protocol for critical thinking
Learning Objective Allocation	Individual	Group	Individual	Group	**Group via *Collaborate Ultra***
Research	Individual	Group	Individual	Group	**Group via *Collaborate Ultra***
Assessment(s)	**Individual written submission**	**PowerPoint** Individual written submission	***Screencast O'Matic presentation*** Individual written submission	**Narrated PowerPoint** Individual written submission	**Virtual group presentation via Collaborate Ultra** Individual written submission

Bold denotes change introduced to the delivery or process

FIGURE 1 The changes to fully online PBL delivery 2014–2020

students who had self-selected into either face-to-face or fully online enrolment mode. The data were de-identified and no demographic data were available. In addition, academic staff who had taught the public health first year unit were invited via email to participate in an individual interview (n = 5). The recruitment email explained the study aims and asked interested staff to contact the research assistant.

3.2 | Measures

3.2.1 | Final Unit Mark and Final Unit Achievement

For all students, the final mark for the unit was calculated by summing weighted marks across all assessments in the unit, creating a mark out of 100. A categorical variable Final Unit Achievement was created using: 0%–49% = Fail; 50%–69% = Pass; and 70%–100% = Distinction.

3.2.2 | Overall PBL Mark and PBL Achievement

For all students, the raw score for each individual PBL assessment task (1–3) was converted to a mark out of 100, as the weighting for each assessment task had changed. An overall PBL Mark for the unit was calculated by summing the individual PBL assessment marks and converting to a mark out of 100. A categorical variable PBL Achievement was then created using: 0%–49% = Fail; 50%–69% = Pass; and 70%–100% = Distinction.

3.2.3 | Student evaluation

Student feedback on their learning experiences was available via the university's online system known as eVALUate.[24] This included both quantitative (agreement with 11 items), and qualitative (open-ended comments) for the period 2014–2020. Students indicated their

agreement with each of the 11 items using a 4-point Likert scale, ranging from Strongly Agree to Strongly Disagree, with Unable to Judge also a response option. Items included "*The assessment tasks in this unit evaluate the achievement of the learning outcomes*". Two open-ended items asked "*Please comment on the most helpful aspects of [unit name]*" and "*Please comment on how you think [unit name] might be improved*". The de-identified aggregated feedback from students was made available to the unit coordinator (JEL) at the end of each teaching period.

3.2.4 | Interviews

A semi-structured discussion guide was developed for the individual academic staff interview. Interviews were conducted by the research assistant (BN) to avoid any concerns about power imbalance[25] from the lead authors (JEL and FL) who had also taught and coordinated the unit. Before conducting the interviews, the purpose of the study was explained and participants' informed consent for their involvement in the research was obtained.

Individual interviews (face-to-face [n = 2] and telephone [n = 3]) using the pre-prepared guide were conducted and were of 20–30 minutes duration. Interviews were audio-recorded and transcribed.

3.3 | Analysis

Existing student results were de-identified and imported into SPSS version 27[26] for analysis. Descriptive statistics were used to summarise enrolment mode. Independent sample t-tests were conducted to compare Final Unit Mark, Overall PBL Mark and mode of enrolment. Associations between mode of enrolment and Final Unit Achievement, and mode of enrolment and PBL Achievement for each year were determined by calculating bivariate Pearson chi-square tests. P values <0.05 were considered statistically significant (two-tailed). Only significant results are reported.

Aggregated de-identified student feedback data (quantitative and qualitative) were downloaded from the university system and entered into Microsoft Excel (quantitative) and Word (qualitative). Due to small cell sizes, statistical tests were not conducted for the quantitative student evaluation data, they were analysed using Microsoft Excel and proportions were reported. Qualitative student evaluation data were subjected to general inductive coding to identify emerging themes.[27] The individual academic interviews were fully transcribed verbatim using Otter.ai[28] and subjected to general inductive coding to identify emerging themes.[27] The research assistant (BN) and one researcher (FL) performed the qualitative analyses independently, and then met to discuss and confirm key themes for both sets of data. The general inductive approach is a straightforward, easily used, systematic set of procedures for analysing qualitative data and provides reliable findings.[27,29] Academic staff and student quotes to support themes were identified to highlight findings and complement the results.[30]

TABLE 1 Final Unit Mark and Overall PBL Mark mean (M) and standard deviation (SD) by mode of delivery 2014–2020 (n = 472)

Year (n)	Final unit mark M ± SD	Overall PBL Mark M ± SD
2014 (n = 81)		
Face-to-face (64)	70.6 ± 9.5	79.8 ± 10.3
Fully online (17)	70.6 ± 7.7	77.3 ± 10.4
2015 (n = 88)		
Face-to-face (64)	71.0 ± 10.2	76.9 ± 16.0
Fully online (24)	70.6 ± 8.4	67.6 ± 13.6*
2016 (n = 82)		
Face-to-face (60)	73.6 ± 10.1	75.7 ± 10.2
Fully online (22)	75.2 ± 12.5	75.5 ± 14.8
2017 (n = 70)		
Face-to-face (53)	69.7 ± 9.8	70.0 ± 11.3
Fully online (17)	73.8 ± 11.5	74.0 ± 16.7
2018 (n = 58)		
Face-to-face (48)	69.1 ± 9.9	73.0 ± 8.7
Fully online (10)	76.3 ± 6.2*	76.3 ± 6.6
2019 (n = 51)		
Face-to-face (38)	73.5 ± 8.1	76.1 ± 7.7
Fully online (13)	80.2 ± 4.6*	79.7 ± 5.1
2020 (n = 42)		
Face-to-face (31)	74.0 ± 10.3	67.5 ± 12.1
Fully online (11)	71.8 ± 10.3	66.5 ± 10.6

PBL, problem-based learning.
*Denotes a statistically significant difference ($P < .05$).

4 | RESULTS

An overall sample size (n = 526) consisting of face-to-face (n = 396, 75.3%) and fully online (n = 130, 24.7%) students were enrolled in the undergraduate unit 2014–2020. Students who did not attempt all assessments and were deemed Failed/Incomplete (n = 54, 10.3%) were removed resulting in a final sample size (n = 472) whereby students were enrolled face-to-face (n = 358, 75.8%) and fully online (n = 114, 24.2%).

4.1 | Final Unit and Overall PBL Marks

The results for students' Final Unit Mark and students' Overall PBL Mark by mode of delivery for the period 2014–2020 are reported in Table 1. The Final Unit Mark was significantly higher for fully online students compared with face-to-face students in 2018 ($P = .007$) and 2019 ($P = .001$). The Overall PBL Mark was significantly lower for fully online students compared with face-to-face students in 2015 ($P = .014$). The Overall PBL Mark was higher for fully online students compared with face-to-face students in 2017, 2018 and 2019, but these were not significant.

TABLE 2 Final unit and overall PBL achievement by mode of delivery 2014–2020 (n = 472)

Year (n) n = 472 Mark achieved (/100)	Final unit achievement % (n)		Overall PBL achievement % (n)		
	50–69	70–100	0–49	50–69	70–100
2014 (n = 81)					
Face-to-face (64)	50.0 (32)	50.0 (32)	3.1 (2)	7.8 (5)	89.1 (57)
Fully online (17)	52.9 (9)	47.1 (8)	0.0 (0)	17.6 (3)	9.9 (8)
2015 (n = 88)					
Face-to-face (64)	45.3 (29)	54.7 (35)	1.6 (1)	20.3 (13)	78.1 (50)
Fully online (24)	45.8 (11)	54.2 (13)	12.5 (3)	37.5 (9)	50.0 (12)*
2016 (n = 82)					
Face-to-face (60)	28.3 (17)	71.7 (43)	1.7 (1)	23.3 (14)	75.0 (45)
Fully online (22)	27.3 (6)	72.7 (16)	4.5 (1)	31.8 (7)	63.6 (14)
2017 (n = 70)					
Face-to-face (53)	49.1 (26)	50.9 (27)	5.7 (2)	47.2 (25)	47.2 (3)
Fully online (17)	41.2 (7)	58.8 (10)	5.9 (1)	23.5 (4)	70.6 (12)
2018 (n = 58)					
Face-to-face (48)	52.1 (25)	47.9 (23)	-	29.2 (18)	70.8 (34)
Fully online (10)	10.0 (1)	90.0 (9)*	-	30.0 (3)	70.0 (7)
2019 (n = 51)					
Face-to-face (38)	31.6 (12)	68.4 (26)	-	13.2 (5)	86.8 (33)
Fully online (13)	0.0 (0)	100.0 (13)*	-	7.7 (1)	92.3 (12)
2020 (n = 42)					
Face-to-face (31)	32.3 (10)	67.7 (21)	9.7 (3)	35.5 (11)	54.8 (17)
Fully online (11)	36.4 (4)	63.7 (7)	9.1 (1)	49.5 (5)	45.5 (5)

PBL, problem-based learning.
*Denotes a statistically significant difference (P < .05).

4.2 | Final Unit and Overall PBL Achievement

Bivariate analyses found a significant difference in the Final Unit Achievement category for fully online students compared with face-to-face students in both 2018 (P = .017) and 2019 (P = .043). There was a significant difference in the Overall PBL Achievement category for face-to-face compared with fully online students in 2015 (P = 0.013) (Table 2).

4.3 | Student evaluation

Overall (n = 521) students were eligible to complete the student evaluation survey of which (n = 148) responded, with a response rate of 28.4% (Table 3). The percentage of students agreeing with each item on the student evaluation questionnaire are presented by study mode and year in Table 3. "*I make the best of the learning experience in this unit*" and "*I think about how I can learn more effectively in this unit,*" achieved 100% agreement with fully online students consistently from 2016 to 2020, the latter exceeding the university average each year. Similarly, "*Learning experiences in this unit help me achieve unit learning outcomes*" achieved 100% satisfaction among fully online students across 2016–2017 and 2019–2020. In contrast, fully online

student agreement with "*Assessment tasks in this unit evaluate my achievement of the unit learning outcomes*" and "*Quality of teaching this unit helps me to achieve the unit learning outcomes*" were lower than the face-to-face and university averages (2014, 2015, 2018 and 2019) (Table 3).

4.4 | Qualitative results

Individual interviews were completed with five (n = 5) academic staff. Participants all identified as female, three (n = 3) tenured, two (n = 2) sessional academics and all five (n = 5) had ≥10 years of tertiary teaching experience. Three themes emerged: The PBL approach; Evolution of PBLs; and Student skills and competencies. Findings for the academic interviews and the student evaluation feedback (2014–2020) are presented below.

4.4.1 | The PBL approach

Students identified the PBL approach enhanced student learning, required an active approach to learning and built their confidence. This was the case, for the face-to-face students, "*The PBLs are a really*

TABLE 3 Student evaluation (percentage agreement) by mode of delivery 2014–2020 with comparison to the university average (n = 521)

	Item	Delivery	2014 87 (43.7) (n = 28) (n = 10)	2015 100 (27.0) (n = 20) (n = 7)	2016 99 (31.3) (n = 24) (n = 7)	2017 80 (23.8) (n = 14) (n = 5)	2018 60 (15.0) (n = 7) (n = 2)	2019 52 (29.9) (n = 10) (n = 4)	2020 43 (23.3) (n = 4) (n = 6)
		n (response rate %) Face-to-face Fully online							
1	Unit learning outcomes are clearly identified	Face-to-face	92	100	96	93	100	100	100
		Fully online	100	86	100	100	100	100	100
		University	88	89	88	89	90	90	91
2	Learning experiences in this unit help me to achieve unit learning outcomes	Face-to-face	78	100	100	100	86	100	100
		Fully online	70	86	100	100	50	100	100
		University	84	85	84	85	86	86	85
3	Learning resources in this unit help me to achieve the learning outcomes	Face-to-face	82	100	100	100	89	90	100
		Fully online	80	86	100	100	86	100	100
		University	84	85	84	85	86	86	80
4	Assessment tasks in this unit evaluate my achievement of the unit learning outcomes	Face-to-face	82	100	100	95	78	90	90
		Fully online	70	80	100	100	86	75	100
		University	84	85	84	85	86	86	86
5	Feedback on my work in this unit helps me to achieve the unit learning outcomes	Face-to-face	82	100	100	100	100	90	100
		Fully online	70	86	100	100	100	75	100
		University	79	80	79	80	82	82	80
6	Workload in this unit is appropriate to the achievement of unit learning outcomes	Face-to-face	93	95	100	93	100	100	100
		Fully online	90	86	100	60	100	75	100
		University	85	87	86	86	87	87	87
7	Quality of teaching this unit helps me to achieve the unit learning outcomes	Face-to-face	86	100	100	100	86	100	100
		Fully online	60	72	100	80	50	100	100
		University	83	84	83	84	85	85	84
8	I am motivated to achieve the unit learning outcomes	Face-to-face	85	100	96	86	80	90	100
		Fully online	90	86	86	80	100	100	100
		University	85	85	85	85	86	86	86
9	I make best use of the learning experiences in this unit	Face-to-face	85	100	100	79	86	100	100
		Fully online	90	80	100	100	100	100	100
		University	86	86	86	87	88	88	87
10	I think about how I can learn more effectively in this unit	Face-to-face	82	100	100	79	71	100	100
		Fully online	100	86	100	100	100	100	100
		University	85	86	86	87	87	88	88
11	Overall I am satisfied with this unit	Face-to-face	88	100	92	93	86	100	100
		Fully online	83	86	100	100	100	75	100
		University	83	83	83	83	84	84	84

great way to actively learn from each other and to improve our academic writing" (face-to-face student, 2015), and similarly for the fully online student in the same 2015 cohort, "*The PBLs are a good idea it allows us to apply our recent knowledge of the unit so we are actually using the information we have learnt.*" Academic staff also described the approach as active learning:

> "*It's a process where the student is handed over responsibility for their learning. So in that way, I think students find it very different. So rather than sitting there passively*

in a classroom hearing someone talk, they've actually got to interact with the content, and come up with responses and answers." (Interviewee 3)

Fully online students described the first time using the PBL approach as harder to follow, "*The PBLs were very confusing and hard to follow*" and "*It was a little confusing and difficult to understand at times.*" (Fully online students, 2014 and 2016, respectively.) However, once familiar with the PBL process, students and staff felt more confident with the learning style "*PBLs were good once aware of what to do – great way of*

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learning" (face-to-face student, 2015), and "*Really enjoyed the PBL once we knew what to do and enjoyed the mix of videos and lectures.*" (Fully online student, 2018)

Similarly, staff reflection of the PBL approach included:

> "*I think there was a little bit of resistance from students at the start, like a lot of stress about a new kind of assessment process or new type of thing they had to do....I think there was another unit doing something similar, so some of the students were pretty chilled about it.*" (Interviewee 1)

Fully online students had commented that their PBL experience was not equivalent compared with their face-to-face peers:

> "*It was very hard as an online student to feel engaged in the PBL discussion process...It certainly didn't feel like a discussion in the same way I imagine it does in on-campus tutorials.*" (Fully online student, 2017)

In contrast, as an instructional design method, fully online student feedback included:

> "*I found the PBLs to be a great way of doing assessments and I wish more units had them as a way of structuring assignments. It was a great way of incorporating concepts from the coursework with independent research.*" (Fully online student, 2020)

4.4.2 | Evolution of PBLs

All academic staff (n = 5) acknowledged the evolution of the fully online delivery was driven and informed by a combination of student feedback, for example, in 2014, a fully online student wrote, "*The PBLs were very confusing and hard to follow.*" An interviewee reflected on the first version of the fully online PBL with static triggers:

> "*I recall working with students in an online environment was quite challenging. At the time, we were limited in terms of our communication tools. I engaged with the students fully online. So that's where my reflection and my feedback comes from. Firstly, via discussion board, we set the triggers and then they would respond to ...it was a little clunky as discussion board can be, I didn't find it as flexible as it could ...but we didn't have the technology then. But I think being able to utilise Blackboard Collaborate would have been a really good approach to elicit those verbal comments, and encourage a bit more engagement.*" (Interview 4)

Academic staff reflected on the impact of changes for fully online delivery, and identified a number of improvements in student engagement and confidence, for example:

> "*The impact on the students over time, I think is we got greater buy-in from fully online students, and they seem to feel like they are getting a more interactive experience.*" (Interview 2)

While fully online students, continued to describe limitations of the PBL approach despite the refinements, which is reflected in a comment from 2020:

> "*Possibly more time to complete the PBL research as a group instead of using a few days to write triggered responses on Blackboard. A live collaborate would be more efficient to discuss the triggers with everyone in the class or group, as well as saving time for further research.*" (Fully online student, 2020)

As the PBLs continued to be modified, the fully online students expressed a greater need for instruction and support. Potentially the PBL process became more complicated and required greater engagement with technology. This is highlighted below:

> "*I think the PBLs could be better explained to fully online students, particularly PBL One. I think a video explanation would be better than explaining how the PBLs work on Blackboard.*" (Fully online student, 2016)

Staff acknowledged the introduction of the asynchronous critical analysis contribution (in 2015) was a positive change and provided the opportunity for all students to contribute and have a "*voice.*" However, fully online students expressed difficulty in peer engagement due to group members being in different time zones, small and uncommunicative groups, and technology issues.

> "*It was very hard as an online student to feel engaged in the PBL discussion process – because the external groups were so small and only a few people from mine tended to comment. It was difficult to really feel invested in the comments or the topic questions.*" (Fully online student, 2017)

Students continued to feel a lack of connection to their tutor and peers despite the refinements over time. A 2018 fully online student suggested, "*Maybe even have a collaborate session available for online students 'only' to communicate with the tutor... just to touch base and feel like you are a part of the university... sometimes I think that people do not see you as a real person when you are studying online due to not meeting you in person.*"

4.4.3 | Student skills and competencies

Staff and students described improved academic writing, critical thinking, problem solving and communication skills. A fully online student

in 2016 commented "*This unit helped me to further develop critical thinking and academic writing skills through the PBL process*." Together with public speaking and presentation skills, interpersonal skills, group work, collaboration, and in-depth understanding of topics, a 2020 fully online student also explained "*PBLs are an excellent way to develop understanding of the learning outcomes and also assist in improving academic writing skills and presentation skills*." The observations were similar for staff in regard to student skill acquisition for critical analysis: "*It forces critical thinking and independent critical exploration by students*" (Interview 4); and communication skills "*PBL is about written communication and the opportunity to speak. So, practicing oral communication skills between peers, between peers and the tutor, and also at the end point... gets the students to practice those public speaking skills that everyone sort of hates*" (Interview 3).

While the PBL scenarios were not specifically designed to meet the International Union for Health Promotion and Education (IUHPE) competencies,[12] staff did identify specific IUHPE competencies students developed as they negotiated the PBL process. These included: #1 Enable Change, #9 Evaluation & Research, and #4 Communication[12] to be inherent in the PBL process through group critical analysis, public speaking, presentations and written communication.

> "*So I think competency 1, 6, 7 and 9 are all addressed through that strong focus on analysing and addressing public health problems. The process also inherently requires communication to unpack the problem.*" (Interview 4)

It was acknowledged by staff that PBLs could be used as a tool to develop other IUHPE competencies. Exemplified by one interviewee:

> "*I think that if you use PBL, from first to third year, or if you scaffold the use of PBLs across the health promotion course, you could actually address a certain number of those competency domains all the way.*" (Interview 5)

5 | DISCUSSION

In higher education during the last decade, and more recently there has been an increased need to offer fully online units and courses as an alternative to traditional, face-to-face learning.[3,14,31] In this study, we compared student results, student evaluation and the staff experience of PBL in the face-to-face and fully online environment in an Australian university. We found that fully online students compared with face-to-face students achieved significantly higher Final Unit Marks in 2018 and 2019. However, significantly lower Overall PBL Marks in 2015. Final Unit Achievement in 2018 and 2019 and Overall PBL Achievement in 2015 were significant for fully online students compared with face-to-face students. Interestingly, 100% of fully online students agreed the learning experiences and learning resources in the unit helped them to achieve the learning outcomes across 2016–2017 and 2019–2020. Suggesting as the PBL delivery was refined, embraced

technology, and became more collaborative between tutors and peers, the student experience improved. Three themes emerged from the student and staff experience, these included: The PBL approach; Evolution of PBLs; and Student skills and competencies. These findings are discussed below and provide important implications for PBLs as a teaching and learning approach for health promotion students in a period of increased demand for online learning and teaching.[3,14,32]

We found the PBL approach, together with the use of new technology can be challenging particularly for fully online students. It places additional demands on both staff and students to become familiar and confident with the process, and the technology. Fully online students expressed a desire for greater clarity of instruction when using the PBL approach, as they are operating in the more complicated online environment. However, our findings suggested the PBL approach builds the capacity of fully online and face-to-face students. Similar to our findings, others have found that additional support is needed to prepare students for online teamwork, develop digital literacy, and stimulate more detailed brainstorming and discussion.[3,14,31] Furthermore, the literature suggests that while the interactive component of the PBL is complementary for the learning and teaching experience it can also be disruptive.[18] In Australian universities, the PBL approach as a student-centred pedagogy has the opportunity to embrace features of the LMS, such as Collaborate Ultra[21] offering increased opportunities for screencasting and real-time information exchange between fully online students and tutors.[33,34]

Analysis of student comments suggests the refinements to the PBL approach had mixed effects in terms of the student experience. The issues identified in this study included: greater support during the PBL process, clarity of instructions, difficulties with time zones, group size, technology and feeling disconnected from the campus. The refinements made by the academic teaching team over the five iterations aimed to improve the student learning experience and support equivalency between the teaching modes.[35,36] This included the replacement of static PBL triggers with asynchronous options (ie, audio clips, video clips and collaborative online groups). This approach embraced flexibility and fostered collaboration, a positive outcome of PBL approaches using interactive technologies.[18] We posit the contribution and online discussion board engagement protocols developed in version two (2015) partly explain the positive gains in the student evaluation. Successful fully online PBL is dependent on the interactions, equal participation, and inclusion of all group members,[14,37,38] and while we made changes to facilitate the group process, this was not always successful. Of interest, recent research suggests that digital PBL alters the atmosphere of traditional curricula and introverted students may become more active in the virtual setting.[14,39–41] Going forward, the fully online PBL approach needs to explore the group process in more detail, specifically the size of groups, impact of time zones, inconvenience[6,41] and how to fully embrace technology to allow those students with different learning styles to feel supported.

The findings from both the students and the academic staff reinforce the notion of building academic skills including critical analysis, self-directed research and the opportunity to gain IUHPE

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competencies. Building student capacity may in turn lead to better prepared students for both future academic pursuits and employment upon graduation.[29,42] Students indicated that they improved their critical thinking and independent research skills, while the academic staff amplified the students' acquisition of critical analysis and communication skills. These findings are reinforced by research that has shown that the online PBL approach enhances interpersonal, communication and collaboration skills[3,29,38]; and supports access to information and collaborative learning among students.[43] Skills that are core to achieving health promotion competencies[12] translating to the workplace upon graduation. These were key outcomes we hoped to impart in our student cohort with each iteration of the PBL approach.

5.1 | Strengths and limitations

Our study had a number of limitations in the design and sampling. First, data were retrospective administrative data collected by the university and not unique evaluation items, and no demographic information was available for the student cohort. In addition, there were small response rates for the student evaluation survey in 2018; and student qualitative data were aggregated preventing a response rate calculation. Furthermore, the two lead authors were interviewees. Despite this, the study is one of a limited number of studies that have combined both student and teaching academic data to explore the transition of the PBL approach from the traditional format to the fully online format over a 7-year period. This study provides a useful insight into both student and academic staff factors that could help support online PBL approaches in the health sciences.

5.2 | Conclusion

Over a 7-year period, the traditional face-to-face PBL approach and the fully online delivery of an undergraduate unit resulted in mixed results, including some improvement in the student and academic staff experience, while supporting the development of critical thinking and self-directed research. While not without challenges, the fully online PBL approach supported the development of core health promotion competencies and enhanced the academic and student learning experience not only for health promotion students but also for others undertaking a Health Science undergraduate degree in an Australian university setting.

5.3 | So what?

Vital for contemporary, global graduates, the fully online PBL approach allows students to build critical academic and professional skills utilising current information technology relevant for collaborative professional practice.

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