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Work-Based Learning (WBL) Model to Develop Self-Directed Learners in Optometry Education - An Evaluation

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Corresponding author:** Li Li Tan, School of Chemical and Life Sciences, Singapore Polytechnic, 500 Dover Road, Singapore**Received:** March 25, 2021; **Accepted:** April 16, 2021;**Published:** April 23, 2021**Abstract*Purpose:** This paper evaluated the effectiveness of work-based learning (WBL) model to develop self-directed learning skills in optometry education.**Methods:** 'WBL cohort 1' in Academic year (AY) 1819S1 (n = 20) and 'WBL cohort 2' in AY1920S1 (n = 65) were studied and compared with a 'traditional cohort' (n = 42). The following were investigated: (i) Student Survey (SS); (ii) Focus Group Interview (FGI); (iii) adjunct lecturer survey and (iv) Final Module Score (FMS) in four core modules.**Results:** Through SS, >60% reported that WBL enabled them to be self-directed learners and >80% felt that it helped to develop useful optometry skills and knowledge. Through FGI, 83% of the 'WBL cohort 1' and 54% of the 'WBL cohort 2' reported that it trained them to be self-directed learners. More than 60% of the adjunct lecturers surveyed reported that students who underwent the WBL model had exhibited good interpersonal skills, critical thinking and good traits of an independent optometrist. However, these were not as clearly evident when the cohort size was increased. Based on academic performance (with FMS as an indicator), WBL produced variable results in the four core modules surveyed, with WBL cohorts 1 and 2 performing differently.**Conclusion:** WBL model was able to develop self-directed learners and professional dispositions as well as generic employability skills. To scale WBL for larger cohorts, considerations must be given to faculty and resource availability, which it demands.**Keywords:** Work-based learning; Self-directed learning; Optometry; Workplace

Introduction

Self-Directed Learning (SDL) is a skill that has received increasing attention in recent years, particularly in the context of Singapore education. The Ministry of Education, Singapore, in its Masterplan for Information and Communications Technology in Education, has identified self-directed learning as one of the key 21st century skills that should be nurtured in our students. Broadly, SDL refers to the process in which an individual learner is motivated to take responsibility and accountability for his/her own learning [1]. Tan, Divaharan, Tan, and Cheah [2] have gone one step further and examined ways of assessing SDL that are viable within our local educational context. They defined SDL as skills that encompasses the following features: (i) Ownership of learning; (ii) Self-management and self-monitoring; (iii) Extension of learning.

Despite many approaches and models in the literature, there is general agreement that SDL involves the following iterative stages, irrespective of the specific terminology employed:

- Planning Learning
- Managing Learning Performance and Process

- Reviewing and Evaluating Learning;

Hence, the use of cognitive strategies is of significant importance in developing students' SDL skills [3].

Work-Based Learning (WBL) is an educational model that provides students with real-life work experiences where they can apply academic and technical skills and develop their employability. It is a series of educational courses which integrate the school or university curriculum with the workplace to create a different learning paradigm. WBL deliberately merges theory with practice, knowledge with experience, and acknowledges the intersection of explicit and tacit forms of knowing [4-6]. WBL encompasses a diversity of formal and informal arrangements including apprenticeships, work placement and informal learning on the job. The key driver is the need for active policies to secure learning that meets the need of the workplace [7]. Smith and Mick [8] refer to programs of WBL as "throwing a net around slippery experience and capturing it as learning".

From an educational institution perspective, Alkestma and McDonald [9] outlined four typical models of work experience and endorsed by Institute for Adult Learning (IAL) Singapore [10] as WBL model:

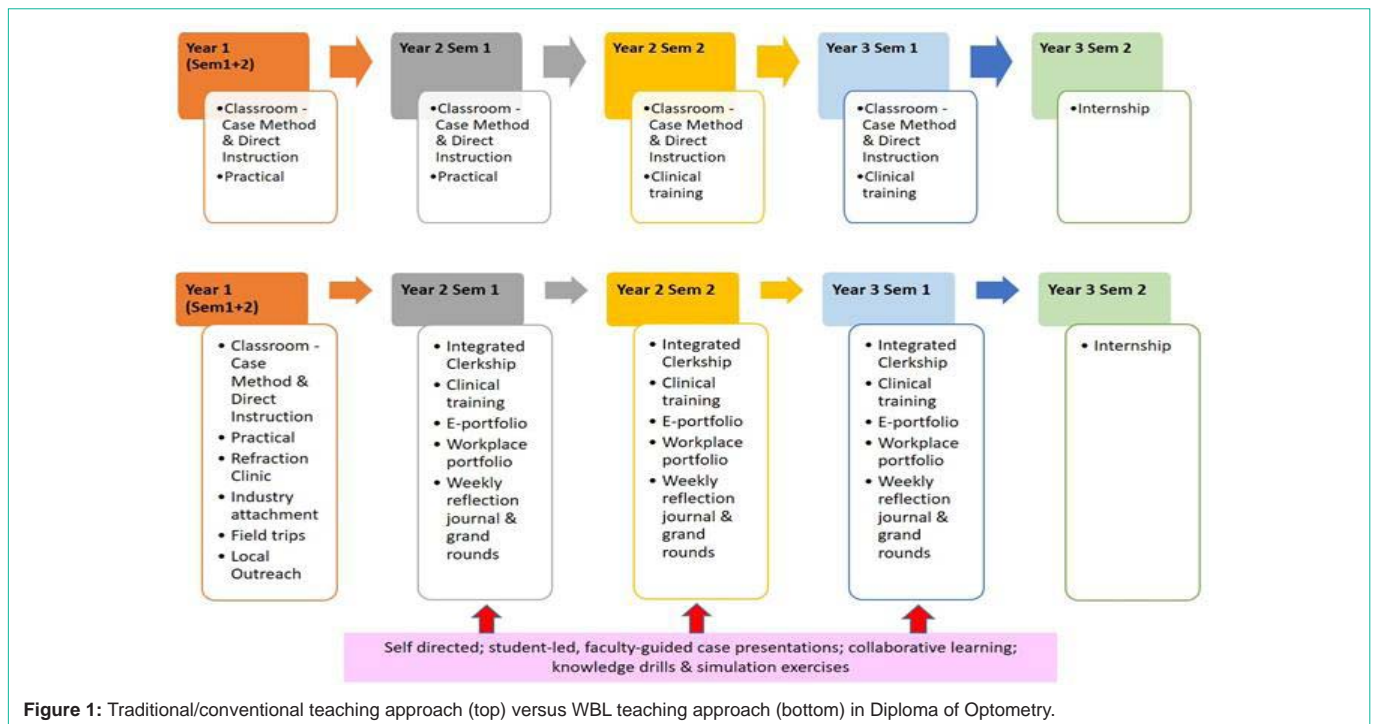


Figure 1: Traditional/conventional teaching approach (top) versus WBL teaching approach (bottom) in Diploma of Optometry.

Fully integrated workplace learning: Most of the learning takes place on-the-job and is supported by learning materials from the workplace and the educational institution. Learners are supported by their employers and by staff (e.g. supervisors at work and in their educational institution). It includes learning for attaining qualifications, as well as professional learning that seeks to develop people already in work.

Learning practicums: Learners - such as chefs, nurses, social workers, or engineers - are placed in workplaces for ongoing blocks of learning during their time of study. These are variously referred to as practicums, placements and field-based education.

Work integrated learning: Learners work on a project basis for short periods of time. This includes internships.

Simulated learning situations: Learners are fully located within an educational institution but participate in replicated workplace learning situations. This can range from using software that workplaces use to simulate the work context, through to simulated clinical settings and actual construction projects or hospitality work within the educational institution.

Work-based learning model in the Diploma of Optometry course at Singapore Polytechnic

Work-Based Learning (WBL) was first introduced to Year 2 Diploma of Optometry (DOPT) students at Singapore Polytechnic in semester one of the 2018/2019 academic year (AY1819S1) in response to curriculum review and pedagogy for the profession. It was introduced to address gaps in the traditional system of block rotations; in recognition that existing clinical training can be structurally and educationally enhanced and last but not least, to inculcate SDL.

WBL is a relative new approach in higher education in the UK [11] and has been used and studied in nursing [6,11,12]. To date,

no study has been done on the impact of this teaching approach in optometry. This paper evaluated if WBL model could develop SDL skills and improve the academic performance (indicated by final module scores) in our optometry students.

Materials and Methods

The annual DOPT course intake comprises three classes of students of approximately 20 students per class. WBL model was first introduced in AY1819S1 for year 2 students, on an opt-in basis. To date, WBL model has been implemented for two cohorts of optometry students: 'WBL cohort 1' in AY1819S1 (the pilot cohort, one class only, $n = 20$) and 'WBL cohort 2' in semester one of the 2019/2020 academic year (AY1920S1) (all three classes, $n = 65$). The other two classes in AY1819S1 were taught using traditional/conventional mode of lesson delivery ($n = 42$) and they are called 'Trad cohort'. Students from AY1819S1 cohort are the 'senior' cohort and the students from AY1920S1 cohort are the 'junior' cohort.

Four core modules were surveyed

CP3065 Binocular Vision (BV), CP3066 Contact Lens (CL), CP3056 Ocular Disease 1 (OD1) and CP3062 Clinical Optometry 3 (CO3). These are four core modules in optometry covering the major clinical disciplines required by a professional optometrist in their workplace. Students in WBL cohorts were taught using WBL teaching approach whereas students in Trad cohort were taught using the traditional/conventional teaching approach (Figure 1). All students, regardless of the cohort they belonged, were taught using the same teaching materials and same means of assessment were applied through-out the semester.

We adopted the four typical models of work experience described by Alkema and McDonald [8] when making pedagogic and curriculum changes in teaching WBL and SDL skills as described by

Table 1: Mapping of WBL with SDL in Diploma of Optometry, Singapore Polytechnic.

The four typical models of work experience [9]		WBL teaching plan	Remarks	Mapping of WBL with SDL skills as described by Dennis Sale [3]: - <ul style="list-style-type: none"> • Planning Learning • Managing Learning Performance and Process • Reviewing and Evaluating Learning
1	Fully integrated workplace learning	<p>This was in the form of clinical training in the SP Optometry Centre (SPOC) where students were exposed to 'real' patients. The learning was supported by learning materials such as eportfolio* and workplace portfolio**. Weekly grand rounds were conducted to review their learning.</p> <p>During clinical training, students were supervised by their supervisors consists of their lecturers and adjunct lecturers. All supervisors must have at least two years of working experience.</p> <p>Four core modules*** taught in the semester were integrated through various in-class activities including Case method. Students are required to learn how to examine and manage their patients by applying skills and knowledge learnt. Content delivery was done through "Flipped learning".</p> <p>They were trained to integrate theory and knowledge from their learning into practice. Students were paired during clinical training to facilitate peer-tutoring.</p> <p>Assessment (formative and summative): Written and oral assessment were done in mid- and end-semester to track students' performance.</p>	<p>*E-portfolio – this outline weekly topics of the course. Questions aligned with learning outcomes. Activity sheets were also incorporated. The activity sheets were designed to be realistic, reflect workplace situations and cover the requirements of the assessment criteria.</p> <p>**Workplace-portfolio – this is a portfolio that contained individual pieces of evidence demonstrating work outputs that were collected by the students during their clinical training. The evidence was clearly benchmarked against the competency/learning outcomes and indicated consistent performance of work activities in accordance with workplace standards. This was done in the form of weekly reflections.</p> <p>***The four core modules were: CP3065 Binocular Vision (BV), CP3066 Contact Lens (CL), CP3056 Ocular Disease 1 (OD1) and CP3062 Clinical Optometry 3 (CO3).</p>	<p>Through e-portfolio: Students were guided to plan and complete the questions by a given timeline (a). It helped them to make sense of the concepts and put the pieces together (b). Feedback for improvement (formative) given by lecturers on the activity sheets & students' progress in mid- and end-semester assessments (c).</p> <p>Through workplace portfolio: Students were exposed to 'real patients' to apply their skills and knowledge in a 'simulated workplace' (SPOC). This helped the students to apply what they learnt in a different situation, to continue review, evaluate and extend their learning (c).</p> <p>Weekly reflection journal: Students reflected what they have learnt and how to improve. These incorporated aspects of integrated clerkship (c).</p> <p>Weekly grand rounds: Students discussed cases they have seen during clinical training, to review and evaluate their learning and seek improvements (c).</p> <p>In-class activities: These were 'student lead, faculty guided'. Students took ownership of their own learning (b).</p> <p>Through flipped learning: Students planned their learning and went through the online material prior to the in-class discussion. Readiness check was done to track student's preparedness (a).</p> <p>Peer-tutoring: Students learn from each other and this inculcated collaborative learning (b).</p> <p>Case method: Students discussed and reviewed different cases, facilitated by lecturers (c). Case method helped to develop few important skills essential for optometrists: Communication/collaborative skills, Adaptability/resilience, Sense making (include analytical-, critical-thinking and problem-solving skills) and Empathy/Ethics. These are also important skills for lifelong learners.</p>
2	Learning practicums	<p>Students were placed in SPOC for ongoing blocks of learning during their time of study. This were accompanied by practical sessions for the four core modules, external placements and field-based activity such as community service.</p>	-	<p>Practical sessions: Students watched videos and prepared before they performed the practical in lab and completed their activity sheets (a). Practical tests were administered at the end of the semester to track students' performance.</p> <p>Practical sessions were conducted in the form of 'crash course' whereby all practical lessons covering the core clinical skills required in the later stage were completed during the first six weeks (b).</p>
3	Work integrated learning	<p>The students were sent for a seventeen-week internship to eye clinics, hospitals, optical outlets, and ophthalmic/contact lens companies at the end of semester 1 of year 3 of their study. They were supervised by a qualified optometrist at their workplace.</p>	-	<p>Internship: Students were placed out of the 'controlled' environment in a 'real workplace environment' without much guidance from lecturers. This helped them to review, evaluate and extend their learning (c).</p>
4	Simulated learning situations	<p>Students were given different case scenarios through simulated practice to be exposed to a big variety of cases that they may not see during their clinical training. Students were trained to complete a task, activity or problem in an off-the-job situation that replicates the workplace context. This was done through various software or face-to-face.</p>	-	<p>Simulated practice: This encouraged students to 'think out of the box', a big variety of cases that they never get to see in SPOC were covered using this approach. This helped to review, evaluate and extend their learning (c).</p>

Dennis Sale [3]. The different components of our WBL model and how they are mapped with SDL skills are summarized in Table 1.

To evaluate if the above WBL model had developed SDL skills and produced good academic performance in the teaching and learning of optometry students, the following were investigated:

Student survey (SS): This was administered on WBL cohorts 1 and 2 as well as the Trad cohort. The survey was designed using a 5-point Likert scale (1: Strongly Disagree; 2: Disagree; 3: Neutral; 4: Agree; 5: Strongly Agree). It consisted of six questions and focused on the following attributes: SDL, skills development, learning experience

Table 2a: Student's evaluation questions (WBL cohorts 1 and 2).

Survey Questions	Rating
SS1. I am becoming a self-directed learner (meaning to some extent, you are able to study, reflect, and evaluate/derive meaning).	
SS2. WBL helps me to develop useful optometry skills and knowledge, so can be work-ready.	
SS3. WBL helps me to develop useful professional soft skills and knowledge.	
SS4. WBL helps me to enhance my clinical practice knowledge.	
SS5. WBL provides engaging learning experience.	
SS6. Overall, I have developed more confidence in my optometry skill sets and knowledge.	

Rating scale: 1: Strongly Disagree; 2: Disagree; 3: Neutral; 4: Agree; 5: Strongly Agree.

Table 2b: Student's evaluation questions (Traditional cohort).

Survey Questions	Rating
SS1. I am becoming a self-directed learner (meaning to some extent, you are able to study, reflect, and evaluate/derive meaning).	
SS2. The teaching approach helps me to develop useful optometry skills and knowledge, so can be work-ready.	
SS3. The teaching approach helps me to develop useful professional soft skills and knowledge.	
SS4. The teaching approach helps me to enhance my clinical practice knowledge.	
SS5. The teaching approach provides engaging learning experience.	
SS6. Overall, I have developed more confidence in my optometry skill sets and knowledge.	

Rating scale: 1: Strongly Disagree; 2: Disagree; 3: Neutral; 4: Agree; 5: Strongly Agree.

Table 3: Students' evaluation on attending work-based learning and traditional teaching approach.

Survey Questions	WBL cohort 1 (20 inputs)	WBL cohort 2 (34 inputs)	Trad cohort (31 inputs)
SS1	3.7	3.9	3.9
SS2	4.3	4.1	4
SS3	4.1	4.1	3.8
SS4	4.4	4.4	4.2
SS5	4.2	4.2	4.1
SS6	3.9	3.9	4.2
	4.1 ± 0.3	4.1 ± 0.2	4.1 ± 0.1

Rating scale: 1: Strongly Disagree; 2: Disagree; 3: Neutral; 4: Agree; 5: Strongly Agree.

Table 4: Self-rated opinions on the six questions (SS1-SS6) of students from WBL cohorts 772 1 and 2 and traditional cohort.

		Strongly disagree % (n)	Disagree % (n)	Neutral % (n)	Agree % (n)	Strongly agree % (n)
WBL cohort 1 (20 inputs)	SS1	0 (0)	0 (0)	35.0 (7)	65.0 (13)	0 (0)
	SS2	0 (0)	0 (0)	0 (0)	70.0 (14)	30.0 (6)
	SS3	0 (0)	0 (0)	15.0 (3)	60.0 (12)	25.0 (5)
	SS4	0 (0)	0 (0)	0 (0)	60.0 (12)	40.0 (8)
	SS5	0 (0)	0 (0)	10.0 (2)	60.0 (12)	30.0 (6)
	SS6	0 (0)	0 (0)	20.0 (4)	70.0 (14)	10.0 (2)
WBL cohort 2 (34 inputs)	SS1	0 (0)	0 (0)	29.4 (10)	47.1 (16)	23.5 (8)
	SS2	0 (0)	0 (0)	17.7 (6)	58.8 (20)	23.5 (8)
	SS3	0 (0)	0 (0)	8.8 (3)	70.6 (24)	20.6 (7)
	SS4	0 (0)	0 (0)	8.8 (3)	44.1 (15)	47.1 (16)
	SS5	0 (0)	2.9 (1)	5.9 (2)	55.9 (19)	35.3 (12)
	SS6	0 (0)	2.9 (1)	23.5 (8)	52.9 (18)	20.6 (7)
Trad cohort (31 inputs)	SS1	3.2 (1)	6.5 (2)	16.1 (5)	45.2 (14)	29.0 (9)
	SS2	0 (0)	3.3 (1)	22.6 (7)	48.4 (15)	25.8 (8)
	SS3	3.2 (1)	3.2 (1)	25.8 (8)	41.9 (13)	25.8 (8)
	SS4	0 (0)	3.2 (1)	9.7 (3)	48.4 (15)	38.7 (12)
	SS5	0 (0)	6.5 (2)	12.9 (4)	41.9 (13)	38.7 (12)
	SS6	0 (0)	0 (0)	19.4 (6)	41.9 (13)	38.7 (12)

Table 5: Adjunct lecturer's evaluation on WBL cohorts 1 and 2 and traditional cohort.

Survey Questions	WBL cohort 1 (43 inputs)	WBL cohort 2 (35 inputs)	Trad cohort (90 inputs)
AL1. This student exhibit interpersonal skills (e.g., build rapport with the patient, etc.)	4	3.5	3.5
AL2. This student exhibit critical thinking (e.g., suggest appropriate clinical test, etc.)	3.8	2.8	3.2
AL3. This student exhibits all traits of an independent optometrist (e.g., minimum guidance needed, etc.)	3.6	2.3	3.1
	3.8 ± 0.2	2.9 ± 0.5	3.3 ± 0.2

Rating scale: 1: Strongly Disagree; 2: Disagree; 3: Neutral; 4: Agree; 5: Strongly Agree.

and professional dispositions/soft skills (SS1-SS6, Table 2a and 2b). Questions in Table 2a were used for WBL cohorts 1 and 2 and questions in Table 2b were used for Trad cohort. They were the same questions but “WBL” in Table 2a was replaced with “The teaching approach” in Table 2b.

Focus group interview (FGI): This was done to gather more in-depth views from students in WBL cohorts 1 and 2. In total 40 students were randomly selected, 12 students from WBL cohort 1 and 28 students from WBL cohort 2. Two lecturers (TL and KS) conducted the interview, TL coordinated the session and interviewed the students while KS was the scribe, taking notes of all the responses given by students using the template formulated with EDU (Appendix A). The template consisted of seven questions (Q1-7). A total of four interview sessions were conducted and each session was about 1 hour duration. The questions were designed with the following objectives:

- **Q(1-3):** To find out if WBL model has helped students to develop the three main iterative stages for SDL as described by Sale [3].
- **Q4:** Overall rating on whether WBL model has trained students to be self-directed learners.
- **Q5:** To find out if WBL model has helped students to better apply their skills and knowledge to examine and manage patients.
- **Q6:** Overall rating on how WBL model has developed their professional dispositions: i) Confidence; ii) Communication skills; iii) Motivation to learn more; iv) Analytical skills; v) Think out of the box; vi) Independence.
- **Q7:** To provide any other comments on the WBL model.

Adjunct lecturer survey (ALS): Adjunct lecturers served as an independent (“third-party”) observer on students as they were only involved during clinical training. ALS was gathered on WBL cohorts 1 and 2 as well as the Trad cohort. Similarly, survey was designed using a 5-point Likert scale.

ALS consisted of 3 questions and focused on the following attributes: interpersonal skills, critical thinking and traits of an independent optometrist (AL1-AL3, Table 5).

Final module score (FMS) in four core optometry modules: In order to study the academic performance of students. FMS was retrieved from the database on WBL cohorts 1 and 2 and compared with the Trad cohort. Final module score (= summative assessment in Table 1) includes assessment score of various components such as teamwork, class participation, communication, practical skills, and also written assessments for application of concepts learnt.

This study was granted exempt status by the Institutional Review

Board of Singapore Polytechnic.

Results

Student Survey (SS)

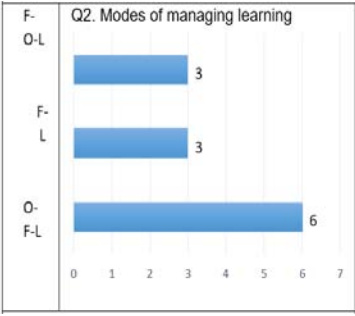
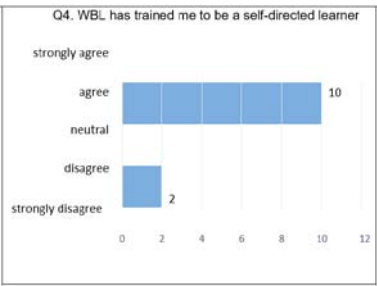
Twenty responses were collected from WBL cohort 1, 34 responses from WBL cohort 2 and 31 responses from Trad cohort. Mean ± SD score was 4.1 ± 0.3 for WBL cohort 1, 4.1 ± 0.2 for WBL cohort 2 and 4.1 ± 0.1 for Trad cohort which were very similar (Table 3).

Self-rated opinions by students on the six questions showed that students from WBL cohorts were happier with their teaching approach as mean score for those indicated “agree” or “strongly agree” was highest in WBL cohort 1 (86.7%), followed by WBL cohort 2 (83.3%) and Trad cohort (78.6%). Looking at the breakdown figures (Table 4), students reported that the teaching approach they underwent enabled them to become self-directed learners (SS1, indicated “agree” or “strongly agree”, 65% in WBL cohort 1, 70.6% in WBL cohort 2, 74.2% in Trad cohort), it helped them to develop useful optometry skills and knowledge, to be work-ready (SS2, 100% in WBL cohort 1, 82.3% in WBL cohort 2, 74.2% in Trad cohort), it helped them to develop useful soft skills and knowledge (SS3, 85% in WBL cohort 1, 91.2% in WBL cohort 2, 67.7% in Trad cohort), it helped them to enhance their clinical practice knowledge (SS4, 100% in WBL cohort 1, 91.2% in WBL cohort 2, 87.1 in Trad cohort), it provided them an engaging learning experience (SS5, 90% in WBL cohort 1, 91.2% in WBL cohort 2, 87.7% in Trad cohort) and overall, they developed more confidence in optometry skills set and knowledge (SS6, 80% in WBL cohort 1, 73.5% in WBL cohort 2, 80.6% in Trad cohort) (Table 4). There were about 3-6% of students from Trad cohort who indicated “disagree” or “strongly disagree” to SS1-SS5.

Focus group interview (FGI)

FGI results were very encouraging especially from WBL cohort 1. Table 6 and 7 show the summarized FGI responses from WBL cohort 1 (Q1-7). All 12 of them (100%) agreed that WBL model helped to develop the three main iterative stages for SDL, that they were able to plan, manage and review their learning (Q1-3). It was observed that students managed their learning by following different strategies (Q2) and regularly reviewed their learning (Q3). Half of them (50%) managed through “O-F-L” meaning own research, followed by discuss with friends, and lastly clarify with lecturers. 83% of the students agreed that WBL trained them to be self-directed learners (Q4) although about 50% felt that workload was too much and there were too many tests at times. Again, 100% of the students agreed that this approach helped them to better apply their skills and knowledge to examine and manage patients as WBL provided early exposure to clinical training and allowed more hands-on (Q5). This cohort felt that WBL helped develop their professional dispositions in terms of confidence (75% has indicated “agree” or “strongly agree”),

Table 6: Summary of the FGI responses of WBL cohort 1 (n = 12) - Questions 1-4.

Q	Response	Description
1	Yes, n = 12 No, n = 0	(+) Flexible learning "Own time-own target", (+) e-portfolio with guided questions, (+) consultation/tutorials, (+) early exposure to SPOC cases-planning learning, (+) "see the full picture", (+) clinician comments helps. -
2	Yes, n = 12	Students manage their learning through different strategies: O = own research, F = discuss with friends, L = clarify with lecturers; in the order as shown below. 
	No, n = 0	-
3	Yes, n = 12 No, n = 0	Students do review their learning as the teaching approach is designed for regular reviewing. E-portfolio feedbacks helped with clinic session. However they felt that workload was too much and there were too many tests. -
4	Rating of students as shown below:- 	

(+) like (-) dislike

communication skills (100%), motivated to learn more (100%), analytical skills (75%) and independence (100%). However, they felt that WBL did not really help them ‘think out of the box’ (50%). Table 8 and 9 show the summarized FGI responses from WBL cohort 2 (Q1-7). 96% agreed that WBL model helped to develop the three main iterative stages for SDL, that they were able to plan, manage and review their learning (Q1-3). One student disagreed to that, due to poor video quality, too much workload with packed schedule and unclear instructions given sometimes. It was observed that students manage their learning through different strategies (Q2) and regularly reviewed their learning (Q3). Majority (75%) managed through “F only” meaning discuss with friends or “O” only meaning own research. 54% agreed that WBL trained them to be self-directed learners (Q4) although they felt that workload was too much and too little time was given. All 28 of them (100%) agreed that WBL helped them to better apply their skills and knowledge to examine and manage patients as they liked the hands-on sessions during clinical training, merging theory and practice, and also the opportunity to learn by mimicking the lecturers and eventually be independent practitioners (Q5). This cohort felt that WBL helped develop their professional dispositions in terms of communication skills (68%), motivated to learn more (54%)

and independence (50%). However, they felt that WBL did not really help to develop their confidence (21%), analytical skills (25%) and be able to “think out of the box” (18%).

In general, students from WBL cohorts 1 and 2 liked the teaching approach but suggested few areas for improvements (Q7 in Table 7 and 9).

Adjunct lecturer survey (ALS)

For Adjunct Lecturer Survey (ALS), all 11 adjunct lecturers responded on WBL cohort 1 as well as the Trad cohort, and 6 adjunct lecturers responded on WBL cohort 2. In total 43 responses were collected on WBL cohort 1 and 35 responses on WBL cohort 2. Mean ± SD score was 3.8 ± 0.2 for WBL cohort 1 and 2.9 ± 0.5 for WBL cohort 2. On the other hand, 90 responses were collected on Trad cohort with mean ± SD score of 3.3 ± 0.2 (Table 5).

According to self-rated opinions of the ALS (Table 10), the adjunct lecturers felt that WBL cohort 1 exhibited remarkably well (>50% indicated “agree” or “strongly agree”) interpersonal skills (AL1, 74.4%), critical thinking (AL2, 72.1%) and had displayed traits of an independent optometrist (AL3, 65.2%). However, they felt that WBL cohort 2 was not as good. WBL cohort 2 only exhibited reasonably

Table 7: Summary of the FGI responses of WBL cohort 1 (n = 12) - Questions 5-7.

Q	Response	Description																																										
5	Yes, n =12	(+) early exposure to clinic, (+) 'professional' feeling, (+) interpretation, Diagnosis, management- troubleshooting, (+) "hands-on", (+) slit lamp/refraction faster, (+) communication-convincing, comforting patients.																																										
	No, n = 0	-																																										
6	<p>Rating of students as shown below:-</p> <table border="1"> <thead> <tr> <th></th> <th>Confidence</th> <th>Communication Skills</th> <th>Motivated to learn more</th> <th>Analytical skills</th> <th>Think out of the box</th> <th>Independence</th> </tr> </thead> <tbody> <tr> <td>strongly disagree</td> <td>0</td> <td>0</td> <td>0</td> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>disagree</td> <td>0</td> <td>0</td> <td>0</td> <td>0</td> <td>0</td> <td>0</td> </tr> <tr> <td>neutral</td> <td>3</td> <td>0</td> <td>0</td> <td>3</td> <td>8</td> <td>0</td> </tr> <tr> <td>agree</td> <td>9</td> <td>11</td> <td>10</td> <td>8</td> <td>3</td> <td>4</td> </tr> <tr> <td>strongly agree</td> <td>0</td> <td>1</td> <td>2</td> <td>1</td> <td>1</td> <td>8</td> </tr> </tbody> </table>		Confidence	Communication Skills	Motivated to learn more	Analytical skills	Think out of the box	Independence	strongly disagree	0	0	0	0	0	0	disagree	0	0	0	0	0	0	neutral	3	0	0	3	8	0	agree	9	11	10	8	3	4	strongly agree	0	1	2	1	1	8	
	Confidence	Communication Skills	Motivated to learn more	Analytical skills	Think out of the box	Independence																																						
strongly disagree	0	0	0	0	0	0																																						
disagree	0	0	0	0	0	0																																						
neutral	3	0	0	3	8	0																																						
agree	9	11	10	8	3	4																																						
strongly agree	0	1	2	1	1	8																																						
7	<p>In general students like the teaching approach particularly the followings: (+) early clinic exposure; (+) increased confidence. On the other hand, students felt that there are few areas for improvement: (-) teaching consistency, prefers to have module coordinator to teach the module, (-) there are few areas that need to be enhanced to help in their internship: dispensing, optics, myopia management, product knowledge, drugs and pharmacology, case studies, simulated clinics, variety of patients and last but not least, patient examination time can be reduced to 1 hour instead of 2 hours to match to real working situation.</p>																																											

(+) like (-) dislike

good interpersonal skills (AL1, 54.3%) but the other two attributes namely critical thinking and traits of an independent optometrist (AL2 and AL3) were not well exhibited (AL2, 28.6% indicated “agree” or “strongly agree” and 42.9% indicated “disagree” or “strongly disagree”; AL3, 17.1% indicated “agree” or “strongly agree” and 60% indicated “disagree” or “strongly disagree”). As for Trad cohort, it was better than WBL cohort 2 but poorer than WBL cohort 1. Trad cohort exhibited reasonably good interpersonal skills (AL1, 54.3%) but the other two attributes namely critical thinking and traits of an independent optometrist were again, not well exhibited (AL2, 43.3% indicated “agree” or “strongly agree” and 36.7% indicated “neutral”; AL3, 35.6% indicated “agree” or “strongly agree” and 44.4% indicated “neutral”) (Table 10).

Final module score (FMS) in the four core optometry modules

On comparing the Final Module Score (FMS) in the four core modules, students performed differently in different modules:

- As compared to Trad cohort, WBL cohorts 1 and 2 did significantly better with higher mean marks in CO3 (76.9 in WBL cohort 1, 76.2 in WBL cohort 2 vs. 71.4 in Trad cohort) (one-way ANOVA, p<0.05). For CL, only WBL cohort 2 did better with significant higher mean marks (78.8 vs. 71.7 in Trad cohort) (one-way ANOVA, p<0.01). For OD1, WBL cohort 2 (mean marks: 77.7) did better than WBL cohort 1 (mean marks: 68.5) (one-way ANOVA,

p <0.01) but no differences were found when comparing with Trad cohort. Lastly, for BV, no significant differences were found in any of the cohorts studied (Table 11 and Figure 2).

- Different trending in mean connect line from Trad cohort to WBL cohorts indicating WBL did not work consistently in all four core modules (Figure 3).

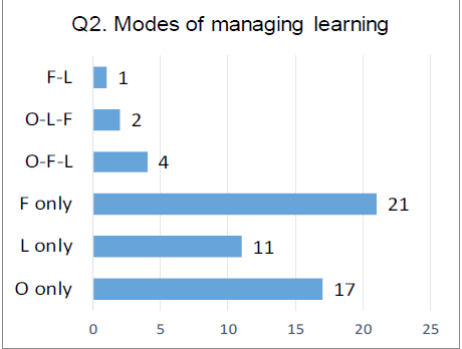

Discussion

SDL had clearly been demonstrated in the WBL cohorts through the Student Survey (SS) and Focus Group Interview (FGI). On the other hand, Adjunct Lecturer Survey (ALS) and Final Module Score (FMS) in the four core modules showed that the WBL cohorts 1 and 2 performed differently which will be discussed below.

From students’ point of view (through SS and FGI)

Through FGI, students reported that WBL helped them to develop the three main iterative stages of SDL [3]. They were able to plan, manage and review their learning. It was observed from how they managed their learning, that the students do take ownership of their learning which is one of the key features of SDL [2]. Subjectively, 83% of the students from WBL cohort 1 reported that WBL trained them to be self-directed learners. In comparison, lesser number of students in the WBL cohort 2 reported the same (54%) and this could be because the WBL cohort 2 were in the junior cohort (they were in Year 2 during FGI as compared to Year 3 for WBL cohort 1) and

Table 8: Summary of the FGI responses of WBL cohort 2 (n = 28) - Questions 1-4.

Q	Response	Description													
1	Yes, n = 27	(+) e-portfolio with clear outline, (+) flipped learning environment, (+) flexible learning, student manage their own time, (+) clear guidelines on learning given													
	No, n = 1	(-) videos with robotic voice, (-) too much workload, (-) packed schedule, (-) unclear instructions sometimes													
2	Yes, n = 28	Students manage their learning through different modes: O = own research, F = discuss with friends, L = clarify with lecturers; in the order as shown below.													
		 <table border="1"> <caption>Q2. Modes of managing learning</caption> <thead> <tr> <th>Mode</th> <th>Count</th> </tr> </thead> <tbody> <tr> <td>F-L</td> <td>1</td> </tr> <tr> <td>O-L-F</td> <td>2</td> </tr> <tr> <td>O-F-L</td> <td>4</td> </tr> <tr> <td>F only</td> <td>21</td> </tr> <tr> <td>L only</td> <td>11</td> </tr> <tr> <td>O only</td> <td>17</td> </tr> </tbody> </table>	Mode	Count	F-L	1	O-L-F	2	O-F-L	4	F only	21	L only	11	O only
	Mode	Count													
F-L	1														
O-L-F	2														
O-F-L	4														
F only	21														
L only	11														
O only	17														
No, n = 0	-														
3	Yes, n = 28	Students do review their learning through watching video, summarise & note taking regularly, mainly prior to tests & exams. Although they would like to do it more regularly, but it was difficult due to lack of time & overloaded.													
	No, n = 0	-													
4	Rating of students as shown below:-														
	 <table border="1"> <caption>Q4. WBL has trained me to be a self-directed learner</caption> <thead> <tr> <th>Rating</th> <th>Count</th> </tr> </thead> <tbody> <tr> <td>strongly agree</td> <td>2</td> </tr> <tr> <td>agree</td> <td>13</td> </tr> <tr> <td>neutral</td> <td>12</td> </tr> <tr> <td>disagree</td> <td>1</td> </tr> <tr> <td>strongly disagree</td> <td>0</td> </tr> </tbody> </table>		Rating	Count	strongly agree	2	agree	13	neutral	12	disagree	1	strongly disagree	0	
Rating	Count														
strongly agree	2														
agree	13														
neutral	12														
disagree	1														
strongly disagree	0														

(+) like (-) dislike

therefore would require more time to adapt to this new approach.

Although students generally felt that WBL curriculum was overwhelming, they liked the hands-on approach, merging theory with practice, the early clinical exposure to ‘real patients’ and learning by mimicking the lecturers/supervisors in a ‘real workplace’ at the SP Optometry Centre (SPOC). All of them indicated that WBL helped them to better apply clinical skills and knowledge to examine and manage their patients.

WBL helped develop their professional dispositions in terms of confidence, communication skills, motivation to learn more, analytical skills and independence. These are few of the generic employability skills as described by Alkema and McDonald [9]. WBL, however, did not appear to help make them ‘think out of the box’. To these students, independence meant that they were able to take responsibility and ownership of their learning and to manage patients independently.

Areas for improvements to the WBL model as suggested by the students include lesser workload and assessments so as to allow more time for learning, doing their own research and also for CCAs; better video quality and bite-size videos; consistency in teaching by a common coordinator; shorter patient examination duration to align

with busy workplace situation, etc.

Based on the six questions given in SS, both WBL cohorts 1 and 2 strongly liked WBL. More than 60% of them reported that WBL enabled them to be self-directed learners. More than 80% of them felt that it helped them to develop useful optometry skills and knowledge, both technical and soft skills, so as to be work-ready and provided them with an engaging learning experience. Last but not least, more than 70% felt that they were more confident in doing their job as optometrist. These attributes were also observed in the Trad cohort but not as much as compared to the WBL cohorts. About 3-6% of students from Trad cohort even expressed disagreement to these attributes. Scores in SS2 and SS3 was relatively higher in the WBL cohorts as compared to Trad cohort. SS2 and SS3 are attributes focusing on readiness in workplace which was well-developed in students in the WBL cohorts. Early clinical exposure and more hands-on in the WBL model may have played a role.

Nevertheless, it must be noted that SS was done in the later time after internship by the Trad cohort as compared to before internship by the WBL cohorts 1 and 2 and this may have some impact on the results.

Table 9: Summary of the FGI responses of WBL cohort 2 (n = 28) - Questions 5-7.

Q	Response	Description																																										
5	Yes, n = 28 No, n = 0	(+) better understanding by self, (+) liked the hands-on sessions in clinic, (+) Learn concurrently (theory & practice), (+) liked to be independent, (+) learn by mimicking the lecturers, (+) initially overwhelming but doable.																																										
6	Rating of students as shown below:-	<p>Q6. AFTER GOING THROUGH WBL, CAN YOUR RATE THE FOLLOWINGS</p> <p>Legend: ■ strongly disagree ■ disagree ■ neutral ■ agree ■ strongly agree</p> <table border="1"> <thead> <tr> <th></th> <th>Confidence</th> <th>Communication skills</th> <th>Motivated to learn more</th> <th>Analytical skills</th> <th>Think out of the box</th> <th>Independence</th> </tr> </thead> <tbody> <tr> <td>strongly disagree</td> <td>1</td> <td>0</td> <td>1</td> <td>1</td> <td>3</td> <td>0</td> </tr> <tr> <td>disagree</td> <td>7</td> <td>2</td> <td>2</td> <td>9</td> <td>15</td> <td>0</td> </tr> <tr> <td>neutral</td> <td>14</td> <td>7</td> <td>10</td> <td>11</td> <td>5</td> <td>14</td> </tr> <tr> <td>agree</td> <td>6</td> <td>12</td> <td>7</td> <td>7</td> <td>5</td> <td>7</td> </tr> <tr> <td>strongly agree</td> <td>0</td> <td>7</td> <td>8</td> <td>0</td> <td>0</td> <td>7</td> </tr> </tbody> </table>		Confidence	Communication skills	Motivated to learn more	Analytical skills	Think out of the box	Independence	strongly disagree	1	0	1	1	3	0	disagree	7	2	2	9	15	0	neutral	14	7	10	11	5	14	agree	6	12	7	7	5	7	strongly agree	0	7	8	0	0	7
	Confidence	Communication skills	Motivated to learn more	Analytical skills	Think out of the box	Independence																																						
strongly disagree	1	0	1	1	3	0																																						
disagree	7	2	2	9	15	0																																						
neutral	14	7	10	11	5	14																																						
agree	6	12	7	7	5	7																																						
strongly agree	0	7	8	0	0	7																																						
7	In general students like the teaching approach particularly the followings: (+) early clinic exposure helps, (+) hands-on & seeing real patients help to relate theory to practice, (+) experiential learning, (+) independent (flipped learning), (+) teachers motivate, (+) increased confidence, (+) pairing up/buddy from same class helps - same knowledge level, (+) the videos help to review and manage learning. On the other hand, students felt that there are few areas for improvement: (-) workload to be moderated and stagger submission deadlines/tests, (-) 1 MC for all 3 classes for standard/consistent teaching, (-) low exposure, high expectation, (-) better quality videos (esp for CL), (-) assessment could be more formative, (-) spread out-longer duration, (-) not enough time for CCA, (-) videos-too long, (-) timetabling could be better (Lecture preceding Tutotials), (-) more case studies.																																											

(+) like (-) dislike

Table 10: Self-rated opinions from adjunct lecturers on the three questions (AL1-AL3) on 778 WBL cohorts 1 and 2 and traditional cohort.

		Strongly disagree % (n)	Disagree % (n)	Neutral % (n)	Agree % (n)	Strongly agree % (n)
WBL cohort 1 (43 inputs)	AL1	0 (0)	0 (0)	25.6 (11)	53.5 (23)	20.9 (9)
	AL2	0 (0)	9.3 (4)	18.6 (8)	58.1 (25)	14.0 (6)
	AL3	0 (0)	9.3 (4)	25.6 (11)	60.5 (26)	4.7 (2)
WBL cohort 2 (35 inputs)	AL1	0 (0)	17.1 (6)	28.6 (10)	40 (14)	14.3 (5)
	AL2	14.3 (5)	28.6 (10)	28.6 (10)	22.9 (8)	5.7 (2)
	AL3	25.7 (9)	34.3 (12)	22.9 (8)	17.1 (6)	0 (0)
Trad cohort (90 inputs)	AL1	0 (0)	4.4 (4)	41.1 (37)	50 (45)	4.4 (4)
	AL2	1.1 (1)	18.9 (17)	36.7 (33)	41.1 (37)	2.2 (2)
	AL3	4.4 (4)	15.6 (14)	44.4 (40)	35.6 (32)	0 (0)

From adjunct lecturers’ point of view and final module score (through ALS and FMS)

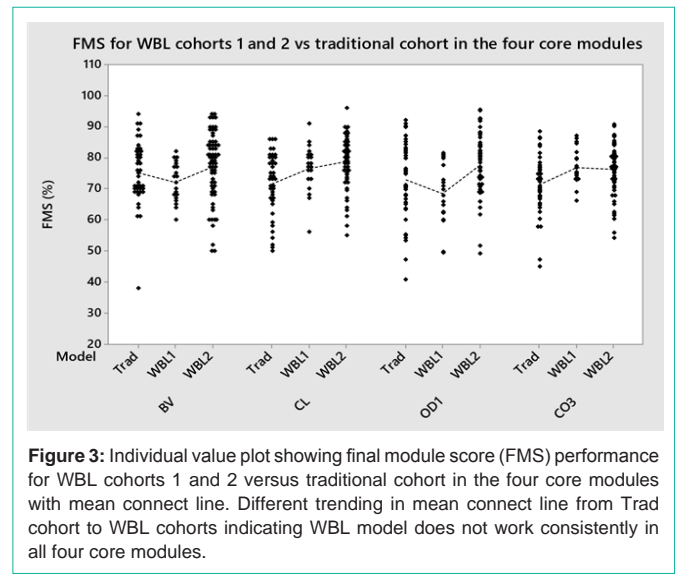
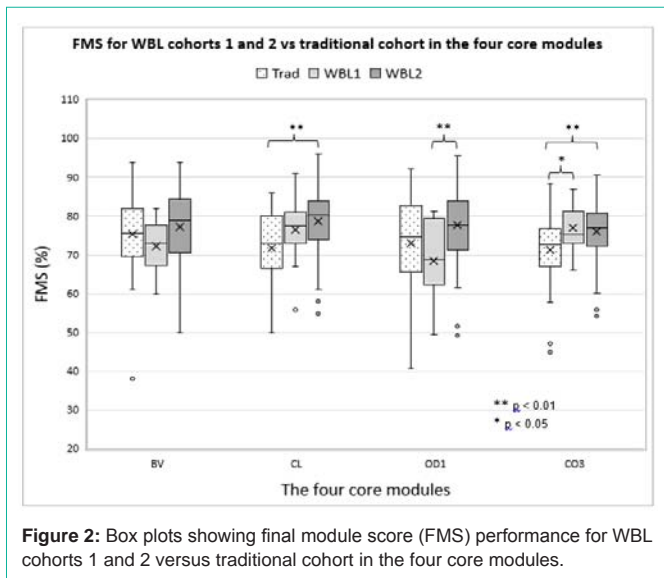
ALS has shown that the adjunct lecturers have remarkably better impression on WBL cohort 1 (mean score of 3.8) as compared to WBL cohort 2 (mean score of 2.9) and Trad cohort (mean score of 3.3) (Table 5). They felt that WBL cohort 1 had exhibited good interpersonal skills, critical thinking skills and traits of an independent optometrist. However, these were not as clearly evident when the cohort size was increased (in WBL cohort 2), which only exhibited reasonably good interpersonal skills but quite poor in the other two attributes namely critical thinking and traits of an independent

optometrist, even poorer than the Trad cohort. This clearly showed that WBL model worked well for one cohort (the smaller cohort) but not the other (the larger cohort). Critical thinking and traits of an independent optometrist are complex skills and may take a long time to develop [13]. A general definition of critical thinking is “the process of analyzing and assessing thinking with a view to improving it” [14]. It is “regarded as intellectually engaged, skillful, and responsible thinking that facilitates good judgment because it requires the application of assumptions, knowledge, and competence and the ability to challenge one’s own thinking.” Moreover, critical thinking requires self-monitoring and active argumentation,

Table 11: Comparison table showing FMS for WBL cohorts 1 and 2 versus traditional cohort in the four core modules.

Cohorts	Acad Year	BV			CL			OD1			CO3			
		FMS marks (%) (mean ± SD)	95% CI	p value (one way ANOVA)	FMS marks (%) (mean ± SD)	95% CI	p value (one way ANOVA)	FMS marks (%) (mean ± SD)	95% CI	p value (one way ANOVA)	FMS marks (%) (mean ± SD)	95% CI	p value (one way ANOVA)	
Trad cohort (n=42)	AY1819S1	75.3 ± 10.1	(72.2, 78.4)	NS	71.7 ± 10.0	69.0, 74.4)	**	73.1 ± 12.4	(69.9, 76.2)	**	71.4 ± 9.3	(69.0, 73.9)	*	**
WBL cohort 1 (n=20)	AY1819S1	72.3 ± 6.3	(67.8, 76.7)		76.7 ± 7.6	(72.8, 80.5)		68.5 ± 9.9	(63.9, 73.2)		76.9 ± 5.7	(73.3, 80.5)		
WBL cohort 2 (n=65)	AY1920S1	77.2 ± 11.0	(74.7±79.7)		78.8 ± 8.0	(76.6, 80.9)		77.7 ± 9.4	(75.1, 80.3)		76.2 ± 7.9	(74.2, 78.2)		

FMS: Final Module Score; SD: Standard Deviation; CI: Confidence Interval; *p <0.05: Tukey Pairwise Comparisons; **p <0.01: Tukey Pairwise Comparisons; NS: Not Significant.



initiative, reasoning, envisioning and analyzing complex alternatives, as well as making contingency-related value judgments [13].

Based on the academic performance (with FMS as an indicator), WBL model produced variable outcomes in the four core optometry modules surveyed, and WBL cohorts 1 and 2 performed differently (Figure 2 and 3). It was clear that WBL model worked well for CO3 and partially well for CL (only in one cohort). On the other hand, it had no impact on BV and OD1. The different FMS in WBL cohorts 1 and 2 in OD1 indicated that the two cohorts performed differently although both cohorts went through the same teaching approach. From Q5 of the FGI, it was noted that the students liked learning through hands-on. This could be the reason why they performed well in CL and CO3 as both modules were “practical-oriented” as compared to BV and OD1 which were “theory-oriented”. Moving forward, a “customized” WBL model may be needed for teaching different modules in optometry.

The different performance seen in WBL cohorts 1 and 2 based on ALS and FMS could be attributed to either or both of the following factors:

Manpower/resource availability: WBL cohort 1 was taught by four full-time lecturers, with one lecturer per module. There was therefore more focused and dedicated teaching and overall attention to students, as compared to WBL cohort 2, which was taught by

two full-time lecturers, with two modules covered by each lecturer. Student to staff ratio in WBL cohort 1 was 5:1 (20 students: 4 lecturers), whereas in WBL cohort 2 was 10:1 (20 students: 2 lecturers).

Cohort size: WBL cohort 1 was a smaller cohort (n = 20) as compared to WBL cohort 2 (n = 65). This made a difference when students were doing their clinical training as the lecturer to student ratio was smaller and again, there was more focus and attention for the smaller cohort. These could be the reason why the ALS scored the cohort 1 higher (Table 5). In terms of statistical analysis, the difference in sample size may also have contributed to different results in both ALS and FMS.

WBL is a faculty intensive and resource intensive model [15] and consistent continuity of care is crucial [16]. Manpower constraint did not allow the teaching team to fulfil these stringent criteria (in terms of i and ii above) for WBL cohort 2. The twofold increase in student to staff ratio in WBL cohort 2 and teaching WBL with a larger student cohort may have contributed to poorer students’ clinical performance that was reflected through ALS.

WBL, differs from conventional or traditional education in that it involves conscious reflection on actual experience. Fundamental to the process is the concept of metacognition, which means that one constantly thinks about one’s problem-solving processes [17]. Metacognition is an important element in SDL.

In our current version of WBL, content of the four core modules were delivered using flipped learning followed by in-class activities/discussions to clear any doubts; and students learned hands-on optometric/eye examination skills through clinical training by following patients from each of the major clinical disciplines and across different venues of care over a substantial period of time at the SPOC. During clinical training, skills and knowledge of the above mentioned four modules were integrated, and students learned to apply theory and knowledge into practice. Alongside this, it also provided learners with the opportunity to gain their generic employability skills (e.g., confidence, communication, teamwork and other work-related attitudes and behaviour) [9].

The WBL model also provide a scaffold to support a functional “community of practice” wherein students learned by directly co-managing patients under the supervision from lecturers or mentors. Fully integrated on-the-job learning provides this on a continual basis, practicums enable regular structured workplace opportunities, internships tend to be more a one-off opportunity, and simulations provide a controlled learning environment replicating a model workplace in which to practice [9]. WBL is a learner-managed rather than academic-managed learning [18] and therefore inculcates self-directed learning. WBL model using integrated clerkship has also been practiced in medical schools such as Duke NUS Medical School, Singapore and Harvard Medical School, USA [19]. It was reported that students in the integrated clerkship perform equally in terms of academic performance to peers in traditional block clerkships, display enhanced patient-centered attitudes and develop meaningful relationships with faculty.

Insights from our experience with the WBL model

Advantages: early exposure to real-life patients with lots of hands-on experience in SPOC. Optometry education requires skills-based and skills-intensive curriculum designed to develop good technical skills and the professional dispositions essential for a practicing optometrist.

Assessment: A mix of formative and summative assessments was favoured by students in this study. Assessment should be cumulative over the entire semester, instead of one major heavy weightage summative assessment. This form of continual assessment helps students to gradually enhance their learning. The assessments also have to be designed to integrate teaching content and the hands-on components.

Facilitation: students take on an active role since most activities of learning are student-led and faculty-guided. The role of the lecturer is that of a facilitator and not that of a direct instructor. Both students and lecturers have to be comfortable with this model to have successful and enriching learning experience. In addition to facilitation know-how, lecturers also have to build rapport with the students and be role models for the students to emulate.

Peer learning/peer tutoring: Students preferred to manage their learning by discussing and clarifying with their peers, within their circle of friends. Chou et al. [20] demonstrated that using peer groups helps in building supportive learning networks and facilitated reflection, and allows students to develop professional dispositions like communication, collaboration and teamwork [21-23].

Resources: WBL is a faculty intensive and resource intensive model [15], planning of details is critical since the learning and assessment needs to be integrated. Students required more personal attention and mentoring from their lecturers who follow through the entire semester with a small group “students-faculty learning communities. It also requires sufficient time for the continuity of care [16]. WBL model hence works better for smaller cohort size particularly in clinical training component [24-26].

There are multiple benefits of the WBL model as clearly reflected in the learning outcomes for our optometry students, the most important of which is the development of SDL skills. However, training highly competent optometrists who exhibit good interpersonal skills, critical thinking and good traits of an independent optometrist is itself a challenging journey. Our WBL adoption may not be perfect but this paper showed that there are positive aspects and also identified several areas for improvements that need to be addressed.

Conclusion

The WBL model was able to develop self-directed learners and produced a better academic performance in “practical-oriented” module, as compared to the students taught the conventional way. WBL helped develop professional dispositions as well as generic employability skills among optometry students, thus enabling them to be work ready. To scale WBL i.e., to adopt WBL for larger cohorts of students and to achieve good learning outcomes, considerations must be given to faculty and resource availability, which it demands.

Declaration of Interest Statement

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper. Part of this paper is accepted for publication in the proceedings of the 17th International CDIO Conference, hosted online by Chulalongkorn University & Rajamangala University of Technology Thanyaburi, Bangkok, Thailand, June 21-23, 2021.

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