**Title:**

Evidence for commonly used teaching, learning and assessment methods in contact lens clinical skills education

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**Abstract**

Introduction: Evidence based practice is now an important part of healthcare education. The aim of this narrative literature review was to determine what evidence exists on the efficacy of commonly used teaching and learning and assessment methods in the realm of contact lens skills education in order to provide insights into best practice.

Method: An expert panel of educators was recruited and completed a literature review of current evidence of teaching and learning and assessment methods in healthcare training, with an emphasis on health care, general optometry and contact lens skills education.

Results: No direct evidence of benefit of teaching and learning and assessment methods in contact lens education (CLE) were found. There was evidence for the benefit of some teaching and learning and assessment methods in other disciplines that could be transferable to CLE and could help students meet the intended learning outcomes. There was evidence that the following teaching and learning methods helped health-care and general optometry students meet the intended learning outcomes; clinical teaching and learning, flipped classrooms, clinical skills videos and clerkships. For assessment these methods were; essays, case presentations, OSCEs, self-assessment and formative assessment. There was no evidence that the following teaching and learning methods helped health-care and general optometry students meet the intended learning outcomes; journal clubs and case discussions. Nor was any evidence found for the following assessment methods; MCQs, oral examinations, OSPEs, holistic assessment, and summative assessment.

Conclusion: Investigation into the efficacy of common teaching and learning and assessment methods in CLE are required and would be beneficial for the entire community of CL educators, and other disciplines that wish to adapt this approach of evidence-based teaching.

# **Introduction**

This review aims to firstly, determine best practice in teaching, learning and assessment (evidenced based teaching-EBT) in the realm of those clinical skills involved in the fitting of contact lenses (CLs) and the management of contact lens (CL) use; and secondly to bring good and best practice together into one resource. The EBT relevant to the teaching, learning and assessment of clinical skills and in particular those relating to CL education (CLE) have been highlighted. The definition that outlines EBT in CLE has been reported in the companion paper associated with this one,[1] but for ease of reference it is included here. The International Association of Contact Lens Educators (IACLE) EBT panel has defined EBT in CLE as, ‘the conscientious, explicit, and judicious integration of best available research in CL related science on teaching, learning and assessment techniques and expertise within the context of CLE.’ Abbreviations used in this review are common with the first paper too and can be found in that paper.

This narrative literature review has been divided into three sections: teaching and learning clinical skills; clerkships, and assessment. These sections align to the steps a student would go through when moving from being a novice to becoming an expert. Those steps are the acquisition of knowledge, the application of knowledge in and the provision of competent clinical care. Where available evidence that comes from the realm of CLE has been relied upon, but where this was absent more general evidence from other medical areas that could be applicable CLE were used.

# **Teaching and learning clinical skills**

Evidence-based practice (EBP) involves integrating the best scientific evidence, the need to consider the patient’s preferences, and the health practitioner’s expertise [2] to make improved, informed clinical decisions using the most relevant and valid evidence available.[3,4] During the CLE of optometrists and CL opticians theoretical and practical knowledge of CLs is taught in order to gain competency in fitting CLs and in the management of CL use. This field is in continuous development[4] due to the fast pace of knowledge progression and development of CL modes and materials,[5,6] and there is a need to review best practice teaching and learning methods and how they translate to clinical skills and practical competencies. Teaching and learning methods that are applicable to clinical skills are:

* Clinical teaching and learning
* Journal clubs
* Flipped classes
* Case discussions
* Clinical skill videos
* Online tools
* New technologies
* Learning management systems

## Clinical teaching and learning

Clinical lectures enable knowledge delivery including general concepts and processes.[7] However, other learning environments are more likely to be effective in the development of clinical skills and reasoning, such as clinic-based sessions. These can include care delivery with simulated patients, students observing qualified clinicians or delivering the care themselves and practising technical skills on peers, before progressing to provide care to patients under supervision.[8]

To attain clinical competency, multifaceted teaching (combining more than one teaching approach) combined with clinically integrated teaching is more effective than when used alone.[9] An example is the teaching of critical appraisal, which is more effective in a clinic setting when compared to a classroom.[2] All clinical teaching methods should include student interaction, so clinical lectures should involve discussion and reflection on decisions made, with the teacher.[10]

Although this method is a traditional teaching tool it lacks an evidence base in the realm of CLE. Intuitively, improvement in clinical skills would be expected from practising them but it would be useful to know if there is an optimum form and length of practice.

## Journal clubs

Journal clubs are a face-to-face teaching and learning activity where students meet to critique and discuss research articles. They are a part of medical education and are thought to be a way to improve knowledge. They are frequently used to help novices understand the structure of research papers. Usually, one or two students present and lead the discussion. This could be a supplement to clinical lectures or as part of a collaboration with clinical practice acting as a good demonstration of EBP, critical appraisal skills and decision-making.[11] These are all important aspects of becoming and being a competent clinician.[12] In terms of teaching and learning clinical skills, linking journal club activities with routine clinical practice is important. However, a systematic review found that there is insufficient evidence to support the effectiveness of journal clubs in improving the knowledge, attitudes, and implementation of evidence-based skills by health professionals in clinical practice. Although this method is a teaching tool used in some optometry schools it lacks an evidence base in the realm of CLE. It would be useful to know if there is an optimum format and the type of the content required to help develop clinical skills.

## Flipped classes

Flipped classes can be considered an active learning opportunity whereby students present prepared material while working in small groups. Discussions and questions are guided by the teacher. Generally, they are used to reinforce understanding of EBP, to begin the development of professional attitudes, and the understanding of the consequences of the lack of an evidence-based approach to clinical decision-making.[7] The combination with clinical practice is an effective and frequently used method for teaching EBP to healthcare students.[13] A study of ophthalmology residents who took a clinical optics exam found that those who were taught using a flipped class method scored around 7% (statistically significant) more in the end of module exam compared to those who were taught using standard lectures.[14] Flipped class teaching and learning is used in CLE but has not been evaluated as it is detailed in the first paper associated to this one.[1]

## Case discussions

Case discussions, also known as case-based analysis, are where a group of individuals share details of a recent clinical case to gain clinical experience and develop critical thinking. Their main aims are to cause discussion and interaction between staff and students. The group is expected to challenge clinical decision making, including what the evidence, and how the decision combined evidence, expertise, and patient preferences. Students reflect on whether care could be improved and whether the best outcome for the patient was achieved. Students can develop triaging and communication skills, and self-reflection.[7] However, one study found that case discussions did not result in better clinical skills.[15] Whether they can improve clinical skills in CLE has not been determined.

## Clinical skills videos

Evidence-based instructional videos proved to be helpful in medical teaching for following clinical protocols[16] and resulted in improved student assessment scores.[17] Use of videos to enhance clinical skills in CLE would require slit lamps with camera/smartphone attachments and computerised imaging systems, which may lead to benefits in the assessment of CL fitting and anterior eye grading.[18] Although this method is a common teaching tool it lacks an evidence base in the realm of CLE. Intuitively, improvement in clinical skills would be expected from viewing videos and then practising but this has not been formally assessed.

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## New technologies

Alternative educational approaches such as simulated learning environments have proven to positively impact the learning experience prior to real patient-facing exposures[8] Having virtual-simulation clinics with scenarios has been validated as a favourable asset for learning by medical students, enabling higher assessment scores in comparison to students not using these tools.[19] Higher knowledge retainment was seen in students that used the online tool prior to an assessment even after 12-months, compared to students whose use of same online learning tool was not compulsory.[19]

In clinical practice, online tools can be used to search for information regarding EBP, the critical appraisal of clinical guidelines[20] and specific task-oriented information relating to clinical practice.[21]

The Coronavirus changed CL education to mostly online.[22] However, the origin of new virtual teaching methods had started before the pandemic, with 50% of the educators already delivering some clinical content online.[23] The pandemic accelerated new softwares, artificial Intelligence (AI) learning algorithm development and adaptation in healthcare.[24] Virtual telehealth platforms improve repeatability with clinical assessments, such as anterior surface grading,[25] and can also help as a learning asset for comparing the students' results. There are also physical simulators, such as slit-lamp based anatomical models with built-in anterior and posterior conditions for diagnostic learning and clinical assessment delivery. Other suggested software applications that support learning include 3D printing of corneal models with different horizontal and vertical diameters to enable the fitting of multiple rigid corneal CLs. This helps visualise fluorescein staining seen in tear film patterns.[26] The student can gain understanding of more CL fitting permutations that could be possible in a real clinical setting over the same time period.

Machine learning makes use of AI to improve the predictability of patient outcomes. This will be an increasingly valuable resource to enhance the skill of trained healthcare professionals and students. Through deep learning, AI can be taught how to predict orthokeratology lens fittings from topographic values[27] and refractive errors from retinal images with high accuracy[28], leading to the potential for other prediction-based solutions.

As the need to deliver quality educational material online has increased many universities have integrated learning management systems into their learning environment. In regard to CLs, some associations are actively sharing their online content to facilitate student learning. The IACLE developed an online learning resource, the IACLE Teaching Online Platform (IACLETOP).

# **Clerkships**

An important aspect of the learning experience, the development of clinical competency and the understanding of the importance of patient centred outcomes are clerkships. A clerkship can be viewed as a transitional clinical environment where a student applies their extensive knowledge but limited clinical skill set to progress toward independent decision making but under the supervision of a clinical teacher or supervisor.

Clerkships are full immersion learning experiences in practice- based facilities, where students will have supervised one-on-one patient inter-actions. They provide opportunities for students to apply their knowledge, improve the clinical skills they have acquired and gain experience in clinical decision making. It is an environment that enables discussions between the student and the clinical teacher in which the teacher and student should be prepared to question and challenge existing ideas on case management.[7]

Implementation of EBT into clinical curricula is considered essential to successful learning, practice and outcomes.[29] In clinical clerkship settings, students lead the discussions with the patient and with the supervisor, with the goal to develop the student’s confidence in applying evidence in the clinical context and being able to challenge clinical best practice in a safe setting. Clerkships are essential to bridge the gap between the academic and clinical worlds, enabling students to experience the ‘real’ translation of EBP in a real clinical context.[30]

One, older study reported on a 10-day ophthalmology undergraduate clerkship. A pre- and a post-test demonstrated a high rate of learning. Specific success factors included well-organised information, self-instructional material, and enthusiastic interaction.[31]

The ideal length of time for a clerkship needs to take into account the learning benefits for the student, the best patient care and outcomes as well as the financial impact on the clinic providing the clerkship. Medical students are placed in government funded health settings, whereas optometry students find themselves in university based clinical environments or independently run optometry practices. At the start of a clerkship a student lacks clinical management experience and will require a more chair time and supervisory time. These would reduce over time. A clerkship offered by a privately run business needs to balance these issues. A short clerkship period may result in the student experience being limited to purely observational opportunities, too long a clerkship and the student may feel the experienced gain becomes increasingly limited. In a study by Bentley et al.,[32] both students and supervisors in a private setting felt a time period of more than 6 weeks was preferred.

Another important aspect to clerkships is whether receiving care from a student is perceived poorly by the patient,[33] reported that in fact, patients saw supervised student care delivery as important and a positive experience. Whether there is any benefit of clerkships to teaching and learning of clinical skills in CLE has yet to be determined.

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# **Assessment of clinical skills**

Entry-level professionals must possess a set of skills identified and described by the profession.[34] This is also applicable to qualified professionals relocating between jurisdictions or countries. Candidates are judged to be competent when they act responsibly and effectively according to the set standards of performance.[35] Assessing skills is a way to ensure that individuals possess the knowledge and clinical skills required to enter the profession.

There seems to be no single agreed definition of competency. The medical fraternity defines competency as ‘an observable ability of a health professional, integrating multiple components such as knowledge, skills, values and attitudes’.[36] The definition that is adopted for drafting entry-level competencies for optometrists in Australia is ‘the ability to perform the activities within an occupation or function to the standard expected in employment’[37] and the examination blueprint for entry-level optometry in Canada defines it as ‘the ability to perform a specific workplace task with a prescribed level of proficiency.’[38] Skill competencies are seen as micro-level abilities leading to a full scope competent healthcare practitioner. In this context, knowledge, skills, abilities, and attitudes required for CL practice may be termed CL competencies.

The process of competency is built around four steps: listing competencies, devising training programmes, appropriate assessment methods, and determining pass levels.[39] Listing and devising training programmes are covered in the first paper associated with this one.[1] This section is devoted to clinical skills assessment methods. There is no literature specifically assessing competencies relating to CLs. However, it is worthwhile reviewing assessment strategies used in optometry or healthcare in general, which will provide insights that can be applied in assessing CL skills.

Miller’s pyramid of competence is often considered as the benchmark model when devising meaningful assessment strategies in health professions (Figure 1)[40] The assessment model presents four levels in a pyramid, with the accumulation of *knowledge* (‘knows’) at the base of the pyramid and progresses to the *action* level (‘does’) at the apex, with the other two components including application of knowledge, *competence* (knows how) and *performance* (shows how) placed in-between. The bottom two levels test knowledge and the top two levels evaluate performance to establish competency. Assessments relating to the bottom two levels (*knowledge* and *competence*) are more applicable in the early stages of a program as it involves knowledge recall and the top levels demonstration of performance.[41] However, CLs are sometimes taught in the later stages of the optometry degree and therefore performance (‘shows how’ or ‘does’) oriented assessments are more applicable. It must be noted that no single assessment method is adequate to test all levels of the pyramid of competence. Therefore, more than one test may be required to evaluate competencies. [41]

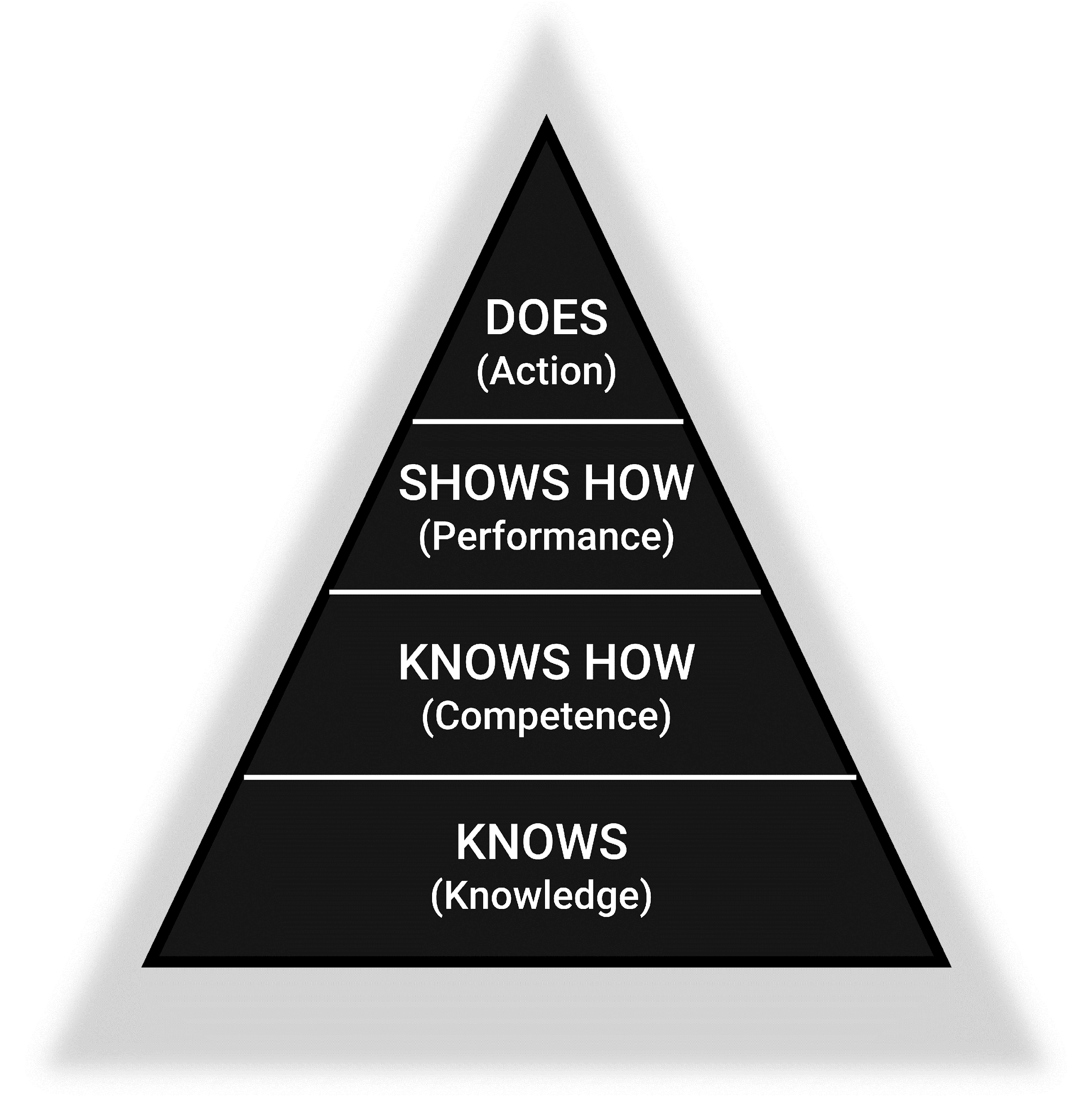


Figure 1: Miller’s Pyramid of competence.[40]

Based on Miller’s model, various types of assessment have been suggested to assess different levels of learners’ clinical competence and to improve applied teaching strategies.[42] The first level in the pyramid, knowledge, can be assessed by written exams and traditional multiple-choice questions (MCQs). The second level, application of knowledge, can be assessed by essays, clinical problem-solving exercises and extended matching questions (EMQs). The third level, clinical skills competency can be assessed by standardised exercises such as clinical scenarios and clinical exams. Finally, clinical performance can be assessed by direct observation in clinical settings using Objective Structured Clinical Examinations (OSCEs).[43] It has been argued that OSCEs are not real clinic settings as the setting is simulated and very controlled (C. Woods, personal communication, 18 January, 2023).

Multiple-choice questions

MCQs are a popular form of assessment used to determine learner performance within the cognitive components of acquired knowledge and application of knowledge competences.[44] MCQs are commonly designed to allow students to choose one option from multiple possible (3-5) answers.[45] True/false questions are also considered to be a type of MCQ.[46] Multi-select MCQs with more than one answer option is also possible.

In extended matching questions (EMQs), a higher level of knowledge acquisition, interpretation and application, can be assessed.[47] Here, an EMQ lists 10 possible answers, such as diagnoses, and investigations. The person being assessed is given some clinical scenarios (often three). For each scenario they choose the most appropriate option from the list. Answers can be used more than once.

MCQs are a reliable tool, easy to create, administer and analyse, and quick to score which is useful when there is a large number of learners.[48,49] Vegi *et al.,* reported that a well-designed MCQ is superior to a modified essay question in testing higher cognitive skills among medical students.[47] Furthermore, Hift (2014) argued that MCQs are better than essay questions especially in summative assessment.[49] Several reports suggested that beside being a valuable assessment method, MCQs are considered a useful learning tool for learners when they are involved in their design, promoting deep learning.[44,50–53]

Some educators claim that MCQs do not assess clinical, problem solving or communications skills.[47,54,55] These skills are important in medical and allied medical professions.[56–58] Another limitation of MCQs is that students can correctly answer questions by recognising the correct option(s) rather than by identifying the answer spontaneously; a concept known as cueing.[42] The shortcomings of MCQs can be resolved by designing MCQs with a case scenario or EMQ format.[47] An EMQ has a list of 10 possible answers (diagnoses, drug options, etc) given at the outset. The candidate is then given three short scenarios. In each scenario they have to choose the most appropriate answer from the list. Answers can be used more than once. There are more answer options, so there is less chance of getting the right answer by guessing. However, the scenarios are short snapshots which do not equate to a real-world clinical problem.

Some of the problems associated with MCQs are that some question may be too easy and some may be too hard. Some questions may not differentiate between good and poor students. If MCQs are changed from one test to the next, then some students may have easy questions and other students may have difficult questions. Those students with easy questions may end up with a grade higher than their ability truly deserves and those with difficult questions may end up with a grade lower than their ability truly deserves. There is no consistency if difficulty level from one year to the next. It is important to use item analysis (the item being each MCQ) in order to build up a bank of MCQs which can be used to make sure a test is valid (it tests what the educator wants to test) and has reliability (how repeatable the test results are for the same student). MCQ item analysis should consist of the difficulty index (percentage of students that correctly answered the item), discrimination index (how well the MCQ distinguishes between high achievers and low achievers), distractor effectiveness (how well the distractors distract from the correct answer). Each MCQ should be evaluated for these indices.[59] This can be done by hand or with use of optical character recognition hardware and associated software or by use of an online LMS. An MCQ which does not perform well in terms of accepted criteria for these indices can be modified and used and tested again or abandoned. In order to be fair to the cohort under test and future cohorts all MCQ tests should be followed with item analysis. It is not clear if assessment of teaching and learning using MCQs is effective in the development of clinical skills as this has not been formally assessed. Although MCQs and their derivatives are a common assessment tool, they lack an evidence base in the realm of CLE.

### Essay writing

Essay writing assesses acquired knowledge and evaluates comprehension at a level higher than fact gathering.[60] Students are asked to process knowledge rather than to reproduce it. which promotes deep learning.[61] Essays are simple to construct and require spontaneous generation of answers, which are not influenced by the cueing effect found with MCQs.[61] They have high validity and allow learners to perform better in clinical medical practice assessments compared to MCQs.[49] However, test-writers may neglect certain topics that are difficult to set as an essay question.[42]

Essay assessment could affect the way that learners study and prepare for assessments compared to other formats such as MCQs and OSCEs.[42] Furthermore, the test may require a longer time to complete which could force test-writers to include less essay questions per assessment. A limitation of essays is that they take longer to grade especially when graded by a single marker.[61] Although essays are a common assessment tool they lack an evidence base in the realm of CLE.

### Case presentations

Case presentations are context-rich assessments aiming to assess higher level knowledge acquisition such as interpretation, application and decision making.[62–64] This assessment format is valid and reliable for assessing problem solving skills in the medical field.[42,62] They may include virtual patients or computer-based cases that simulate real-life clinical scenarios.[65] The case scenario is usually brief, and contains relevant information such as, signs, symptoms and findings. Test-writers can include several scenarios in an assessment, but a well-constructed case scenario could take several hours for an inexperienced writer to prepare.[42,66] Although case presentations are a common assessment tool they lack an evidence base in the realm of CLE.

### Oral exams

Oral exams (also referred to as *viva voce)* assess a student’s critical reasoning, problem solving and judgement.[67] However, they were abandoned by US medical boards several years ago citing little value in the evaluation process.[68] There are several concerns with this assessment format including examination scores affected by student’s personality,[69] verbal style and dress,[70] and poor reliability of the exam format.[41,71] Despite this evidence, oral exams continue to be used in schools of optometry across the world for assessing CL competencies. Some medical educators argue that oral exams have a place in the student evaluation process when using best practice guidelines.[68]

### Objective structured clinical examinations

OSCEs may be considered as the standard practice of assessment for clinical skill competency. This type of assessment is mainly used to assess observable behavioral components of clinical skills competency and clinical performance based on Miller’s model.[40] OSCEs are a common exam format used in optometry around the world and in other disciplines such as medical schools.[72] OSCEs are also used to assess clinical competencies of optometrists for licensure in some countries.

Typically, OSCEs involve several timed stations where, at each station, the student performs a defined task on a standardised or simulated patient. The examiner may provide some verbal or written instructions prior to performing the task. As the student carries out the task, the examiner scores their performance on a pre-set explicit criteria/checklist. Each station mark may be used to evaluate a student’s global performance.[73] The main advantage of OSCEs are that they assess discrete and comprehensive skills[74] such as medical history recording, physical examination, and patient management across timed stations on simulated patients.[75]

OSCEs are recognised as a valuable assessment type that has an accepted level of objectivity, versatility of clinical scenarios that can be assessed, and strong predictive value for learners’ ability in integrating medical information.[76] In addition, OSCEs assist learners in incorporating clinical findings in clinical reasoning and decision making.[77–79] Early use of OSCEs fosters gaining important clinical skills, such as clinical reasoning, pattern recognition and problem-based learning.[80] OSCEs effectively evaluated communication skills among pharmacy students and qualified pharmacists.[55] However, OSCEs can be expensive and require more administrative time, material, and human resources in terms of examiners, support staff and access to patients in a clinical

situation, making it difficult to assess large number of students.[81]

OSCEs do have limitations as there is no relationship between students’ knowledge and clinical performance.[82,83] A good clinical performance during an OSCE does not indicate that the student possesses the required clinical knowledge. Furthermore, not all conditions and investigations lend themselves to an OSCE. Acute care and invasive procedures can only be assessed when they are well simulated. Examples in CLE are any acute condition such an active keratitis or CL associated red eye. Although OSCEs are a common assessment tool they lack an evidence base in the realm of CLE.

### Objectively structured practical examinations

Objectively structured practical examinations (OSPEs) may overcome the limitations of OSCEs, [84] by incorporating knowledge and performance levels of Miller’s pyramid in the assessment format. Although OSCE and OSPE formats may seem similar, there are differences. Both use procedure stations where students are required to demonstrate their clinical skill competencies on given tasks and the examiner assesses the performance on a checklist. However, in OSPEs, each procedure station is followed by a question station, where students must answer questions relating to the task(s) demonstrated at the station. The questions must be answered on an answer sheet, which are in MCQ or short answer type formats.[85] OSPEs can be applied when assessing competencies in optometry and specifically for CLs, where question stations are incorporated immediately after demonstrating a specific skill. While some initial studies showed consistency in OSPEs performance, its validity is yet not tested.[85] Although OSPEs are a common assessment tool they lack an evidence base in the realm of CLE.

### Holistic assessments

Some in the medical fraternity argue that standardisation of an assessment (such as OSCEs and OSPEs) achieves objectivity and reliability, but risks losing validity when applied to real clinical environments.[86] In other words, an outcome derived from multiple single assessments in a test environment is not comparable to an outcome from assessing competencies in real clinical situations. Holistic assessment, in contrast, assesses not only analytic components (e.g., knowledge, skills and attitudes) but also critical thinking and problem-solving dimensions[86,87] reflecting real-world settings. Therefore, competencies assessed in real practice allow an overall understanding of students’ knowledge and performance. Such a format of clinical competency assessment involves observation, interviewing (viva), mapping, and feedback,[87] suggesting competency assessment is a continuous process.[86] An example of holistic assessment is observing students examining a real patient in a usual practice on several occasions. This approach can be applied to CL skill competency assessments during students’ clinical rotations or placements. However, some limitations with this kind of assessment include long duration, requirement to train assessors, and the stress the student experiences. Although holistic assessments are a common assessment tool they lack an evidence base in the realm of CLE.

### Self-assessment

Self-assessment, sometimes called reflection, is an important aspect of learning as it enables an individual to understand their level of knowledge as well as developing meta-cognitive skills which are an important aspect of learning throughout their professional life.[88] To achieve this, learners need to be aware of the learning objectives as these are a guide for planning. Also, self-assessment activities enable the learners to value the worthiness of each activity as support in aiding learning.[89]

One of the established methods of self-assessment is self-regulated learning (SRL)[90] which includes feedback from teachers or peers,[91] recall and reflection of what was taught,[92] and application of information.[93] This is important for optometry students as there is a direct relationship between understanding a concept and its application to patients.[94] This strategy was authenticated in an exploratory study where a group of optometry students who received feedback showed an improvement in their communication skills with patients as opposed to a group of students who did not receive any feedback.[95]

The importance of self-assessment on what the students learned helps in the long-term retention of information. In another study, it was noted that frequent recall testing improves learning more than repetitive reading of content.[92] Learning is further enhanced with feedback.

Creating rubrics/scales and training learners to grade themselves based on these provides more accuracy in their assessments. Sadler and Good state that learners who were trained to grade themselves with appropriate rubrics showed a high correlation with grades from teachers. The study also emphasised that students showed improvement in their learning outcomes when tested on the same topic a week later.[96]

One of the authors (CW) noted that rubrics may be viewed by students as definitive - which they are not - so important aspects of the learning may not be in the rubric, as rubrics cannot be all inclusive, and students fail to learn what is not in. the rubric. Rubrics should be a very high level guide but can be criticised as not providing sufficient detail (C Woods, personal communication, January 2023).

The benefits of self-assessment can be summarised as follows:

* Improves learning ability becoming a deep integral lifelong process.
* Develops a better understanding of the concepts, enhances learners’ autonomy, cognitive and meta-cognitive abilities.
* Learners are involved in the process by making a conscious effort in understanding the assignments/projects rather than passively accepting their grades.
* Diminishes learners’ apprehension about the grading process and improves the learner-teacher relationship.
* Aids in personal, cognitive, and conceptual growth along with the development of interpersonal and communication skills.[97]

Introducing self-assessment as part of the learning curriculum is gaining more importance as concepts such as the Integrated Student Self-Assessment (SSA) model and Learning Contract Design (LCD) have shown improved cognition.[98]

The Integrated SSA model provides learners with score sheets, defined criteria and standardised guidelines. Once the learner submits the self-graded answer and scoresheets, they are graded by tutors based on the same criteria and feedback provided. This is shared with peers for further feedback. After the learner has received feedback from the tutor and peers, they revisit and re-grade themselves. The advantage of this method is that the learners do not have any grade pressure; they understand their shortfalls and learn through positive criticism.[98]

LCD is where learners are the primary decision-makers. There are three contributors. Learner, tutor, and learning resources. The learners decide on the assessment tasks, along with an appropriate timeline which is discussed with the tutor. The learner proceeds with the relevant learning resources. Agreed appropriate criteria are used and the learner conducts regular self-assessment as per these criteria. After submission of the final assignment, the tutor grades the work.[99] A study carried out among final year nursing students revealed that the factors which influenced successful completion were appropriate skills, an understanding of theoretical knowledge, and support from tutors. Three types of learners were identified; happy, pragmatic, and fearful, and the outcome was successful learners with a good holistic approach to learning.[100] Self-assessments lack an evidence base in the realm of CLE.

### Formative and summative assessment

It is important to maximise the efficacy of learning in educational institutions. Stimulating learners and increasing motivation to study is an effective way to enhance learning efficacy. Formative and summative assessment have proven to be valuable in this respect.[101–104]

Formative assessment determines progression during the course[105] and helps educators to identify and improve deficient areas. [106] Instructors can monitor learning to provide ongoing feedback that can be used by instructors to improve their teaching and by learners to improve their learning. Formative assessments help learners identify strengths and weaknesses and help instructors recognise where learners are struggling. Formative assessments are generally low stakes, where they have low or no point value. Learners have the opportunity to self-reflect and improve. Common formative assessments include quizzes, projects, presentations, and group activities.

The goal of summative assessment is to evaluate learning at the end of an instructional unit by comparing it against some standard or benchmark. Summative assessments are often high stakes, where they have a high point value. Examples of summative assessments include midterm and end of term exams, and a final project. Summative assessment determines learning results at the end of the course. [105] This assessment strategy allows instructors to determine the competencies acquired and learning achieved.[106]

Formative assessment can be defined as an assessment for learning and summative assessment as an assessment of learning.[107] Formative and summative evaluations are complementary approaches. Information from summative assessments can be used formatively when students or faculty use it to guide their efforts and activities in subsequent courses.

Formative assessment was associated with better learning outcomes for learners, especially those with lower grades.[108] Interestingly, formative assessment was a predictor of final results.[109,110] Learners who are given feedback increased involvement in the learning process.[109] (Additionally, if the students perceive they have a satisfactory grade in a formative assessment, they are motivated to do the same, if not better, in a summative assessment.[111] A study has shown that offering different assessment types, learners use many, and sometimes all available assessments.[112] Online revision quizzes and picture quizzes were the most chosen, which was attributed to their fun nature. Other studies have demonstrated that learners prefer stimulating and entertaining approaches because these encourage involvement.[113,114] Including fun in the learning process reduces anxiety and stress and helps reduce the initial overwhelmed feeling.[115–117] Also, immediate instructors’ feedback was appreciated by learners.[112]

For clinical competencies, the nature of the simulation environment was found to be important in formative assessments, especially those involving complex cases.[118] Satisfaction with clinical simulation was greater when learners were assessed using formative evaluation. Some learners complained about the time constrained nature of summative assessment in simulated scenarios leading to increased anxiety during their clinical performance.[118] Increased anxiety may negatively influence the learning process.[119,120] Formative assessment has been described as a debriefing phase.[107] Students consider debriefing the most rewarding phase in clinical simulation. [121–123] Formative and summative assessment help to evaluate learners’ knowledge, progress, and acquisition of competencies to apply them in and theoretical clinical settings. Our search of the peer reviewed literature did not find any studies on the use of formative and/or summative assessment in CLE. There was evidence that the following teaching and learning methods helped health care and general optometry students meet the intended learning outcomes; clinical teaching and learning, flipped classrooms, clinical skills videos and clerkships. For assessment these methods were essays, case presentations, OSCEs, self-assessment and formative assessment. There was no evidence that journal clubs and case discussions helped health care and general optometry students meet the intended learning outcomes. Nor was any evidence found for the following assessment methods; MCQs, oral examinations, OSPEs, holistic assessment, and summative assessment.

# **Post graduate learning**

Finally, as learning is considered a lifelong journey, and with the expectation that health care practitioners maintain their clinical competency, many registration bodies require ongoing continuing professional development (CPD). The regulatory and legislative environments which encodes the training and qualification for optometry and CL practitioners and governs the sale of CLs to consumers is diverse matching the diversity in global consumer expectations. At one end of the spectrum, disposable soft CLs are bought online as fast-moving consumer goods, without the input of an eyecare practitioner.[124] [125] At the other end, specialty rigid gas permeable (RGP) lenses are fitted by an optometry or ophthalmology degree trained practitioner with additional post-graduate training or certification in CL practice.[126] Within this spectrum, there are many eye care practitioner qualifications which allow the fitting, prescription and sale of CLs. These qualifications can be categorised as providing: vision function services (typically a certified dispensing optician); ocular diagnostic services (typically a degree qualified optometrist); and ocular therapeutic services (typically a post-graduate degree qualified optometrist or ophthalmologist). [127]

Globally, significant efforts to harmonise both the legislative and regulatory environment of eyecare provision and CL supply, as well as the education of eyecare and CL practitioners, are underway. Reflecting that the majority of CL fitting is done by optometrists, this effort is being spearheaded by international organisations such as the European Council of Optometry (31 member countries), The World Council of Optometry (44 member countries), The Asia Pacific Council of Optometry (18 countries), the African Council of Optometry (14 member countries), and is supported by many educational and professional bodies.[127–131] Not all CL practitioners are regulated or licensed. Opticianry and optometry are regulated as a profession in most countries where accredited degree or diploma qualifications are offered.[132–134]

Graduating optometrists have obligations around scope of practice and ongoing continuing education in order to maintain and renew registration each year. Before registration, most degrees include a period of internship or external clinical placements within the course or program and some degrees also require an external one-year residency or pre-registration year. This period of external clinical immersion allows students to acquire clinical acumen which is hard to gain in a university teaching environment. Post-graduate external licensing examinations, administered by the national registering body or department of health, are required after this period of clinical placement for optometrists practising in Canada, Ireland, Saudi Arabia, Thailand, UK and USA.[135–140]

While there are pockets of reciprocal registration or mutual recognition in optometry, with Canada recognising many USA qualifications and Australia and New Zealand offering mutual registration.[141,142] For the most part, optometry is regulated within national borders or even within state borders, as is the case in the USA and Canada.[143,144]Within the USA there is variation between state boards on scope of practice for opticians, ophthalmologists, and optometrists with regards to CL fitting and prescription.[145]

In China and Taiwan, optometry is considered a subspecialty of medicine. In the UK, USA and Russia optometry graduates can work within the hospital system where a lot of specialist CL fitting is done and scope of CL practice is gradually increasing.[146][147] Most universities offer post-graduate master of science and doctor of philosophy qualifications in CL and anterior eye research, or a master of public health degree.

Many countries offer voluntary post-graduate courses in CL practice. In Norway, graduates complete a three-year optometry degree, then an additional six-month post-graduate qualification in CL fitting.[148] Other voluntary post-graduate courses allow the use of the addition of post-nominals letters to a practitioner’s name, allowing recognition of their specialist qualifications. Whilst it does not entitle them to the use of the term CL specialist, Australian optometrists can complete post-graduate certificates of advanced CL practice, or specialty CL studies, and this allows practitioners the use of post-nominal letters after their name.[149,150] CL educators around the world can study the IACLE course materials and sit the IACLE Fellowship examination in CL practice, successful completion of the examination allows the use of FIACLE as post-nominal.[131] In the US, registered practising optometrists can apply for additional post-doctoral residency programs. This allows graduates to effectively demonstrate competency in a specialist area and assessment of this competency can take place at any point following graduation as there is no time limit on commencement. The CL residency programs currently on offer in the US receive a high number of applicants per program compared to other optometry specialist residency programs on offer.[151] Completion of this program, or of three years of practice, entitles the optometrist to sit an additional Board certification examination, a credential which entitles them to be a diplomate of American Board of Optometry.[152] American Academy of Optometry offers additional recognition for expertise in CL and anterior eye through its fellowship and diplomate of anterior eye programs, successful candidates can use FAAO or Diplomate AAO.[153] Membership with a CL society can also develop practitioner expertise, provide a hub for networking and support research through sponsorship and publication. CL societies such as the British Contact Lens Association (BCLA) hold clinical conferences and also offer Fellowship credentials, which members apply for via submission of evidence of their CL and anterior eye expertise and passing an oral examination.[154] The BCLA Contact Lens Evidence-based Academic Report, comprising a series of journal articles, was recently published offering evidence-based guidance for many aspects of CL practice.[155] The Cornea and Contact Lens Society of Australia hosts the International Cornea and Contact Lens Congress allowing practitioners to learn from international experts in the field, and also holds regular continuing professional development meetings for local chapters in each state.[156] One advantage of mandatory continuing professional development (CPD), where evidence of CPD is required for annual registration renewal, is that it is often accompanied by a requirement for the optometrist to generate a formal learning plan, providing structure and intentional reflection around areas of practice that need development (https://optical.org/en/education-and-cpd/continuing-professional-development/).

**Conclusion**

New teaching and learning techniques and environments have emerged over the last few decades based upon scientific evidence. Some of these techniques have found wide applications in the education of healthcare-related professions since they could potentially be very useful for students who need to learn a broad theoretical knowledge and develop practical clinical skills. A discrete body of evidence has demonstrated these techniques and environments being particularly useful in health professions education and more specifically in the optometric HE. Notwithstanding these premises, in this review, no direct evidence of the spreading and benefit of these strategies in CLE was found.

Nevertheless, the authors engaged in this review found evidence for the benefit of some teaching and learning and assessment methods in other disciplines that are transferable to CLE and could help students meet the intended learning outcomes. There was evidence that the following teaching and learning methods helped healthcare and general optometry students meet the intended learning outcomes; clinical teaching and learning, flipped classrooms, clinical skills videos, and clerkships. For assessment these methods were essays, case presentations, OSCEs, self-assessment and formative assessment. There was no evidence that the following teaching and learning methods helped healthcare and general optometry students meet the intended learning outcomes; journal clubs and case discussions. Nor was any evidence found for the following assessment methods; MCQs, oral examinations, OSPEs, holistic assessment, and summative assessment.

Further investigation into the efficacy of these teaching and learning and assessment methods in CLE are required and would be beneficial for the entire community of CL educators, and other disciplines that wish to adapt this approach of evidence-based teaching.

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