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An upgrade of the Malmö model by implementing case-based teaching and learning, in an undergraduate dental education

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Abstract

Background: At our dental education, the examination failure rate amongst students has increased, resulting in subsequent involuntary dropouts. One of the main problems seems to be that the students struggle with taking the necessary responsibility for their learning, as required by the problem-based learning (PBL) methodology.

Aim: To describe the background to, and the transition process from, pure PBL to case-based teaching and learning (CBT) with flipped classroom seminars at the dental programme at [anonymised for peer review].

Methods: In this position paper, we describe our observed problems with the PBL methodology, as implemented at this faculty, and the potential benefits of a change towards CBT. The current implementation of CBT is presented, along with educational research supporting the choice of activities.

Results: Tentative findings are that the flipped classroom seminars and the clearer instructions appear to be successful with higher levels of activity, engagement and attendance amongst the students, and the students have evaluated the seminars as very good learning activities.

Conclusion: Tentative findings suggest that the current implementation of CBT may be a fruitful way of teaching in dental education today. Most of the teaching staff have been reawakened to teaching, and as a result, the content of the courses are being reviewed and improved. The students appreciate that what is expected of them has been made clearer and that there is a variety of learning activities.

KEYWORDS
case-based teaching and learning, dental education, flipped classroom, PBL

1 | INTRODUCTION

For almost 30 years at the Faculty of Odontology at [anonymised for peer review] University, the curriculum for the undergraduate dental education has followed what is referred to as the "Malmö model".[1] This model, which was originally devised in strict accordance with the principles of problem-based learning (PBL), has served us well for many years, both as a strong foundation for the education of new dental professionals and as support for the continued learning of the graduated practitioners. However, our dental education has recently faced new challenges, in particular an increased examination failure rate amongst students, resulting in subsequent involuntary

dropouts. Although many factors may contribute to the observed decrease in student achievement, one of the main problems seems to be that the students struggle with taking the necessary responsibility for their learning, as required by the PBL methodology.[2] Also, given that several other limitations of PBL have been reported during the last decades, we have chosen to follow the recommendation by Tärnvik[3] to loosen the strong connection to PBL and focus more on the merits of case methodology. In this paper, we describe how we, as of the first semester in 2018, started to move from PBL to case-based teaching and report on some tentative findings from this transition.

1.1 | The advantages and limitations of PBL

Several advantages of PBL methodology have been proposed, but the core aspiration is to foster autonomous and reflective practitioners[2] through involving the students in collaborative group work, in which the students take responsibility for their own learning process. A number of studies, most focused on medical education, support the idea that PBL is beneficial for student learning. For example, Albanese and Mitchell[4] performed a meta-analysis on studies reporting the effects of PBL, and the results show that students perform just as well, and sometimes even better, on examinations when compared to students who were taught with conventional teaching methods (see also[5]). Another example is a study by Watmough et al.,[6] who interviewed educational supervisors after the introduction of a PBL curriculum. In this study, the supervisors observed that the students were better prepared when compared to "traditional graduates." In addition, Koh et al.[7] performed a review of studies investigating the effects of problem-based learning in medical school on physician competencies after graduation. The findings, based mainly on self-assessments, suggest that PBL had positive effects on physician competency after graduation. The specific competencies that moderately or strongly supported PBL for both self- and observed assessments were the ability to cope with uncertainty, showing appreciation of the legal and ethical aspects of health care, demonstrating communication skills and taking responsibility for self-directed continuing learning.

Working with PBL has been shown to have many advantages. However, as with all pedagogical methods, there are also drawbacks, such as significantly increased teaching time[8] or problems with dysfunctional groups.[9] Some difficulties with PBL programmes also seem to accumulate over time, if these programmes are not properly maintained, which has led advocates of PBL to provide a number of suggestion on how to minimise or avoid erosion of PBL curricula.[10] Furthermore, more recent reviews of the PBL literature have questioned the conclusions from previous, more optimistic, publications. For example, in a review of research on PBL, Colliver[11] examined the credibility of claims about the ties between PBL and educational outcomes and the magnitude of the effects published in previous reviews. According to Colliver, no convincing evidence can be found that links PBL to improved student knowledge and

clinical performance, at least not of the magnitude that would be expected given the resources required for a PBL curriculum. Part of the problem in determining the effectiveness of PBL when compared to other forms of instruction is that there are many variants of PBL. In their overview, Taylor and Miflin[12] note that the context is just as effective as the method in shaping the success of PBL. The decision about whether to keep using PBL is therefore not simple and binary. Not only does it involve an evaluation of the specific operationalisation of PBL and the surrounding context, but it also involves balancing the costs to amend the difficulties that have accumulated over time, and then maintain and guard against future erosion,[13] against finding other, less costly and/or more adequate and methodologies with similar advantages.

1.2 | The Malmö model

The Faculty of Odontology at [anonymised for peer review] University has implemented a pure PBL-based curriculum since 1990, in accordance with the Malmö model.[1] This model was built on a holistic view of the acquisition of knowledge, understanding, skills and attitudes. It is an educational strategy based on evidence from cognitive psychology[14] leaning on (1) the activation of prior knowledge, (2) encoding specificity by contextual learning and (3) the elaboration of knowledge for better storage and retrieval of the knowledge,[15] where "learning" was the most central concept and students' responsibility for their own learning was thought to drive the learning process.

The Malmö model contains certain important pillars or elements:

- Active learning—actively engaging students through discussions, problem-solving, case studies, roleplay and other methods.
- Spiral curriculum—concepts and topics recur throughout the programme in different and more complex contexts.
- Contextual learning—the linking of theoretical constructs to practical real-world contexts.
- Lifelong learning—an ongoing and self-motivated pursuit of knowledge.
- Early contact with patients—auscultations during the first course and treatment of patients in the second course.
- Critical thinking—disciplined thinking that is clear, rational, open-minded and informed by evidence.

PBL has been used throughout the entire education (dentists, dental technicians and dental hygienists) in the Malmö model. However, during the last years of their education, the students struggled with the motivation to work through the seven steps to problem-solving, as developed by the University of Maastricht[16]

In attempts to reduce resources in facilities and tutors, some changes have been made in recent years concerning the amount of time students spend in study groups and also to the teacher/student ratio. In several courses, the teachers were facilitators in two groups at the same time or with each group for only a part of the

problem-solving process. These changes were not evaluated specifically but may have contributed to an erosion of the model.

The interest and commitment to act as a facilitator in the study groups had developed from being a highly regarded task undertaken by several experienced teachers to that of a task given to a few, sometimes unexperienced, teachers.

Our yearly evaluations with the students showed the following outcomes:

- It was unclear to the students how comprehensively and deep they should learn.
- Emerging IT resources and an increased offering of study material made it difficult for them to find and limit the required amount of literature.
- The seminar did not function as a good learning environment and did not support learning in the intended way.

The seminars were student-led, in that they were based on the study groups' unanswered questions regarding the PBL cases. The students were also instructed to send their questions to the teachers a few days prior to the seminar to give the teachers an opportunity to prepare the answers. Apart from the student evaluations of the seminars, we noticed a decline in interest from the students, reduced student attendance and seminars were sometimes also shortened or even cancelled due to the lack of questions from the study groups.

To capture the attention of the millennial students reared on rapidly evolving technologies and with different qualifications than previous generations, we had to change some of the principles of the curriculum. We needed to find a way to better meet their needs yet keep the important pillars of the Malmö model.

Our hypothesis is that a modified case-based teaching, with more active and varied learning strategies such as "flipped classroom" seminars, could better meet the requirements of the millennials and at a lower cost. Both PBL and case-based learning are pedagogical methods used in a challenge-based learning approach.

1.3 | Case-based teaching

Case-based teaching (CBT) has both similarities and differences when compared to PBL. The similarities are that both methods require active participation on behalf of the students, often revolving around an authentic, clinical case. However, whilst the PBL process is essentially driven by the students and the tutors primarily observe and guide, the teachers have a more active role in CBT. For instance, in CBT, the teacher designs the cases based on their subject-matter expertise in order to focus the students' attention on what they think are the most relevant aspects given the students' current level of competence. This also means that the students may receive direction, study materials, structure during small-group sessions and lectures from the teacher rather than define their own learning goals and depend on the peer group for their learning.[3,17] Whilst PBL

requires no prior experience or understanding in relation to the subject matter, CBT requires the students to have some degree of prior knowledge that can assist them in addressing the case at hand.[18] Srinivasan et al.[17] measured the perceptions of students and faculty after a curricular shift from traditional PBL to CBT at two institutions and showed that this "guided-inquiry methodology" may be appreciated and sometimes even preferred.

Taken together, CBT offers the possibility to keep some of the major advantages of PBL whilst addressing some of the limitations, most notably, the heavy reliance on the students' responsibility for their own learning and heavy reliance on functional groups. In addition, CBT is likely to be less time-consuming,[14] because neither the "7-steps of PBL" nor the tutors are used,[19] and it is also compatible with teacher-directed delivery of disciplinary knowledge.[3]

2 | AN UPGRADE OF THE MALMÖ MODEL BY THE IMPLEMENTATION OF CASE-BASED TEACHING

As outlined above, CBT is compatible with teacher-directed delivery of disciplinary knowledge. Consequently, in the current implementation, not all of the learning objectives concerning knowledge and understanding are studied through cases.[19] During the earlier courses of the programme, the students are given thorough study instructions, with learning goals and literature references that are put in a learning context, and cases are introduced gradually in the programme. We tried to follow the three steps for the successful change of a curriculum, as implemented by Licari.[20] The first step— that the faculty members should feel that a change is needed— was achieved, as a majority of the teaching staff felt the need for a change because they were frustrated by the students' thoughts about learning and the impaired test results. The second step—to prepare the faculty for the new teaching and learning approach— was carried out in collaboration with a pedagogical unit [anonymised for peer review], where they had introduced case-based teaching and flipped classroom seminars a whilst ago. To this date, nearly all of our teaching staff have had a 3-day course at [anonymised for peer review], where they could assimilate new knowledge and develop new skills, which has been followed by support from this pedagogical unit. Regular meetings have also been held, where all the teachers meet and discuss this updated model of teaching and learning together. Early adopters, who can demonstrate to other faculty members how a successful course change can be implemented, are invaluable when successfully adopting a curriculum change.[20] Therefore, we used two early adopters as mentors for other faculty members who experienced difficulties in adapting to the new way of teaching and learning. These early adopters also continuously evaluated and revised the implementation of case-based teaching.

As a result, case-based methodology is now successively introduced throughout the programme. Together with instructions and cases, we also have introduced additional learning activities built on the notion of "active learning" (such as "flipped classroom" seminars,

quizzes and peer-assessed assignments), and as a complement to the early clinical training, we are in the beginning of implementing a programmatic assessment for development towards clinical independence and a professional approach.

The core elements of active learning are student activity and engagement in the learning process, as it is known that active learning encourages the brain to activate cognitive and sensory networks, which helps process and store new information. Learning is enhanced when multiple neural pathways are activated simultaneously. This means that engaging many sensory, cognitive, emotional and social processes in each student's brain will increase their learning potential.[21] There is also considerable support in the literature that active learning facilitates the retention of knowledge and improves academic achievement.[22] We needed to find new methods to continue and improve the possibilities for active learning for the students and believe that working with CBT in combination with flipped classroom seminars will achieve this. When students have the opportunity to interact actively with each other and the lecturers in the flipped classroom sessions, they can analyse, synthesise and evaluate course content and use their new learning to construct a shared meaning, which falls in line with the higher levels of Bloom's taxonomy.[23]

2.1 | Flipped classroom seminars

As mentioned, our seminars were failing to be a good learning environment. To better activate and support the students, we introduced flipped classroom seminars to the updated Malmö model. In addition to the flipped classroom seminars,[24–26] CBT made the seminars a better learning activity[27,28] and helped the students understand threshold concepts.

Lage et al. define flipped or inverted classrooms[29] as "events that have traditionally taken place inside the classroom now taking place outside the classroom and vice versa." A flipped classroom requires that students do self-directed homework before class and then get together in small groups to discuss faculty-designed learning activities during class time.[30]

In a review, O'Flaterty and Phillips[31] found that there is not just one but rather several models for the flipped classroom and that core features of the "flipped learning approach" generally include students receiving content in advance (often in the form of a pre-recorded lecture), the lecturers' awareness of students' understanding, and higher-order learning during the flipped learning activities. They also state that the flipped learning approach has the potential to improve student engagement, both within and outside the class, to enable the cultivation of critical and independent thinking in students, creating the capacity for lifelong learning and thus preparing the students to use their knowledge in future real-life situations.[31] Studies show advantages with flipped classroom in dental educations, compared to traditional methods,[32,33] but further studies comparing flipped classroom methodology with other active learning methods are needed.[34]
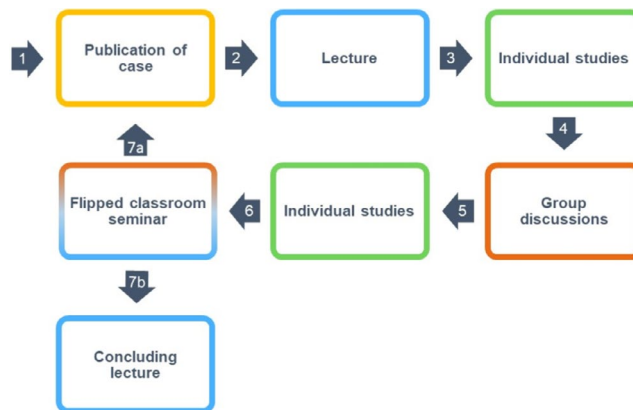

FIGURE 1 Example of the stages in the flow of teaching and learning in the upgraded Malmö model. Stage 1: A case, study instruction or assignment is published on the students' digital platform along with a list of recommended literature and learning outcomes. Stage 2: One or several lectures are held in a lecture room or online. Stage 3: The students work individually to acquire, remember, understand and sometimes apply the knowledge corresponding to Stage 1. Stage 4: The students continue to work in groups to gain understanding, apply and occasionally analyse and synthesise, depending on the case or assignment. Group work is mandatory during the first year; thereafter, it is voluntary, but highly encouraged during the following four years. Stage 5: Continued individual studies. Stage 6: The flipped classroom seminar, which is based around discussions arising from quiz questions and/or cases. The lecturer leads the seminar, but the students are supposed to contribute the most to the discussions. Stage 7a: A new case, study instruction or assignment is published, along with a list of recommended literature and learning outcomes on the students' digital platform, or Stage 7b: A concluding lecture is held at the end of a block of several cases, study instructions or assignments

In our model, we typically start with a lecture, which is accompanied by reading instructions or a case (Figure 1). The students then study and prepare individually and/or in groups. The following seminar is where the students get to practice, test, analyse, synthesise and evaluate their acquired knowledge (Figure 2). After we introduced the flipped classroom approach into seminars, we noticed higher levels of activity, engagement and attendance amongst the students, and for the first time in many years according to the course evaluations, the students considered the seminars to be very good learning activities.

Our goal is to gradually implement and increase the number of digital lectures preceding the flipped classroom seminars. The incorporation of digital learning strategies into the classroom can be critical for reaching millennial students because most of them may be considered "digital natives," in the sense that they have been exposed to information technology from a very young age.[35] Students supplied with optional video lectures come to class much better prepared than when they have been given textbook reading.[36] However, active learning with a technology-enabled flipped

FIGURE 2 The flipped classroom seminar uses active and cooperative learning strategies. The seminar starts with an individual quiz (circa 7 items with 4 alternatives), and then, the items from the quiz are discussed, one at a time, in small groups (5–7 students), where the group must come to an agreement and vote on which alternative they find the most correct. After the vote, the lecturer(s) leads the discussion, and each group justifies their choice. The lecturer summarises the discussion, and a new discussion starts on the next quiz item. The students develop their capacity to analyse, synthesise and evaluate the course content and use their knowledge to construct a shared meaning, thus making sense of what they are learning

What is a pseudo pocket?	Answer frequency
A. The gingival pocket is deeper because of attachment loss	2%
B. The gingival pocket is deeper because of swelling of the gingival tissues	46%
C. The gingival pocket is "false" because there is no bleeding on probing but the tissue is swollen	38%
D. The gingival pocket is deeper than 3 mm, most often 4–5 mm deep, but never deeper than 6 mm	15%

FIGURE 3 This figure shows an example of a question (single best answer) used in a quiz at a flipped classroom seminar during the second semester of the dental programme in the block on periodontology. Concepts that are difficult for the dental students to understand were identified in the clinical training and at examinations. One of these concepts was the pseudo-pocket. When the question was answered individually by 61 students, the discrimination index was 0.62, which is considered as very good,[46] and the distribution of answers was high, which created a good basis for discussion both in the small and the large groups. Alternative B was considered as the best answer

classroom requires a shift in the minds of both educators and students, hence the gradual implementation.[37]

Still, as a consequence of the COVID-19 pandemic, instructions and cases have been further supported by digital on demand-lectures, so much appreciated by the students that they have asked for a post-pandemic continuation. The pandemic has also forced us to conduct flipped classroom seminars and concluding lectures in virtual environment, such as Zoom (Zoom Video Communications, Inc.), mimicking the design of real-life seminars. We have used chat-function and break-out rooms for questions and discussions in smaller groups, which have made the seminars more interactive.

2.2 | Quizzes

The flipped classroom seminars usually start with a quiz to activate acquired knowledge, increase motivation and give the students feedback on how well they have learned the objectives of the associated case or study instructions given by the teacher (Figure 3). In our experience, the students have come well prepared, which allows for more active participation and more developed contributions to the seminar discussions. This is in accordance with findings reported by Park and Howell,[30] who suggest that the purpose of quizzes in relation to flipped classroom seminars is to ensure that the students have viewed the online materials prior to class in order to facilitate classroom discussions. The quiz results can therefore be used to determine the level of student readiness for class activities. However, using the quiz as a motivating factor for student participation in-class activities was not the original intention. Nevertheless, a motivating effect was observed, even though the quiz results were not included in students' overall course grades. Students' performance on the quizzes helped the instructor identify any concepts the students were failing to grasp, which led the instructor to develop in-class exercises to address those shortcomings.[30]

The quizzes are also meant to stimulate the continuous acquisition of knowledge during the whole semester, which promotes the retention and processing of knowledge and can be considered a good predictor of a higher examination score.[38] The results are put in each student's portfolio, where it can be seen if some students are struggling with their learning process and then additional support can be provided. Although Park and Howell[30] did not find any relationship between online quizzes and improved test scores when they implemented the flipped classroom as an educational model in a predoctoral dental course, Dobson[38] saw a significant correlation between mean online quiz scores and mean summative exam scores. We draw from Dobson, who considered the use of online quizzes as an indicator of students' chances of passing the final examination because, even at this early stage of our evaluation, we have seen a correlation between our students' performance on the quizzes and their scores on the final examinations. This is a topic for future research, but for now, we find that the quizzes are a good way for the student to test their knowledge, and they also enjoy and learn from the discussions around the different MCQ alternatives in the seminars. In addition, it is a useful tool for us to find and then help any students who, for whatever reasons, are not following their study plan. However, in the beginning, some students perceived the quizzes as grades and explored ways of cheating. When realising this,

we gave the students more clear explanations about the idea of the quizzes.

2.3 | Peer-assessed assignments

We consider the seminars to be a vital part of the updated model; therefore, they are mandatory. If, for whatever reason, a student cannot join this learning activity, they will be given a written assignment dealing with the questions and discussions that took place in the seminar. The assignment will be read and reviewed by a student peer. Studies indicate that the students' learning can be improved by peer assessment[39] and that these assessments are sometimes equally as effective as those conducted by the lecturers.[40]

Peer reviews have the capacity to improve students' learning and help develop self-assessment skills, moving them towards becoming independent thinkers and writers.[41] In addition, we give both peer- and teacher-reviewed assignments to students continuously throughout the programme to promote academic literacy and a research-based process for learning. The topics for these may by predefined by the lecturers or may be based on the students' own questions or interests related to the topic at hand.

2.4 | Assessment and development towards clinical independence and professional approach

Programmatic assessment is an assessment programme focused on learning outcomes that are identified for an entire programme, not just a single course or module. We have been influenced by this perspective in our new model.

If programmatic assessments are based on several low-stakes assessments during the whole semester, then it is easier for the teachers to identify students who, for whatever reasons, are not keeping up with their studies and clinical training during the semester. One single assessment can only address part of a student's competency, and no all-encompassing assessment exists that can address all the aspects of student competency all at once. Furthermore, a single assessment cannot capture student change or growth. Therefore, in our upgrade of the Malmö model, we strive to combine different assessments, and most importantly, the development of a digital assessment tool for the continuous observation of the students' development towards independence in clinical practice. The limitation of single data points of assessment are what drives, legitimises and informs our thinking about programmatic assessment.[42]

The idea of low- and high-stakes assessments is fundamental to programmatic assessment. High-stakes assessment decisions, such as the awarding of credits, progressing in the programme, and the awarding of final qualifications, should ideally always be based on the aggregation of a number of low-stakes assessments. Single low-stakes assessments should provide feedback for learning[43] and not, as is commonly the case, be associated with grades, because grades give students very limited information about their performance.[44]

The many observations of student performance provide evidence of competence and progression and may stimulate reflection, which is an important component of professionalism. A student portfolio can integrate multiple components, and it is suitable for both low- and high-stakes assessments. One main purpose of assessing the students' development towards clinical independence is to strengthen, systematise and improve the feedback that we give our students and thus further improve the quality of the students' clinical training.

Observations of professionalism are incorporated in our assessments. Professionalism is a broad competency needed by dentists who provide high-quality patient care. Professionalism and a professional approach have been represented in the learning outcomes for the dental programme in the Malmö model, but the lecturers have found it difficult to assess whether students have reached the expected level of these outcomes. In our upgraded way of teaching, we have increased the focus on these outcomes through new learning activities and the introduction of continuous assessments. Given that students need feedback on their development as professionals, we have chosen to work actively with ongoing and formative assessments on professionalism and the professional approach in both clinical settings and in other teaching and learning environments. We discuss and assess matters such as showing respect to peers, patients and faculty personnel in addition to demonstrating integrity, a sense of responsibility, cooperation skills, punctuality to learning activities and patient appointments and so on. Formative assessment motivates students to learn the importance of professionalism, but since the lack of summative assessment may send a conflicting message to students, we as educators must actively work to produce clear expectations that students can strive for.[45]

3 | CONCLUSION

After almost 30 years of having implemented a teaching and learning approach in accordance with the Malmö model, with strict PBL, both teaching staff and students found it necessary to upgrade the curriculum to better suit today's students. There was a generally expressed desire from the students to be given clearer instructions on what they were supposed to learn and how they should learn it.

An upgrade of the pedagogical model was carried out with an introduction of case-based teaching and flipped classroom seminars. The students are now given thorough study instructions with clear learning goals and literature references. These instructions are put in a learning context, and cases are introduced to the students gradually through the programme.

The seminars that previously received negative feedback from the students were redone as flipped classroom seminars with quizzes to stimulate and activate acquired knowledge, increase motivation and give the students feedback on how well they have learned. These seminars appear to have been successful, as we have noticed higher levels of activity, engagement and attendance amongst the students. Furthermore, according to recent course evaluations, for the first time in many years, the students have considered the

seminars to be very good learning activities. At this early stage of our evaluation, we also see a correlation between our students' performances on the quizzes and their scores on the final examinations. Another important aspect is that the quizzes are good tools for us to find and help students who, for whatever reasons, are not following their study plan.

After the implementation of the updated model to the first courses of the dental programme, we feel that this is the right path and a fruitful way of teaching and learning in dental education today. Most of the teaching staff have been reawakened to teaching, and as a result, the content of the courses are being reviewed and improved. The students appreciate that what is expected of them has been made more clear and that there is now a variety of learning activities.

We will continue to prepare the staff for this new teaching and learning approach through continuous education and workshops with different topics. We have also started to evaluate and research our implementation from both a student and a teacher perspective, where we will use data from student questionnaires, as well as interviews with students and staff about their perceptions and experiences. Additionally, examination results and data on student completion will be used to evaluate the changes made. In conjunction with these continuous evaluations, plans are being made for qualitative studies on the working environment and the digitalisation of the education. This will help us further develop and improve our model of teaching and learning.

CONFLICT OF INTEREST
We certify that our research is free of any conflicts of interest.

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