Clinical decision-making in undergraduate surgical education. Exploring a TBL-course and the application of digital technologies

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Competence-based education in surgery needs to include diagnostic strategies, problem-solving skills and understanding of the indications in individual patients as well as learning of manual techniques. Upon completion of their training, students will need to know how to use these for the patients' benefit. We introduced Team-Based-Learning (TBL) in a large class format using digital teaching aids, to teach surgical patient management. Participants were introduced to digital tools increasingly common in clinical practice. Questionnaires, semi-structured interviews and focus groups investigated their effects and student perceptions. Students were highly satisfied with the course, were motivated and improved their surgical knowledge. The course generated a successful learning process in surgical patient management and improved students' confidence. Embedding future digital health technologies is welcomed and enhances students' activity but has to be introduced carefully.

1 Introduction

Competence-based undergraduate surgical education in Germany

In Germany, teaching surgical competencies is traditionally based on lectures and seminars. Lately, surgical curricula increasingly focus on teaching technical skills (Ruesseler et al., 2013). Competence-based education in surgery needs to go beyond this and should include diagnostic strategies, problem-solving techniques and an understanding of indications for interventions, benefits, limitations, risks and possible complications of procedures and therapies (Agha et al., 2005). Diagnostic thinking and decision-making skills can be acquired by clinical reasoning (CR) or clinical decision-making (CDM) courses (Young et al., 2020). CR/CDM is complex and challenging to teach (Baker et al., 2015) and to measure (Covin et al., 2020). While important for future practice, CR/CDM is not regularly implemented in curricula (Koenemann et al., 2020; Rothdiener et al., 2020). Previous research regarding CR or CDM explored case-based approaches with critical reflection of action (Homberg et al., 2019), serious games and virtual patients (Fleiszer et al., 2018), and paper or video-based discussion

groups (Weidenbusch et al., 2019), usually in small groups (Harendza et al., 2017; Koenemann et al., 2020), with a need for multiple tutors. Positive effects of course concepts might be attributed to collaborative learning (Weidenbusch et al., 2019). Teaching small groups has not been compared to lectures with large audiences or interactive online cases. A careful case selection, active student participation, immediate feedback and thoughtful involvement enhance the learning of CR/CDM (Kassirer, 2010). Team-Based-Learning courses (TBL) also facilitate the development of clinical decision-making skills (Michaelsen & Sweet, 2008). TBL further enhances teamwork skills through small group active learning in large classes (Burgess et al., 2018; Parmelee et al., 2012). TBL yielded positive results on surgical exam scores, with TBL being received favourably by participants (Burgess et al., 2014), albeit with potential for improvement (Kaminski et al., 2019).

Applying digital technologies for teaching and learning

Digitalisation in medical education should maximise the benefit from digital teaching and learning and prepare students to master digital technologies in patient care (Haag et al., 2018). One of the essential elements of TBL is the structured preparation. Guided questions can be used for preparation as learning tasks (Jakobsen & Knetemann, 2017). Preparatory material can be provided in a paper-based (offline) or online format. The advantages of an online format (ease of access, updates, structure, media availability) are apparent. Digital technologies are increasingly present in every aspect of medicine. Upon completion of their training, students will need to know how to use them for the patients' benefit. Digital tools can support educational techniques (Woods & Rosenberg, 2016).

We developed a surgical clinical decision-making course in a large group setting. Based on student ratings and perceptions, we analysed the TBL-structure concerning: use of online-learning/preparation with learning tasks – learning activities during the course – perceived differences to traditional formats – student satisfaction – change of interest in surgery – effects on their clinical decision-making strategies – experiences with the use of tablet computers as technical teaching aid. Questionnaires, semi-structured interviews and focus-group-interviews were used to answer these subjects.

2 Material and methods

Goals of the course

The novel course was developed for the 5th year of medical school to enhance student activity, team-based learning and provide clinical decision-making strategies in surgery.

Participants of the study

The students had no previous experience with clinical reasoning or decision-making courses. 142 students in the summer cohort 2018 and 124 students in the winter cohort 2018/2019 were trained. TBL was conducted in a large classroom setting with one tutor, in which the students were grouped into 5–6 students.

TBL structure

The TBL approach was used in the inverted classroom format with mandatory online preparation. Course material, literature and hyperlinks to the adaptive learning and reference platform Amboss® (AMBOSS GmbH, Berlin, Germany) were provided via the learning-management platform Moodle (Moodle Pty Ltd, West Perth, Australia). Learning tasks were provided to foster knowledge for pathologies, related to patient cases. Nine sessions covering various surgical cases leading to specific interventions were conducted. The cases were selected to cover frequent pathologies, adequately reflect the scope of surgical medicine and according to areas covered most frequently in Germany's centralised medical licensing exam. The "Team Readiness Assurance Test" often used in TBL (Parmelee et al., 2012) was modified to oral testing: Three pathology-related questions were presented and discussed in the beginning of the class, assessing and balancing the participants' level of knowledge. Sessions began in a large class with a case presentation. Diagnostic tests and examinations were performed in a virtual fashion by groups of 5–6 students. Results were presented on tablet computers. Eventually, the diagnosis made by the students led to a specific surgical intervention. Benefits and potential risks of the intervention were discussed together with the perioperative management. The students learned to gather sufficient information to make a sound decision in each case (Table 1).

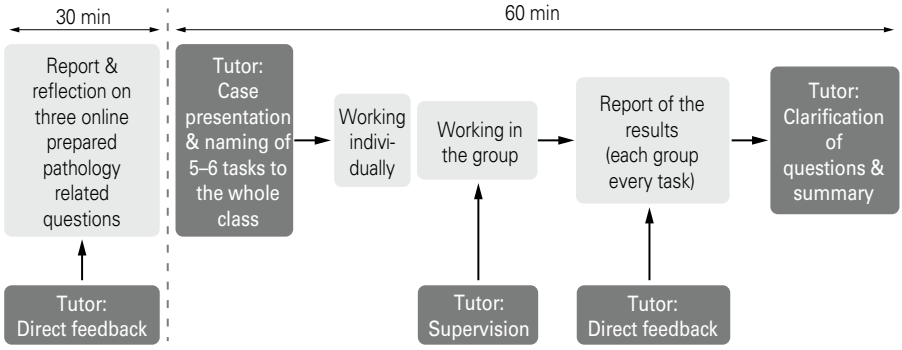
Table 1: Development of a patient case based on the learning objectives

Patient case – Development based on learning objectives:
– **History and physical examination is presented**
1. What do I have to initiate to find out the diagnosis?
– **Results of clinical testing (e.g. laboratory, imaging, etc.) is presented**
2. What differential diagnoses do I have to consider and how can I exclude them?
3. Why do I choose which therapy?
4. What do I have to take into consideration? (e.g. pre- and post-operative procedures)

Students were encouraged to evaluate, analyse and make decisions regarding five to six tasks in their group. The tasks covered specific learning objectives. Each group presented their conclusions to the class. A tutor acted as a facilitator, answering questions during the team time, providing test results, and feedback for clinical decisions and summarising the case at the end of the course (Figure 1). Tutors were taught how to provide feedback and were supported by written instructions. While each student

group developed different strategies, tutors' actions were as standardised as possible (digital supplement).

Figure 1: Course schedule in the novel "clinical decision-making in surgery" course



Digital technologies as teaching aids

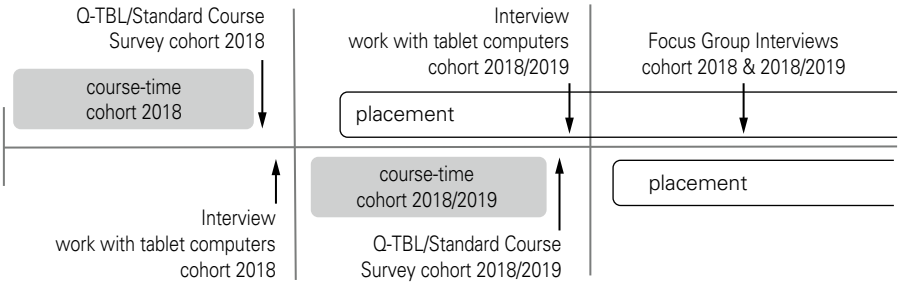
Results from imaging, diagnostic procedures and laboratory tests were presented on a tablet computer (iPad, Apple Inc., Cupertino, CA, USA). Imaging studies were provided using an app for DICOM (Digital Imaging and Communications in Medicine) data and telemedicine (Join – Medical Communication, Allm EMEA GmbH, Erlangen, Germany). Thus, results of diagnostic procedures were presented in a realistic fashion and students were introduced to the usability of these digital tools. Issues like data protection, ethics and potential benefits were discussed.

Data collection and analysis

We used a multi-method approach to evaluate the TBL-format, the problems and effects of the course and its multiple components (Timeline: Figure 2). After the course, students were given a questionnaire (Q-TBL) with 18 items derived from the "Knowledge Re-Consolidation Inventory" (Ahn et al., 2017) and adapted to our course. Questions covered the TBL structure like self-guided preparation, knowledge consolidation, retrieval practice, peer elaboration, feedback, and transfer of knowledge. Questions regarding attainment of surgical competencies, surgical interests and items on feasibility and acceptance of the course (including the use of digital tools) were added. The usability of these tools was explored in semi-structured interviews with ten randomly selected students of the two cohorts immediately after the course. Standardised questions included: "How was working with the tablet computers and the app?", "What was especially positive or negative about it?" and "What were the challenges?". The faculty of medicine conducts a mandatory survey for each course at the end of the semester. Results of the latter survey are included in this study; however, the questions were not specifically designed for this study and could not be modified. This led to different scales used for the answers.

A randomised sample of 18 students was selected for focus group discussions after completion of their exams and having started their placements. We assessed the impact of the course in preparing students for their exams and the applicability of the decision-making strategies in their routine clinical practice. The data was transcribed verbatim from recordings. The data analysis was conducted manually using a constant comparison approach. We used the deductive method for the interviews (Schulz et al., 2012). Each transcript was read by two independent persons. Topics were indexed, analysed, and a consensus was made to categorise content into different themes.

Figure 2: Timeline of the study



3 Results

Standard course survey of the faculty

75% (2018; n = 107) and 90% (2018/2019; n = 113) of the two cohorts participated in the standard course evaluation. Students were rather satisfied with the course and components (Table 2). Evaluation results are reported as mean ± standard deviation (*M* ± *SD*), Likert scale (1 = unsatisfied to 7 = absolutely satisfied).

Table 2: Results of the standard survey of the faculty: Standard Course Evaluation (N = 220, Likert scale 1 = absolutely unsatisfied, 7 = absolutely satisfied)

How satisfied are you with ...	*M* ± *SD*
… course content	5.6 ± 1.2
… organisation	5.6 ± 1.3
… preparation for exams	5.0 ± 1.7
… performance of the tutors	5.4 ± 1.2
… general conditions (rooms, technical support)	5.9 ± 1.1
… tools for preparation and postprocessing	5.6 ± 1.5
… subjective knowledge gain	5.3 ± 1.2
… course all in all	5.5 ± 1.3
… exam situation	4.9 ± 1.7

Questionnaire TBL (Q-TBL) – Components of the course

65% (2018; n = 93) and 90% (2018/2019; n = 113) of the respective cohorts answered the questionnaire regarding TBL components. The results are reported as *M* ± *SD*, Likert scale: 1 = strongly agree to 6 = strongly disagree. The results indicated that the students worked regularly with the *online material*, prepared for each course and found it relevant and helpful. TBL stimulated student activity, was useful, and tutors' feedback was helpful. Group work was rated average regarding recalling the content previously prepared online. Students appreciated the better memory of the content of the new course compared to traditional courses and of the content they applied themselves. The course was positive in teaching surgical content but did not change interest in surgical specialities. Satisfaction with the course concept was in the upper half of the scale (Table 3).

Table 3: Results of the Q-TBL – Components of the course (Likert scale 1 = totally agree; 6 = totally disagree)

Component		*M* ± *SD*
Online-Learning/ Preparation for the course (N = 206)	Regular preparation	2.2 + 1.3
	Material was relevant for the course	1.9 + 0.8
	Worked with learning aids	2.3 + 1.3
	Learning aids helped preparing the course	2.1 + 1.1
Learning Activities during the course (N = 209)	Regularly engaged myself in the course	2.2 + 1.1
	Was able to apply my knowledge	1.8 + 0.9
	Questions in the course were appropriate in relation to preparation	1.9 + 0.9
	High engagement of the group during discussions	2.3 + 1.0
	Group work helped to recall the content learned online	2.8 + 1.3
	Feedback of the tutors was helpful for understanding	2.2 + 0.9
Comparison of new course/experience of traditional seminars (N = 209)	Boredom during the course	4.6 + 1.0
	Good memory of the content of the course	2.6 + 0.9
	Better memory of the content of traditional lectures	3.9 + 1.2
	Better memory of the content that I applied in the course	2.3 + 1.0
Satisfaction with course/Surgical content (N = 206)	I think TBL is good	2.7 + 1.4
	I don't like group work	3.9 + 1.5
	Satisfied with course concept	2.1 + 0.8
	Think I learned surgical content	2.4 + 0.9
	Interest piqued	3.3 + 1.3
	More interest after course	3.4 + 1.6
	Interest before the course	3.1 + 1.7

Questionnaire and semi-structured interviews – "Work with tablet computers"

65% (2018; n = 93) and 87% (2018/2019; n = 109) of the cohorts rated the work with the tablet computer. Enthusiasm and didactic use received average marks (Table 4).

Table 4: Results of the Q-TBL – Supplementary questionnaire: "Work with tablet computers" (N = 206, Likert scale 1 = totally agree; 6 = totally disagree))

Item	*M ± SD*
It was fun to work with the digital tools	3.6 ± 1.3
Went flawlessly	3.1 ± 1.3
Was applied at sensible points	3.1 ± 1.2
Self-directed work with patient images was possible	3.2 ± 1.1
Realistic viewing was possible	2.5 ± 1.1

Positive and negative comments from the *semi-structured interviews* and suggestions were categorised. Students found the tools realistic, highlighted the self-directed working and would welcome the use in other courses. Technical issues and tutors not implementing the tools correctly counteracted efficiency (Table 5).

Table 5: Selection of answers of the semi-structured interviews – "Work with tablet computers"

Positive	Negative
– *"Very practice-orientated!"* – *"… good idea, I can Imagine working with it in other courses"* – *"… at last we can look at all the images of the CT-scan …"* – *"… to look at it and find the pathologies by ourselves was cool…"* – *"… should be used more often in other courses …"* – *"It activates a lot in the course … should be used more …"* – *"I would like to try it again!"*	– *"Not all of the tutors haven't used it in a meaningful way – some even didn't know what was on it … !"* – *"We didn't have enough time to work with the iPads."* – *"… the App didn't work always error free!"*

Focus group interviews

The focus group interviews explored how students experienced the self-directed online learning, the in-class (group) learning and if or how they adapted decision-making strategies during their placement. The interviews reflected, that *online preparation* motivated the students to work with the literature provided. Online learning tasks stimulated them to work not only with the provided material but motivated them to seek other links and literature. The acquired knowledge was sustained and helpful for the state exam. The success of working in groups depended on group dynamics and composition. The groups were helpful to accumulate knowledge. Refreshing previous knowledge was mentioned as well as the motivation to reassess the cases after the

course. The stimulated discussions in the course encouraged students to comment, discuss and clinically reflect in their placement. Students also highlighted an increase in confidence initiating discussions on diagnostic and therapeutic strategies with colleagues and residents. Reflecting on the appropriated *clinical decision-making in surgical management*, they now apply the structures learned to clinical practice, they especially mentioned evaluation of findings, result-related procedures, taking consent from patients. Students now apply the structure for processing differential diagnoses and therapy in their daily work. The course did not have substantial influence on career decision with most students having made their choices before the course, which was offered late in the curriculum. Students with few interests in surgery expressed new respect for surgical patient management.

4 Discussion and evaluation of the results based on recent literature

TBL has gained popularity in medical education, mainly in the US, Asia and Australia (Hong & Rajalingam, 2020) and surgery (Kaminski et al., 2019). It has been evaluated superior for the learning of specific skills compared to other methods (Cremerius et al., 2020; Parmelee et al., 2012). TBL should be highly organised with explicit instructions and useful resources (Kaminski et al., 2019). In Germany, we only know of one published TBL-format in the medical field, tested in continuing medical education of surgery (Kühne-Eversmann et al., 2008). We introduced TBL in a clinical decision-making course in the surgical field in a large class format. We used a multi-media approach with digital technology commonly used in patient care, to facilitate acquisition of digital competence. Students were introduced to telemedicine tools. The contents covered in our course were previously covered in various courses throughout medical school or not covered at all. Thus, a direct comparison to other formats taught previously or simultaneously was not possible. We believe that our course will become a regular feature of our curriculum. Based on the *standard course survey,* students were satisfied with the new course, its content, setup, and knowledge acquisition. Students' satisfaction is known to have influence on student motivation and their learning behaviour and thus on learning success (Peus et al., 2005). It is a valid measure for quality of teaching (Rindermann, 2001). The goals of our course concept concerning TBL have been achieved. Students worked with the prepared online material on a regular basis and found it helpful and relevant. They were able to retrieve and apply knowledge in class and learning retention was reported. In their self-assessment they rated their peer-work as very active and the tutor feedback supportive, the course in general was rated educational. A learning progress in the surgical field associated with TBL was established. Focus groups are appropriate to explore participants' views as well as the underlying perceptions and considerations (Rabiee, 2004). As interviews have been proven to analyse complex questions related to medical training (Stalmeijer et al., 2014), we used the focus groups to investigate and deepen the understanding

of the results of the questionnaire. Clinical decision-making is a complex competence, and it is difficult to measure this multidimensional construct (Covin et al., 2020). The results of our focus-group interviews show a good sample of how students perceived their self-directed learning using online learning tasks. This underlines that online preparation for TBL is crucial. The interviews also highlighted a known limitation of TBL: Group dynamics are important and can promote but also limit learning (Rajalingam et al., 2018). In the interviews we qualitatively explored students' perceptions reflecting on the TBL-course. Students applied the learned structure of clinical practice in their final year. It is remarkable that students credit the course with improved confidence in discussing clinical problems with residents and colleagues. We were able to teach surgical content and encourage learning retention. The course was able to develop clinical decision-making competencies in surgery. *Digital technologies* can support and facilitate self-directed learning activities (Curran et al., 2017; Han et al., 2019) and may be more effective than traditional learning due to improving knowledge and skills (Tudor Car et al., 2019). With digital technologies being further integrated into healthcare, medical curricula must prepare students for the healthcare environment they will work in (Haag et al., 2018). Embedding digital tools in undergraduate medical education is a challenge. It has been successfully implemented in optional electives in small groups, but not on a large scale in Germany (Kuhn et al., 2018). We demonstrated that the integration of digital tools can activate students in a large class format. These tools facilitate clinical decision-making. The data from structured interviews clarify the average rating in the questionnaire. If the tutor does not apply those skills in the correct way or does not allow enough time for learning, students become unsatisfied or even annoyed. Technical problems with the app or the image presentation were criticised and led to limitations in acceptance.

Study limitations

The results of this study are based only on student perceptions. Students voluntarily took part in the questionnaires, focus groups and semi-structured interviews, biasing our results. Their views may or may not be representative of the wider student or staff population, or applicable to other universities. No objective testing of factual knowledge was performed. Improvement in factual knowledge and analysing CR development was beyond the scope of this study and can be the focus of future research.

5 Conclusions

We successfully implemented the "clinical decision-making in surgery" course using a multi-media approach in a large class format. The complex course scenario included various didactic approaches as TBL using digital teaching aids and introducing digital tools. The investigation confirmed student satisfaction with the course and motivation with the pre-class learning process, sustained during class time. This led to a success-

ful learning of concepts in surgical patient management, which was sustainable and rated superior to traditional lectures. It influenced students' self-assurance in a positive way. Embedding future digital health technologies in an undergraduate clinical decision-making course enhances student activity but must be thoroughly introduced to teachers and students. Technical problems must be avoided. Career decisions were not influenced with the participants being very advanced in their training and decided regarding future careers.

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