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RESEARCH ARTICLE

Medical students' metacognition and perceptions of learning behavior in problem based versus science-based curriculum

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ABSTRACT

Background: This study explores metacognitive competencies of medical students and provides insight into student's perceptions on self-regulated and co-regulated learning preferences depending on curriculum type. Once in Germany universities medical students are taught either a problem-based curriculum (PBC) or the classical science based curriculum (SBC), this study evaluates the impact of these two teaching methods on students' learning behavior.

Methods: Semi-structured interviews with 28 medical students were performed. Data collection and analysis were conducted iteratively, informed by principles of constructivist grounded theory. These study function as the basis to conceptualize a quantitative questionnaire.

Results: Although learning strategies were similar, major differences between groups were the motivation in undergraduate level. PBC - students preferred early patient presentation in undergraduate courses which eases the acquisition of the underlying scientific knowledge base, further triggering the desire to learn beyond the regular curriculum. SBC - students learn primarily for exams using simple memorization, arguing that the tight curriculum and the amplitude of learning matter impede them to study beyond the necessary evil. Studying motivation in PBC is higher than in SBC students although the latter expressed their excitement to see patients when entering the postgraduate study level.

Conclusions: PBC teaching style and working with patients already in undergraduate level motivates students in learning beyond the required minimum than in SBC. With increasing learning load students focus on exam preparations. The study findings suggest an educational model being learner driven, patient case-centered and preferably based on real time observations in order to better apply medical knowledge to the patient case at hand.

Keywords: medical students, learning strategies, perceptions, curriculum

Introduction

Students are prone to struggle with learning, especially when transitioning from high-school to university and later on while transition into their profession. Because clinical knowledge is rapidly advancing, students and doctors alike are expected to be “life-long learners”, self-regulate their learning and update their knowledge autonomously in less structured learning¹. Learning opportunities in today’s academic environment became much wider than in past decades. Modern course content is presented as a multimedia content with a mixture of classical up-front lectures, scripts, books, question banks and various e-learning sources¹. Mobile electronic devices give students ample opportunity to obtain, study and check medical information at any given time and location, and thus broadening available learning resources dramatically compared to simply go to the library, buy teaching books or physically attending lectures². The learning style theory where individuals have been taught using methods which are matched to their “learning style“ result in better scores, have been proven false^{3 4}. While “learning styles” do not correspond with exam scores, learning approaches do⁵. The Tripartite Model separates the learning approaches nicely into three categories: Deep, strategic and surface learning. The first occurs when students have an intrinsic motivation and personal interest in the educational material. The main goal of the strategic learning approach is to excel. Fear of failure with the trend to rote learning and consequently poorer understanding of the educational material motivate the latter⁶.

Various factors influence students’ learning priorities including whether they need to improve in the subject, whether the material is interesting, whether the material is manageable and whether the assignment is in their major area of study or interest⁷. Other factors is the diversity by medical students and residents, which is linked to individual (goal setting), contextual (time pressure, supervision) and social (supervisors and peers) factors⁸. Past research has explored the learning styles and learning approaches among “traditional” medical students, and some studies suggest that non-traditional medical students differ in the way they learn from their traditional counterparts⁵. German medical schools offer two different teaching approaches a) the traditional science based curriculum (SBC) focusing in undergraduate classes mostly on pure memorization e.g. from up-front lectures, and b) the problem based curriculum (PBC) which starts early on with self-regulated and problem-based learning strategies⁹. This gives the

unique opportunity to learn more about today’s students’ perceptions of learning patterns and learning approaches depending on their respective curriculum type.

Aims

This study explores metacognitive competencies and perceptions of medical students on learning preferences depending on curriculum type. It is our belief that this information may possess the means to improve teaching methods in health care, enhancing students’ confidence in learning and therefore better equipping our future physicians with sufficient knowledge.

Methods

In order to inquire the thoughts and goals of medical students a qualitative research approach was chosen using semi-structured interviews which will function as a template for the development of a quantitative questionnaire in the near future. The interviews were carried out between November 2019 and March 2020. The interviews were conducted face-to-face - at the University Witten-Herdecke or at the Kreiskliniken Reutlingen – Ermstarklinik, Germany - or at home over the phone. The interviews lasted about 30 minutes, were electronically audio recorded and transcribed verbatim. All the quotations in this paper were translated into English language. Participants were students of various semesters in German medical faculties of private or state universities. The participants were selected consecutively by chance using in part snowball until theoretical saturation of the answers had been reached. Data were anonymized by designating each student a code through a computerized assignment system which guaranteed anonymity.

A thorough literature search was conducted to register themes medical students might eventually be interested in or which they expected to be confronted with as a student or as a physician in the near future. The following themes were extracted:

- The motive to become a physician, specifics of their studies while being at their respective university,
- learning habits as an undergraduate and postgraduate student,
- their career expectations and future challenges,
- their personal anticipation being an intern, and
- how to balance their private life with the intended career path. Based on these results, a

semi-structured interview template was compiled.

Number	• Questions
1	• What is your learning preference, what are your learning tactics?
2	• Do you learn for exams only or also beyond the curricula requirements?
3	• What kind of learning resources do you use?
4	• Do you use digital or e-learning tools offered by your university?
5	• What kind of learning environment do you prefer, e.g. university library, learning at home?
6	• Do you prefer learning alone or in a group?

Table 1: Semi structured interview guide. The students were asked to elucidate their answers in terms of reasoning for their learning preferences, time management, and to give examples for clarification.

Prior to the study, the raw template was piloted with five medical students not involved with this study, allowing further refinement prior to the final interviews. The items are listed in [Table 1](#).

Depending on the category up to 7 adjunct questions could be asked as a stimulus, if needed. The questions were asked to stimulate the respondents to talk freely. This study uses a qualitative study design instead of a standardized questionnaire, because it allows a deep exploration of experiences, as well as interpretation of the data¹⁰. Semi-structured interviews based on grounded-theory were performed which excludes a statistical analysis.

Ethics

Ethical approval of the study was obtained from the University Faculty of Medicine and Dentistry Committee for Ethics at the University Witten-Herdecke (# 137/2919).

Data analysis

Students' responses were analyzed using an inductive coding approach according to Mayring's principles, as also exploited by others^{11 12 13}, aided by the use of Quirkos 2.4 software (Quirkos, Edinburgh, United Kingdom www.quirkos.com) accessed on 11 March 2022). A thematic analysis was performed by all authors and themes linked and grouped to develop a schema for interpreting the data, ensuring rigor in analysis¹⁴. When the perceptive content of the interviewees replicated itself, data saturation was assumed, and the interview series was terminated. The authors read each transcript up to three times to familiarize themselves with the contents and in order to analyze the content properly. Data were then independently coded ([Table 2](#)).

Code	Descriptors	Sub-themes
Learning resources	Sources of knowledge Primary and secondary learning resources	Textbooks Scratchpads Scripts Copies from lecture presentations Digital resources: index cards, learning software, learning apps.
Learning style	Uni-polar/bi-modal/multi-modal learning pattern	Selection of one or more learning resources Deep learning strategy Self testing
Ambitiousness	Ambition to excel Promotion of personal career	Learning for life Learning primarily to pass exams Learning to quite bad conscience Learning to achieve best grades
Self regulated learning	Techniques of memorization	Learning to meet lecturers' requirements Learning with practical reverences vs pure memorization of textbook contents
Physical learning environment	Best places to learn	Learning at home Learning in the library Switching learning environments
Co-regulated learning	Learning alone versus learning with peers	Learning in a group/team Knowledge control among peers Group only for exams Always learning alone
Preparation for exams	Special learning methods to pass exams	Preparation in courses/seminars Individual learning timescale Preferred learning places Preferred learning resources

Table 2: Interview themes of 28 students recruited from five German universities.

The process involved the recognition of patterns and connections across the data and the establishment of themes and sub themes that were pertinent and applicable to the whole data set. Differences were discussed until general consensus was achieved. Reflexivity was maintained by the three researchers involved in the data analysis, being cognizant throughout of their own personal context as, respectively, practicing clinicians and educators and of any potential effect this may have had on their interpretation of the data as described earlier ¹⁵. Using this approach, the authors followed a quantitative inquiry approach, which is also the cornerstone of grounded theory ¹⁶.

Results

17 women and 11 men were recruited. 13 students came from a university with a problem-based curriculum (PBC) and 15 were taught with a science based focus (SBC). Obvious differences between the groups were the higher age which was related to the higher proportion of occupational activity between high school exam and entry into medical school, and the lower number of female students (Table 3).

Parameter	Specifics of interviewees
Students (n)	28
Age (years)	24.76±3.05
Gender distribution	♀ n = 17 (60.7%) ♂ n = 11 (36.3%)
Semester	
(1-4) = undergraduate	n=10
(5-12) = postgraduate	n=18
Interview time (minutes/ interviewee)	29.5±2.6
PBC-students	n=13 (46.4%)
gender	♀ n= 5 (38.5%), ♂ n= 8 (61.5%)
age	26.9±4.1
SBC-students	n= 15 (53.6%)
gender	♀ = 12 (80.0%), ♂ = 3 (20.0%)
age	22.60±2.03

Table 3: Baseline data of interviewees.

In undergraduates the self-regulated learning patterns differ between the curricula. Further, the ambitions are different insofar as students in PBC group show greater motivation for topics they are interested in, but not to achieve the best scores in exams.

Learning resources

Medical students make extensive use of digital self-directed learning resources, especially during preparation for the first state examination (M1, "Physikum"). Undergraduates also spend a large part of their learning time reading textbooks. Some make personal notes from lectures in scratchpads, some learn from teaching materials like scripts obtained from the local student union or they use copies from lecture presentation material provided by the professors.

"I usually used to work with books, wrote bullet points and drew and then read through them and marked them. And then I wrote down small tasks on a different piece of paper." (SBC)

Some use digital learning sources like the software AMBOSS (www.amboss.com), Via Medici (www.viamedici.thieme.de), ANKI (index cards, www.apps.ankiweb.net) or Meditrix (www.meditricks.de) in parallel to the use of medical textbooks which weans however in postgraduate students. In both student groups, a minority was found who preferred to write learning

contents on paper or highlight those in books in order to memorize them better.

"I'm studying for the state exam [M1, "Physikum"] with AMBOSS, there is everything in the system. And I see how others learn in the final run and simply cram through the individual subjects, I find that not quite reflective" (SBC)

Contents presented through digital sources are for most of the students easier and quicker to comprehend. Some digital sources even provide a learning plan, a step by step strategy which also includes exam questions from previous exams to verify and check the educational attainment. Further, it seems easier to survey for medical contents which is regarded to be more time consuming with books, provide presentations from operation theaters or other themes in in video format.

"I am a very visual learner. That's why I usually dive into the anatomy book and study it. At the same time, I prefer to speak out loud, which structures are there right now. Apart from that, I also watch videos. So I rely a lot on my eye." (PBC).

Learning style

Most students had multi-modal learning styles. Most started as uni-modal (read/write) learners preferring reading from books or scripts as undergraduates but became bimodal learners in higher semester levels using printed and electronic

media or even multi-modal learners with auditory - reading and auditory-kinesthetic type learners. The proportion of uni-modular vs multi-modal learners was equal in PBL as well as in SRL. With approaching exams deep learning strategies preferring digital learning tools enabling a condensed knowledge transfer in a short period of time including self testing methods mostly based on using the vast library of old multiple choice question prevailed in both groups.

"In undergraduate level I learned mostly from books and lectures. In postgraduate level I switched to digital learning sources"

Ambitiousness

Although no questions regarding their motivation and academic ambition in scoring best during their undergraduate or postgraduate studies had been asked explicitly, some participants of the PBC group mentioned their desire to learn as much as they can. Successful students stated high academic demands on themselves. They wished to prevail with a "pure conscience" in their clinical clerkship. No students in PBC groups claim to aim at achieving highest possible overall grades in order to become a good doctor.

Self-regulated learning pattern: Learning for exams only or beyond, learning for life

Students adapt both what and how they learn to meet the lecturers' requirements, which are manifested in assessment. The PBC group frequently mentioned that patient presentation in undergraduate courses eases the memorization of the underlying scientific knowledge base. Interesting patient cases or themes trigger the personal desire to learn beyond the regular curriculum. In the SBC group students predominate who learn primarily for exams regardless if they are tests in courses or seminars, or for state examinations. Further, they claim that the tight curriculum and the sheer size of learning volume make it difficult to study more than what is inevitable.

"I only study for exams. Even though I'm actually interested in reading a bit more about it, but mostly ... yes, I'm a bit too lazy or maybe I don't have the time or I don't take the time." (SBC)

Physical learning environment

Most students in this study claim to prefer learning in the university library or a combination of learning at home and in the library. Some students of a

higher semester describe a change in learning pattern as they learned more frequently at home as an undergraduate, but preferring the library as a postgraduate.

All of the interviewees had a mobile phone, a laptop computers or a tablet computer with the capability to search online for information. Their positive response and attitudes towards mobile learning refers to the use of any e-learning devices through which flexible learning opportunities are created along with higher mobility i.e. any time and any place.

"I often study on the road or wherever I happen to be. The advantage is that you always have it with you. You have a lot of things bundled together in one mobile electronic device." (PBC)

Co-regulated learning

Novice students indicated being unsure of clerkship expectations from their learning plans and thus relied on one another to prepare for courses, develop a learning schedule and depended on others for the understanding of the new learning environment. Interactions with peers exposed gaps in students' knowledge or skill proficiency, helping them to prepare for exams. Most students in both groups saw co-regulated learning to control one's skills and individual study progress. Only a minority of students claim a) studying solely alone or b) of being 100% dependent on group learning sessions.

Preparation for exams

Most students in this study preferred for the exam preparation in courses and seminars a co-regulated learning strategy combined with individual learning intervals alone e.g. at home. Since multiple choice questions (MCQs) are the common format in medical state exams, students use for the preparation condensed learning sources like the AMBOSS software combined with intense practicing former MCQs.

"At the moment [I use] for the exams only AMBOSS and our question banks, which is based on memory protocols of old exams" (SBC)

Discussion

This study provides deep insights in medical students' perceptions how they preferred to learn, the favored learning materials, the physical learning environment and strategy in order to acquire knowledge in a most economic manner.

Although undergraduate students start with traditional learning resources, most of them also use e-learning materials, either online or off-line with tablets or computers. During the transition from undergraduate to postgraduate level this changes and utilization of e-learning platforms like AMBOSS dominate. Interestingly, they did not mention the internationally common electronic information resources like electronic textbooks (e.g., Harrison's Online) and textbook collections (e.g., AccessMedicine), textbook-like resources (e.g., UpToDate) or electronic encyclopedias (e.g., Wikipedia) although they are available in German language¹⁷. In higher semester levels learning preferences change to a more pragmatic and economic learning strategy favoring an exam focused approach, like reported elsewhere^{18 5 19}²⁰. The increasing use of question banks for exam preparation are emblematic for poor alignment to individual medical school curricula but also to the required efficacy to memorize the content for later responsibilities as a physician¹⁹.

Although earlier studies found, that traditional face-to-face lectures remain the most popular for learning new material in over 90% of medical students, some SBC students in this study questioned the efficacy of face-to-face lectures. One must keep in mind that this study had been undertaken at the very beginning of the Corona pandemic. However, a recent study found that the switch from mainly live lectures and courses pre-pandemic to mostly virtual teaching during the pandemic did not change preferences. Students still favor face-to-face learning over e-teaching^{21 22}.

Students in undergraduate level in the PBC group were more engaged in deep learning strategy and preferred to elaborate, than the SBC group whose curriculum has a scientific focus causing a predominant strategic learning. These differences in learning preferences between the different curricula had been acknowledged in an earlier study using the Vermunt's Inventory of learning styles questionnaire where PBC students showed a significantly more self-regulated learning and more constructive conceptions of learning²³.

Putting this in the perspective of the Tripartite model, this study revealed grave differences in learning preferences comparing students' attitudes from SBC and PBC in deep learning as well as in the frequency of surface learning, but not in strategic learning patterns⁶. These differences are most likely the direct result of the curriculum in which PBC causes more interest in deep learning techniques which contrasts SBC. To our best knowledge, the results have not been shown

previously in questionnaire-based studies. This might also explain why scores of undergraduate PBC students tend to be higher than those from SBC students in another German study²⁴

Roughly 50% of students use university libraries and their services²⁵. Particularly the combination of e-learning technologies with physical presence in university libraries and self-regulated learning alone are the most common learning environments students choose²⁶. Digital learning sources in medical education are now mainstream and are used very purposefully as shown in this study, although the use of digital media is not yet an integral and comprehensive component of the teaching framework of medical studies in Germany, but is rather used as a punctual teaching enrichment²⁷.

Motivation drives medical students who all want to become a "good doctor" but only a few studies have specifically examined if this driver affects medical students' performance²⁸. The roles of self-efficacy and learning engagement in the mechanisms that govern how motivation affects academic performance is influenced by many different factors such as gender, selection process of students for entry to medical school, university type, country and culture specific factors and individual personality^{29 30 31}. To become a good health professional rather to excel in exams with high scores is in contrast to other studies, particularly from Asia²⁹. In this cohort, intrinsic motivation and self-efficacy in medicine regarding medical students' academic performance are not necessarily intertwined directional. The efforts to foster intrinsic motivations for higher academic grades as suggested elsewhere^{29 32} is not considered from any of the students in this study.

Learners go through a repetitive cyclic process of setting learning goals, choosing learning strategies and assessing progress towards goals. Like van Houten-Schat et al. (2018), this study found a great diversity in the use of self-regulated learning strategies by medical students, which is influenced by individual (goal setting), contextual (time pressure, patient care and supervision) and social (supervisors and peers) factors. Three types of intervention were identified (coaching, learning plans and supportive tools) by van Houten-Schat et al.⁸. With a few exceptions, students of the present study preferred to learn alone most of the time. They did that task-oriented with a comprehensive approach to obtain professional competence either at home or in the university library. The shift from self-regulated to co-regulated learning intensified when students prepare for exams to verify their

knowledge or when they progressed toward clerkship^{8 33}. Essential of this strategy are social interactions between students and others on their networks. They regulate their cognition, motivation and behavior together with other fellow students. At the downside, some students interviewed, had adaptation problems regarding co-regulated learning and learning with peers, particularly after the transition from undergraduate to postgraduate study level, when some of their peers moved to another university. During collaborative work, students but also residents and physicians that are more experienced mediate one another metacognitive and cognitive actions and thus their ability to engage independently in self-regulated learning. Increasingly, workplace assessments, electronic portfolios, required reflections, and progress meetings are being used as external mechanisms to regulate residents' learning^{34 35}. However, such arrangements are uncommon in student education. Once co-regulated learning is seen from students as an assortment with self-regulated learning which depends on the learning situation and its purpose, it might be worthwhile to help with this kind of collaborative work even as early as graduate study level³³.

This study has several limitations: Based on the purpose of this study, it was conducted only with a limited sample of 28 medical students. Students were recruited from different semesters (1-12) and universities, and age varied (19-37) indicating a certain heterogeneity of the student sample. This means that the students might express different views solely because of these differences but not due to the different curriculum type. Regardless of these limitations, the learning types were, except of learning strategy in undergraduate level, pretty unique, indicating that age did not seem to be a major bias factor. Learning preferences may highly dependent on national culture and curricula, it could therefore not be ruled out that findings in this study would be different in other countries.

Conclusion

The curriculum type has a profound influence of learning strategies, particularly in undergraduate classes. Particularly in undergraduate classes PBC promotes deep learning strategies, while in SBC encourages memorization throughout the study. Students want to ask questions, speculate, being encouraged to actively engage into the learning process which should ideally be patient case-centered. Students rate a conducive learning environment the most valued teaching behavior to prepare them for learning tasks. With an eye toward educational models, curricula that emphasize student/instructor alliances, focusing on the voices of learners with the emphasis on practical medicine suits students learning behavior more than simple memorization of medical and scientific contents. Understanding the nuances of student learning experiences is the key to designing more comprehensive curricula, and in this sense the results of this study may also function as a role model to improve more science teaching programs.

Declarations

Ethics approval and consent to participate

Informed consent was confirmed with individual participants at the start of the survey. All participants agreed to the audio recording either verbally or in written form. The study was performed in accordance with the Declarations of Helsinki. Confidentiality was warranted through an anonymization process. Ethical approval of the study was obtained prior to the first interview from the University Faculty of Medicine and Dentistry Committee for Ethics at the University Witten-Herdecke (# 137/2919).

Conflict of interest statement: The authors declare that they have no competing interests.

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