

Development of National Competency-based Learning Objectives “Medical Informatics” for Undergraduate Medical Education*

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Keywords

Medical informatics, learning objectives, undergraduate medical education, competency based education, curriculum

Summary

Objectives: The aim of this project is to develop a catalogue of competency-based learning objectives „Medical Informatics” for undergraduate medical education (abbreviated NKLM-MI in German).

Methods: The development followed a multi-level annotation and consensus process. For each learning objective a reason why a physician needs this competence was required. In addition, each objective was categorized according to the competence context (A = covered by medical informatics, B = core subject of medical informatics, C = optional subject of medical informatics), the competence level (1 = referenced knowledge, 2 = applied knowledge, 3 = routine knowledge) and a CanMEDS competence role (medical expert, communicator, collaborator, manager, health advocate, professional, scholar).

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Results: Overall 42 objectives in seven areas (medical documentation and information processing, medical classifications and terminologies, information systems in healthcare, health telematics and telemedicine, data protection and security, access to medical knowledge and medical signal-/image processing) were identified, defined and consented.

Conclusion: With the NKLM-MI the competences in the field of medical informatics vital to a first year resident physician are identified, defined and operationalized. These competencies are consistent with the recommendations of the International Medical Informatics Association (IMIA). The NKLM-MI will be submitted to the National Competence-Based Learning Objectives for Undergraduate Medical Education. The next step is implementation of these objectives by the faculties.

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1. Introduction

Physicians spend up to 40% of their time on documentation. Due to an increased use of information technology (IT) in healthcare [1, 2], a growing number of decisions and processes are assisted by IT or even depend on it. Examples reach from digital radiology imaging, computerized physician order entry and clinical decision support systems to economic aspects (like controlling or billing) and quality management. This increased amount of information available brings new requirements for IT systems and demands physicians to develop new skills. Hence physicians require specific competencies in the area of medical informatics that should be part of their undergraduate education [3].

Epidemiology, medical biometry and medical informatics are traditionally conjoined in Germany. To date they have a common scientific association, the German Association for Medical Informatics, Biometry and Epidemiology (GMDS). According to German regulations (Deutsche Approbationsordnung; ÄApprO [4]), each medical student has to pass a combined exam in these subjects. Neither the amount of lessons for medical informatics nor their contents are specified in detail. In addition,

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each faculty can offer optional courses in any field.

The International Medical Informatics Association (IMIA) suggests 40 hours of lectures during undergraduate medical education [5]. Most medical faculties in Germany offer far less than that, ranging from 4 to 30 lessons according to a 2011 survey. Two out of twelve do not offer a lecture at all, two others substitute the courses with eLearning or unspecific exercises (► Table 1). In addition to the rare and heterogeneous learning opportunities, there is also a deficit in (public) perception. Medical students rate the significance of medical informatics for their job as low [6–8]. Stang et al. hypothesize that the way of teaching is one reason for this. Among other things, they cite an overly high level of abstraction and too few relations to a physician’s occupation [7].

The GMDS assigned the project group “Medical Informatics Education in Medicine” with the task to create a catalogue of competence based learning objectives for medical students in medical informatics (called: Nationaler Kompetenzbasierter Lernzielkatalog Medizin – Medizinische Informatik: NKLM-MI). The NKLM-MI was consented by the joint committee medical informatics of GMDS and German Computer Science Society (GI) in November 2012. The NKLM-MI was published in December 2012 [9]. This publication aims to introduce the development and the results of the NKLM-MI.

2. Methods

The method is partly based on three previously published reports: development of national competence-based learning objectives for undergraduate medical education (NKLM) [10], national catalogue of learning objectives in orthopaedics and traumatology [11], and national catalogue of educational objectives in anaesthesiology, including aspects of intensive care medicine, emergency medicine, and pain management [12].

Table 1 Lessons in medical informatics at 12 medical faculties in Germany. Source: an internal survey issued by GMDS project group “Medical Informatics Education in Medicine” (2011).

Hours of Education	unweighted sum	hours lecture	exercise course in small groups	eLearning/exercise
University 1	30	20	10	0
University 2	30	20	0	10
University 3	23	20	3	0
University 4	17	11	6	0
University 5	14	12	0	2
University 6	10	0	10	0
University 7	8	8	0	0
University 8	8	6	2	0
University 9	6	4	2	0
University 10	6	3	3	0
University 11	6	0	6	0
University 12	4	2	2	0

2.1 Development Process

The NKLM-MI was developed by the project group “Medical Informatics Education in Medicine”. It consists of faculty members from all sites that teach medical informatics to medical students in Germany. First, the project group discussed superordinate areas of competences to be taught in periodical meetings. Second, a list of topics for each area was compiled and prioritized as either main or supplementary through a voting process. The resulting catalogue was consolidated and amended with a glossary. The third step was the systematic formulation of competence based educational objectives. An educational

(learning) objective “describes a student behavior [...] and some content topic [...] on which the behavior will be performed” [13].

2.2 Specification of Learning Objectives

For each topic, the project group gathered competences vital to a first year resident physician and a reason, why they are needed. A student’s necessary depth of knowledge was then assigned (level of competence). Lacking a binding definition for levels of competence, we assessed the published catalogues of learning objectives mentioned before [11, 12]. They applied a

Table 2 Taxonomy of the competence level

Level of competence	Knowledge dimension [10]	Cognitive process dimension [10]	Operationalized expression
1 – Referenced knowledge	Factual knowledge	Remember	The students remember the learning objective and know, where to read about it
2 – Applied factual and conceptual knowledge	Factual and conceptual knowledge	Understand and apply	The students can explain the learning objective
3 – Applied knowledge and practical experience	Procedural knowledge	Analyze and create	The students can apply the learning objective independently

Level	Context of the learning objective
A	Basic level of competence. Not specific to medical informatics. Medical informatics is well suited to convey the topic due to competences in that area. Vital to every first year resident physician.
B	Basic level of competence. Specific to medical informatics. Medical informatics is well suited to convey the topic due to competences in that area. Vital to every first year resident physician.
C	A competence that exceeds level B or is specific to a specialty. It can be acquired in additional lessons.

Table 3
Context of learning objective (modified according to Breuer et al. [12])

revised Bloom’s taxonomy and Miller’s pyramid [12, 13] with six cognitive processing levels (remember – level 1, understand – level 2, apply – level 3, analyze – level 4, evaluate – level 5, create – level 6). They also distinguished between knowing something (knowledge) and being able to apply it to a problem (capability). Furthermore, the learning objectives catalogue for trauma surgery and orthopaedics distinguishes four levels of competence [11]: theory (level 1), having seen, been demonstrated to (level 2), applied, executed (level 3), routine (level 4). Fusing all the above definitions and adapting them to the domain of medical informatics, the project group developed a one dimensional scale with 3 levels: remember – level 1, understand & apply – level 2, analyze & create – level 3 (► Table 2).

2.3 Context of the Learning Objective

In some areas, medical informatics teaches competences arising from a context or a cooperation with other specialties. Every learning objective was assigned one out of three levels of context as specified in ► Table 3.

2.4 Roles of Physicians

The Royal College of Physicians and Surgeons of Canada defined seven roles of physicians in the CanMEDS™ Roles Framework [14, 15]. Medical informatics conveys methods required in numerous situations and roles a physician can be in. The project group assigned every learning objective to the roles that require the par-

ticular competence. See ► Table 4 for roles and coding.

2.5 Finding Consensus on the Learning Objectives

The catalogue’s first draft was revised and commented by the domain experts forming the GMDS project group “Medical Informatics Education in Medicine”. This version in turn formed the basis for a second, several week long commenting phase. A web application, specifically built for this project supported the discussion by enabling every faculty to submit comments and suggestions. Afterwards, the project managers generated a consolidated version of NKLM-MI.

3. Results

3.1 Preamble

In addition to teaching students knowledge and capabilities, we strive to mediate an ethical and responsible attitude in handling information in health care. This has been

Table 4 CanMEDS™ Roles [14]

No	Roles
1	Medical expert
2	Communicator
3	Collaborator
4	Manager
5	Health advocate
6	Scholar
7	Professional

inscribed into the preamble in form of the following theses:

1. Methods, tools and solutions of medical informatics improve prevention, diagnosis and treatment.
2. Medical informatics is becoming a discipline like laboratory medicine, radiology, pathology and other specialties with a direct relevance to the individual patient’s treatment.
3. Medical informatics improves the rate of cured patients, prolongs life, reduces time to diagnosis and improves efficiency in health care.
4. No effect without side effect: Any method, every tool, every solution of medical informatics can be harmful to an individual patient.
5. Accordingly, knowledge and skills in medical informatics are a prerequisite, a “conditio sine qua non” for doctors.
6. The doctor bears the responsibility not only for her/his own patients. A structured, valid and complete documentation enables scientific evaluations and thus contributes to improving care and health care research.

3.2 Content

The project group identified and concerted the following seven areas as relevant for a physician’s competences:

- Medical Documentation and Information Processing
- Medical Classification Systems and Terminology
- Information Systems in Health Care Services
- E-Health and Telemedicine
- Privacy, Data Protection and Data Security
- Access to Medical Knowledge
- Medical Signal and Image Processing

Overall, 42 learning objectives have been developed. For each of them, a reason was given, why it is vital to a physician; who’s just starting out, and should therefore be reached in medical school. Each objective was also assigned a context, a level, and a role of competence. Objectives with context C that can be accomplished in additional lessons are just examples.

The joint committee medical informatics of GMDS and GI reviewed the NKLM-MI, endorsed and issued it on November 30th 2012 [9]. The complete catalogue amended with a list of abbreviations can be found as electronic appendix supplement.

4. Discussion

The rapid development of informatics and medical informatics during the last decades – both in hard- and software – influences and changes all aspects of life and especially medicine. IT has played an important role in research for a long time; it widened its influence on routine patient care in recent years. The vision of electronic patient records has been realized, digital imaging technology is widely adopted and telemedicine gains traction.

Methods developed by medical informatics can not only help to make patient care more efficient, it can help significantly improve treatment results for patients [16]. But there is no effect without a side effect: IT systems can endanger patients through handling error, malfunctions or organisational shortcomings. A popular example is the Han's work [17], who reported a two-fold increase in mortalities after deploying an IT system in a paediatric clinic. Hence, medical informatics becomes a medical discipline with immediate relevance for a patient's treatment. In addition to the facts and skills, we need to mediate a responsible state of mind [3, 5, 14, 15].

For the first time, the NKLM-MI operationalizes the required competences for physicians in the field of medical informatics. There is a variety of recommendations regarding the education of medical students in regard to medical informatics. For instance, IMIA issued recommendations on education in biomedical and health informatics [5]. These should be regarded as global educational objectives following Bloom's taxonomy [13]. The NKLM-MI is consistent with these IMIA recommendations and could be regarded as an amendment thereof.

In other countries, for example Switzerland or The Netherlands, there is a complete catalogue of learning objectives for

undergraduate medical education available [10, 18]. These catalogues are mostly structured around specific diseases or CanMEDS™ roles. Therefore, medical informatics objectives are spread over several areas. The NKLM-MI is consequently focusing on medical informatics. It was created by members of a scientific society and is therefore a discipline specific catalogue, just like its counterparts in anesthesiology and surgery [11, 12]. This offers a precise support for the national committee creating the general counterpart. The next step will be a discussion on how to implement the objectives in lessons at the various medical faculties in Germany. To overcome the lack of immediate relationships to a physician's occupation, cooperation with other clinical disciplines should be considered [7]. For instance, the objectives concerning digital imaging could be integrated into radiology lessons. However, to establish this interdisciplinary teaching concept requires a lot of effort in coordination and – last but not least – willingness to cooperate.

5. Conclusion

With NKLM-MI the competences in the field of medical informatics, vital to a first year resident physician, are identified, defined and operationalized. The catalogue is consistent with the recommendations of IMIA. Due to an ongoing nationwide ballot-process, the NKLM-MI can be submitted to the development of the National Competence-Based Learning Objectives for Undergraduate Medical Education (NKLM). The next step is implementation of these objectives by the faculties.

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