A framework for students' competence development in undergraduate medical education

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In the medical profession, a main focus is on the situation-specific integration of different competencies for optimal patient care. Thus, undergraduate and postgraduate medical education must integrate a competency-based approach to enhance students' growth towards authentic and complex healthcare practice. Frameworks to guide the development of medical curricula centred on consecutive, situation-specific competence development barely exist so far. Thus, in this paper, we propose a theoretical framework for competence development in undergraduate medical education. We combined Blömeke et al.'s (2015) model known as *competence as a continuum* and Grossman et al.'s (2009) frame called *approximations of practice.* Our framework can be understood as a structural concept for medical curriculum designers and teachers to deliberately approximate students' cognitive and affective resources, situation-specific skills and performance.

1 Introduction

In the medical profession, a main focus is on the situation-specific integration of different competencies for optimal patient care (ten Cate, Snell, & Carraccio, 2010). Consequently, worldwide, undergraduate and postgraduate medical education is increasingly aligned with a competency-based approach. Consensus exists that competence in performing tasks of high complexity goes beyond knowledge or simple skills (ten Cate et al., 2010). *Competency* (plural *competencies*) refers to the different constituents (cognitive and affective dispositions, skills) of competence; *competence* (plural *competences*) describes the integration of all the necessary constituents in a performance situation and is, therefore, the "*broader term and a complex characteristic*" (Blömeke, Gustafsson, & Shavelson, 2015, p. 5). In this paper, we will predominantly refer to *competence* as we focus on medical students learning to successfully integrate these constituents in performance situations as required for their later professional practice (ten Cate et al., 2010). Frameworks for facilitating the development of consecutive, situation-specific competence in medical curricula barely exist so far. In the German context, a new Licensure Act for Medicine expected in 2025 will make the implementation of such competence-based curricula compulsory.

The concept of Entrustable Professional Activities (EPAs) focuses on the performance of defined and interrelated complex units of practice within the clinical environment (ten Cate & Scheele, 2007). Each EPA is based on different competencies (Berberat, Harendza, & Kadmon, 2013; ten Cate & Scheele, 2007). Initially, EPAs were introduced for postgraduate medical education, but the concept is receiving increasing attention in undergraduate medical education (Berberat et al., 2019; Chen, van den Broek, & ten Cate, 2015), too. In Germany, a recent revision of the National Catalogue of Competence-Based Learning Objectives for Medical Education [NKLM] (MFT Medizinischer Fakultätentag der Bundesrepublik Deutschland e. V., 2015) defines the graduation profile for medical students by means of such EPAs (e.g. "performing discharge management of a patient or ambulatory care of a chronically ill patient"). Further deconstructed EPAs, called "nested EPAs", break down these daily clinical routines into manageable, less complex components which are suitable for students in earlier semesters (e.g. "performing an anamnesis and physical examination appropriate to the situation and summarising the results in a structured manner"). In this sense, nested EPAs are used as learning activities that provide opportunities for students to apply their knowledge and skills to clinical demands early in the study programme. These nested EPAS are subsumed in the "full" EPAs during the final practical year.

In this paper, we propose a theoretical framework for competence development towards the EPA level in undergraduate medical education. The framework seeks 1) to identify the relevant determinants for competence development and 2) to suggest approximation steps to foster the development process towards authentic medical practice. In addition, the framework assists researchers in investigating competence development more precisely. In developing the framework, we focused on a well-established model by Blömeke et al. (2015) known as *competence as a continuum*. Secondly, we invoked an interdisciplinary teaching and learning framework for approximating authentic practice developed by Grossman et al. (2009), called *authenticity in approximations of practice*. The resulting framework addresses a relevant gap in the competence literature by combining a competence modelling perspective with a student development perspective (Blömeke et al., 2015).

2 Current competence modelling

As stated in the introduction, Blömeke et al. (2015) define competence as a complex interplay of a person's cognitive and affective resources and skills as applied in real-world performance. To model competence, the typical real-world performance demands of a field (criterion situations) serve as points of reference, for example, a pilot flying an airplane, a heart surgeon performing a heart surgery, or a seven-year-old primary school pupil reading a book. Blömeke et al. (2015) explain the two dominant perspectives on competence as follows:

2.1 The holistic and the analytic perspective

The holistic perspective is centred on performance or behaviour in a real-world situation. In a performance situation, a person needs to integrate their cognitive and affective resources and skills dynamically during the course of a performance situation. To assess competence from a holistic perspective, one would observe a medical student carrying out concrete activities in a real-world (criterion) situation (Blömeke et al., 2015, p. 6). Such situations should be carefully chosen to represent the demands, complexity and variety of tasks in the real world. The holistic perspective, therefore, focuses on how someone performs and behaves in a dynamic real-world situation.

The analytic perspective focuses on deconstructing the complex and dynamic interplay of cognitive (factual, procedural, strategic and attitudinal knowledge), affective (emotion), motivational (motivation) and conative (effort) components. These are collectively referred to as a person's *dispositions* or *resources.* These resources are dynamic and amenable to educational influence. Analytic deconstruction of a person's resources can help to reduce complexity and identify knowledge and motivational components that can be taught deliberately and assessed in suitable learning environments. Thus, the analytic perspective disentangles the resources latently guiding real-world performance.

2.2 Competence as a continuum

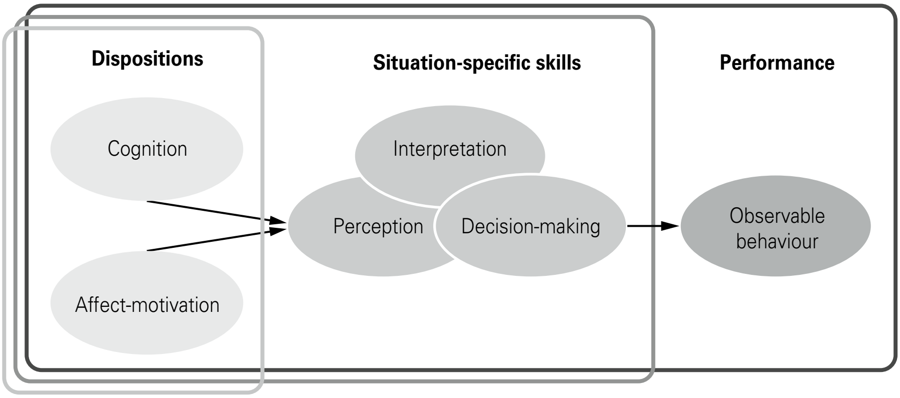
Blömeke et al.'s (2015) account of competence integrates the holistic and analytic perspectives. In their model (Figure 1), the authors identify situation-specific skills as the connections between resources (referred to as *dispositions*) and performance. The combination of a person's cognitive and affective resources is manifested in situation-specific skills that lead to observable behaviour in a performance situation. Situation-specific skills situate the processes of perception, interpretation and decision-making (Blömeke et al., 2015, p. 7).

Perceptions and interpretation. From a cognitive science perspective (Rumelhart, 1980), the way we perceive information about the world is determined by our concept of the world. In teacher training, for example, this process is regarded as professional vision, which considers teachers' selective attention to classroom events (= noticing), followed by a knowledge-based interpretation of those events (= reasoning) (Seidel & Stürmer, 2014).

Decision-making. After perceiving and interpreting a situation, decision-making represents the transitional step towards observable behaviour. A decision can be influenced by a subjective cost-benefit analysis (Schoenfeld, 2015) of the alternatives (Kahneman,

2013) and by additional factors such as situation-specific knowledge, experience with similar situations, intuition, attitudes and motivational/emotional states. If the situation is familiar, the decision can invoke familiar routines; otherwise, it involves reconsideration (Schoenfeld, 2015, p. 234).

Figure 1: Competence as a continuum (recreated from Blömeke et al., 2015)



"Collating" real-world scenarios and their relevant resources and skills. As *"competence ultimately refers to real-world performance"* (Blömeke et al., 2015; p. 6), one needs to identify real-world situations, describe their features (e.g. features of the patient, the surroundings, the necessary tools, the relevance of time, team aspects, communication and unexpected changes during the situation) and the performance demands for mastering these features. More complex situations require higher competence. As explained earlier, EPAs can be understood as a collection of real-world situations as they "*are core units of professional practice*" (ten Cate et al., 2018, p. 506). To foster the development of competence toward the EPA-level, students need to be provided with smaller (nested) practice activities in the course of their study (ten Cate et al., 2018). Therefore, the resources and situation-specific skills underlying competent performance need to be defined analytically.

Example: Taking a blood sample. We illustrate competence as a continuum in the criterion situation of taking a blood sample together with its features and performance demands. While taking a blood sample is often regarded as a basic procedural skill, we argue that it needs to be considered as an operationalised competence of the nested-EPA "carry out medical procedures in a patient-safe manner". Safe and competent blood sampling requires cognitive resources: factual knowledge, (e.g. knowing the vein anatomy as well as indications and contraindications) as well as procedural knowledge (e.g. knowing how to handle the needle and having knowledge of correct disinfection procedures), strategic knowledge (knowing how to react to a patient who is uncomfortable during blood sampling and threatens to lose consciousness due to circulatory problems) and attitudinal knowledge (e.g. "I am good at drawing blood") (Mayer, 2010). Affective resources involve worries about harming the patient, fear of drawing blood and a reduced self-concept of ability after mispuncturing. Variations in patients' vein discernibility, patients' different reactions to pain and variations in the amount of trust they place in the physician, and knowledge about indications for blood sampling require situation-specific skills such as perceiving vein discernibility in the left and right arm's vein, interpreting which arm is more promising and deciding which arm to choose. The latent interplay of these resources and situation-specific skills is followed by observable behaviour (the actual procedure of drawing blood while communicating with the patient). The whole process unfolds differently for a medical student without experience and for one with a background in nursing, or in a situation with a higher stress level, for example, if the patient blacks out.

Summary. For a competent real-world performance, a person must successfully draw on an interplay of cognitive and affective resources and then translate them into situation-specific skills (through perception, interpretation and decision-making). These latent processes manifest in an observable performance. Despite capturing the interplay described and moving beyond both the holistic (the performance) and the analytic (the resources) viewpoints, the model does not yet address how individuals are to be supported in their development of the resources and situation-specific skills required.

3 Approximation steps to support students' competence development

3.1 The developmental perspective on competence

A developmental perspective on competence introduces additional complexity (Blömeke et al., 2015). In the sequential conception of higher education programmes, certain resources have to be established before situation-specific skills can be developed, giving someone the accountability to perform. This is evident in curricula that place theoretical courses first and practical experience second. Knowledge is certainly a pre-requisite for competent performance. However, such a curricular structure neglects the fact that growth in competence in all dimensions can take place simultaneously (Blömeke et al., 2015). The artificial separation of resources and situation-specific skills/performance can lead to the often discussed gap between theory and practice (Grossman et al., 2009) or to the development of inert knowledge (Renkl et al., 1996). Deliberate approximation of real-world scenarios can support the explicit growth of the various determinants of competence (resources, situation-specific skills and performance).

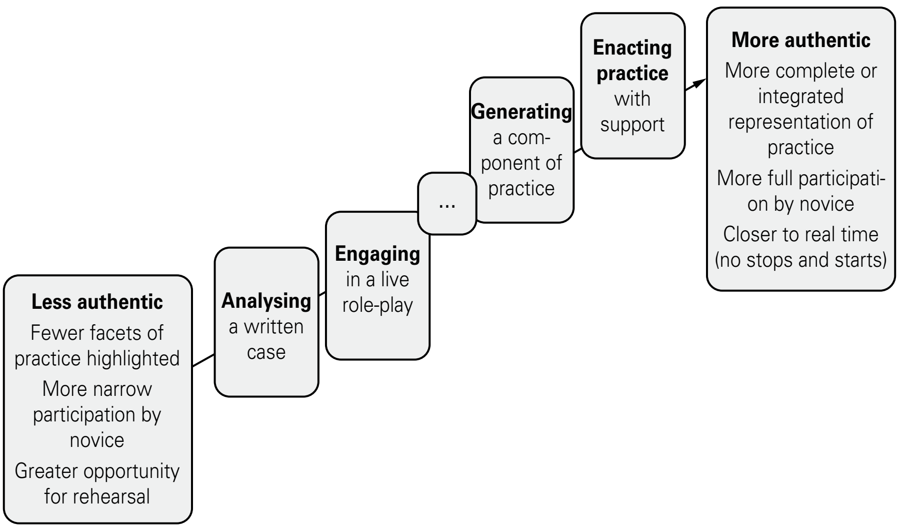
3.2 Approximations of practice

Grossman et al. (2009) suggest a stepwise approximation model (Figure 2). They define practice in complex domains, such as in teaching or medicine, as an orchestra "*of understanding, skill, relationship, and identity to accomplish particular activities with others in specific environments*" (Grossman et al., 2009, p. 2059). They emphasise the following:

1) Relationship and identity: The term *relationship* describes the growth and maintenance of productive professional interactions such as those between doctor and patient. *Identity* captures personality and individual ethics.
2) Particular activities and specific environments: Each discipline has specific characteristics that determine its ethos. For example, a general practitioner is confronted with different types of decision-making than a physician in an emergency room. In approximating practice, medical education needs to take these specifics into account even at the undergraduate level.

The "approximations of practice" model shown in Figure 2 is stratified along an authenticity axis. Less authentic settings reflect fewer facets of real practice, more scaffolding and more options for rehearsal. More authentic settings are closer to real practice in real time.

Figure 2: Approximations of practice (adapted from Grossman et al., 2009)



Deconstruction. The steps (analysing, engaging, generating and enacting) taken to deconstruct the authenticity spectrum (Grossman et al., 2009) can be understood as a deliberate guide toward authentic practice. Examples might include *analysing* through discussion of a paper or video case, *engaging* in a role-play of physician-patient communication or conducting a physical examination of a fellow student, *generating* documentation for a patient case and *enacting* a patient examination at the bedside.

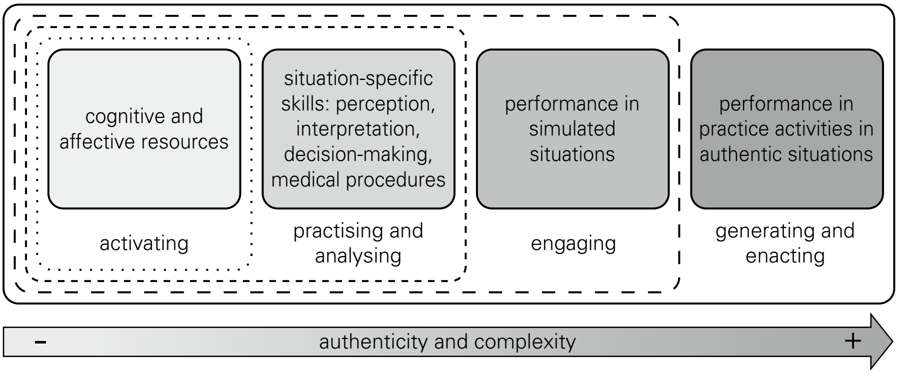
Representations of practice. Representations of practice support the learner in observing and understanding practice and can be understood as teaching mediums for the mentioned deconstruction steps. They include written case vignettes, video depictions of professional situations, equipment and tools used in practice and real-life observations in clinical settings. They vary in their representation of the realistic aspects of practice. For example, a video may illustrate the interactivity and liveliness of a situation (e.g. a knee joint puncture) while failing to reveal the underlying reasons for the observed behaviour (e.g. the physician's decision to use a certain technique or the application of certain equipment).

4 A framework for students' competence development in undergraduate medical education

4.1 Premise of the framework

When performing in a specific situation, a competent physician has to apply resources and situation-specific skills correctly. Thus, a competence-based curriculum needs to provide learning environments that deliberately address aspects of the competence continuum and achieve adequate deconstruction without risking the *"acquisition of disembodied skills"* (Grossman et al., 2009, p. 2070). Therefore, a competence development framework needs to consider both the determinants of competence and their deliberate approximation. Following this premise, we integrated Blömeke et al.'s (2015) competence model with Grossman et al.'s (2009) approximation steps. The resulting competence development framework for medical education is illustrated in Figure 3.

Figure 3: A framework for students' competence development in undergraduate medical education



4.2 Conceptualisation of the framework

4.2.1 Authenticity and complexity axis

The framework is structured by an authenticity and complexity axis from left to right. The right represents the graduate level of medical education and, therefore, includes authentic practice under supervision. On this level, the student should be able to integrate his or her resources and situation-specific skills to perform competently in the authentic situations defined by the EPAs.

4.2.2 Identifying determinants of competence development

For the next conceptualisation step, the question was: What do we need to consider from a competence development perspective in medicine? The reconsolidation of Blömeke et al.'s (2015) determinants led to the following:

Cognitive and affective resources were kept as the relevant pre-condition for any competent performance. *Medical procedures* (e.g. saturation, needle handling, disinfection, handling a transducer etc.) were added to the situation-specific skills to explicate their inevitable need in the medical context. Further, we disentangled performance. From the developmental perspective, this led to *performance in simulated situations* and *performance in practice activities in authentic situations*. Simulated situations imitate real world situations but take place in the context of a scripted scenario (e.g. in a training centre) with previously defined learning objectives that are reduced in complexity to increase safe-space learning (e.g. physical examination on an actor or peer).

4.2.3 Approximation steps to foster competence development

After identifying the determinants for medical competence development, the question was: How can we visualise suitable approximation steps while making the following assumptions? 1) Competence growth might occur simultaneously in terms of resources, situation-specific skills and performance (Blömeke et al., 2015), 2) learners' competence development might be uneven during their study programme, depending on their growing level of expertise and specialised medical interests and 3) learning environments need to provide options for re-consolidation and rehearsal of individual resources, situation-specific skills and performance.

Therefore, the approximation steps were visualised by nested boxes with perforated lines. A demonstration of the framework is provided below using the example of sonography of the kidneys (nested EPA "Situation-specific anamneses, patient examination and documentation of results").

Activating. Learning environments such as lectures focusing on the teaching of predominantly factual knowledge (e.g. anatomy and physiology of the kidneys) need to provide activating learning elements to avoid inert knowledge. Low-threshold, visual representations of procedures and strategies applied in medical practice (e.g. pictures of a healthcare professional handling a transducer for kidney sonography) can be a didactical feature. The fine-granulated line around "activating" indicates that at any higher approximation level, the learners should be able to access their cognitive and affective resources.

Practising and analysing. Following the logic of the authenticity and complexity axis, medical students should be provided with learning environments that support practising and analysing situation-specific skills (e.g. first, observing video material of kidney sonography with patients of varying ages and varying treatment decisions and then trying the technical functions of sonography). Suggested by the perforated lines, these learning settings should allow for both the reconsolidation of resources and the availability of gained skills in consecutive performance situations.

Engaging. In these activities, students apply their resources and situation-specific skills in scripted scenarios, simulations and safe-space learning settings with an actor, peer or virtual patient. Depending on students' level of expertise, such settings can be deliberately varied in terms of demands and time pressure; for example, a first-year student carries out a sonography with a peer who expresses no pain and communicates as a fellow peer, while a student in second year is confronted with an actor imitating pain or restricted communication abilities.

Generating and enacting. These take place in the highest approximating step subsumed in the competence level of an EPA. The learner enacts in a supervised authentic performance situation (e.g. conducts a kidney sonography with a real patient) and/or generates practice pieces (e.g. documents the results of a sonography). Variation of complexity and authenticity is achieved by a deliberate choice of challenging patient cases (e.g. sonography with an uncooperative patient with pain) or time pressure (e.g. in an emergency setting).

The perforated lines indicate variable learning trajectories towards this approximation level. A first-year student might benefit from sequentially experiencing all the approximation steps, whereas an advanced student may skip the approximation steps for certain competencies. The perforated lines also indicate opportunities for rehearsal or review of previous approximation steps when difficulties arise in a performance situation (e.g. re-watching video material about sonography after difficulties with an authentic patient situation).

5 Conclusion

Curricular designers can apply the suggested framework to develop and schedule relevant approximation steps for competence development characterised by an intensification of authenticity and complexity in accordance with learners' medical expertise or discipline-specific emphasis, for example, in a spiral curriculum (Davis & Harden, 2003). The transparent communication of the heuristic of the framework both for students and teachers could additionally foster students' reflection on their competence development as well as shape teachers' feedback; for example, a teacher might advise a student to go back to the simulated performance level after the student experiences difficulties in an authentic performance situation. A competence-based curriculum should provide opportunities for such feedback and self-reflection in an "approximation [of] practice jumping".

Medical teachers can consider the approximation steps as the didactical implications of deliberate deconstruction and representation on the authenticity and complexity spectrum. The following questions (inspired by Grossman et al., 2009) can support a deliberate choice of approximation levels and their representation:

- What determinants of competence should be addressed in a teaching unit or semester or work placement, and which representations trigger them best?
- Have students had sufficient prior experience and developmental opportunities to be able to engage in the intended learning activity?
- What facets of authentic and complex practice are visible to the learner by the representation, which remain (purposefully) hidden?

- To what extent does a certain representation enforce students' involvement in practice?

From a research perspective, we encourage empirical testing of the suggested framework. Research questions could investigate whether the competence determinants are best learned one step after another or via short-cuts and rehearsal of certain approximation steps. Additionally, a differential understanding of learning trajectories by diverse learners is needed. Consequently, the framework could benefit from a revision based on these empirical findings.

The framework is currently a conceptual contribution that has not yet been implemented in a medical curriculum. The challenges of transferring concepts to practice are known (Nousiainen et al., 2017), and this is a limitation of our contribution. Medical education programmes with opportunities to redesign and revise the curriculum will play a pivotal role in demonstrating the implementation of our conceptual frame.

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