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4C/ID in Medical Education:

How to design an educational program based on whole-task learning

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Contents:

Abstract

Medical education increasingly stresses that medical students should be prepared to take up multiple roles as a health professional. This requires the integrated acquisition of multiple competences such as clinical reasoning and decision making, communication skills and management skills. To promote such complex learning, instructional design has focused on the use of authentic, real-life learning tasks that students perform in a real or simulated task environment. The 4C/ID model (van Merriënboer, 2002; van Merriënboer & Kirschner, 2013) is an instructional design model that starts from the use of such tasks and provides students with a variety of learning tools facilitating the integrated acquisition of knowledge, skills and attitudes.

In what follows, we guide the reader as how to implement educational programs based on the 4C/ID model and illustrate this with an example from general practice education. The developed learning environment is in line with the whole-task approach, where a learning domain is considered as a coherent, integrated whole and where teaching progresses from offering relatively simple, but meaningful, authentic whole tasks to more complex tasks.

We describe the steps that were taken, from prototype over development to implementation, to build five learning modules (patient with diabetes; the young child with fever; axial skeleton; care for the elderly and physically undefined symptoms) that all focus on the integrated acquisition of the CanMEDS roles in general practice. Furthermore, a change cycle for educational innovation is described that encompasses practice-based challenges and pitfalls about the collaboration between different stakeholders (students, developers, teachers) and the transition from traditional, fragmented and classroom-based learning to integrated and blended learning based on sound instructional design principles.

Take Home messages

- Innovation in medical education is a cyclic process of change and stepwise improvement
- Whole-task learning in medical education requires strong collaboration between developers and end-users
- End-users of medical innovation are both students and teachers as well
- The 4C/ID model is an instructional design model that guides the design of whole-task based learning environments
- By following ten concrete steps, medical courses and curricula can be transformed into powerful whole-task based learning environments

Introduction

There is a general agreement that medical curricula should be outcome- and competency-based (Fernandez et al., 2012). This implies that the primary goal of modern medical education is to train students to become competent physicians (competency-based medical education or CBME). Inspired by this idea, many fruitful attempts have been made on how to define medical competence. Using national training frameworks such as CanMEDS (Canadian Medical Education Directives for Specialists; Frank & Danoff, 2007), ACGME (Accreditation Council for Graduate Medical Education; Swing, 2007) and the Dundee Outcomes (Davis, 2003), curricula in medical education can be organized according to competence-linked outcome expectations and standards that should be met by the learners. Because the CanMEDS framework is used as the backbone for the medical education curriculum at the University of Leuven in Belgium, this framework was also used for the development of the learning environment described in this Guide.

The CanMEDS 2005 Physician Competency Framework (Frank, 2005) is an internationally used definition that describes how physicians should integrate their roles (as medical expert, communicator, collaborator, academic, organizer, health promoter and professional) in order to apply their knowledge, skills and professional attitudes to provide patient-centered care. In practice, the roles as described in the CanMEDS framework have to be integrated into a seamless whole, reflecting the daily activities of the physician. Hence, for a physician's (in this case, a general practitioner) successful performance in daily practice, it is not sufficient just to have the knowledge about and insight in, for example, diabetes. Physicians should also be able to translate this knowledge into appropriate care policies for the patient, to communicate with the patient and to organize practice in such a way that health care goals are achieved. This integration of knowledge, skills and attitudes is crucial to a successful completion of a physician's task performance.

Consequently, the CanMEDS framework and its specific implementations imply that medical education may benefit from instruction and learning environments that foster the integrated acquisition of knowledge, skills and attitudes. Frank (2005) and van Herwaarden et al. (2009) argue that focusing on the real, authentic tasks that health professionals need to deal with will support such integrated learning. By doing so, they refer to what is called complex learning or whole-task learning. **Box 1**

Box 1

Complex Learning

Complex learning refers to the integrated acquisition of knowledge, skills and attitudes, and to the coordination of qualitatively different constituent skills. Moreover, complex learning also involves the transfer of what is learned in school and training settings to daily life or professional settings (van Merriënboer & Kirschner, 2013).

Whole-task learning in medical education

There are two compelling reasons for using the approach of complex or whole-task learning in medical education.

Firstly, whole-task models provide a solid framework for the development of learning activities that foster students' functioning in variable and complex settings (Yardley et al., 2013). As a result of using a whole-task approach, the development of a rich set of mental models and cognitive strategies is facilitated, allowing students to use efficient problem solving strategies in various health care situations. By using real-life authentic tasks, complex learning is supported and hence the transfer from the curriculum to the workplace becomes more feasible (Mayer, 2010; van Merriënboer & Sweller, 2010).

Secondly, models of whole task learning may meet the call for a more explicit use of evidence-based principles in the practice of medical education (Gibbs et al., 2011). Although there is a general agreement on the key aspects of competency-based curricula, its practical implementation has had little scientific underpinning. Instructional design models can be used to guide medical curricula towards whole-task learning. The four-component instructional design model (4C/ID-model) **Box 2** (van Merriënboer & Kirschner, 2007, 2013; van Merriënboer & Sweller, 2010), is an evidence-based instructional design model that supports the design and development process of whole-task learning environments. It does so by providing concrete guidelines and usable designs (Hoogveld et al., 2011). This model has already been applied in several domains for the acquisition of complex skills like business conversation skills (Vandercruysse et al., 2013), physiotherapy (Gerards-Last & Geraets, 2011) and vocational education in nursing care (Fastré et al.2010).

Box 2

The four-component instructional design (4C/ID) model

The four-component instructional design (4C/ID) model applies a holistic approach to learning and instruction, hereby dealing with the complexity of real-life tasks without losing sight of the separate elements and the relationships between those elements (van Merriënboer, 1997). This approach deals with persistent problems like: compartmentalization;*, separation of a whole competence in distinct parts or categories like declarative knowledge, procedural knowledge and attitudes;* fragmentation, *breaking complex skills or competencies in smaller parts without taking into account the interactions between the parts, and the* transfer paradox, *when students learn complex tasks in an isolated manner, it will be more difficult for them to transfer what they have learned to the reality of the work settings because what works well for reaching isolated, specific objectives often does not work when it comes to reaching integrated objectives.*

The aim of this AMEE Guide is to provide the reader with a stepwise instruction on how to implement educational programs based on the 4C/ID model in a medical curriculum. In this Guide, the focus is on the development of a course for general practice students; however the principles are transferable to other courses. The course is blended, providing a blend of face-to-face instruction, computer-based instruction and workplace learning. This is reflected by the computer-based individual or group tasks, the classes, and the alignment of tasks and classes with internship weeks.

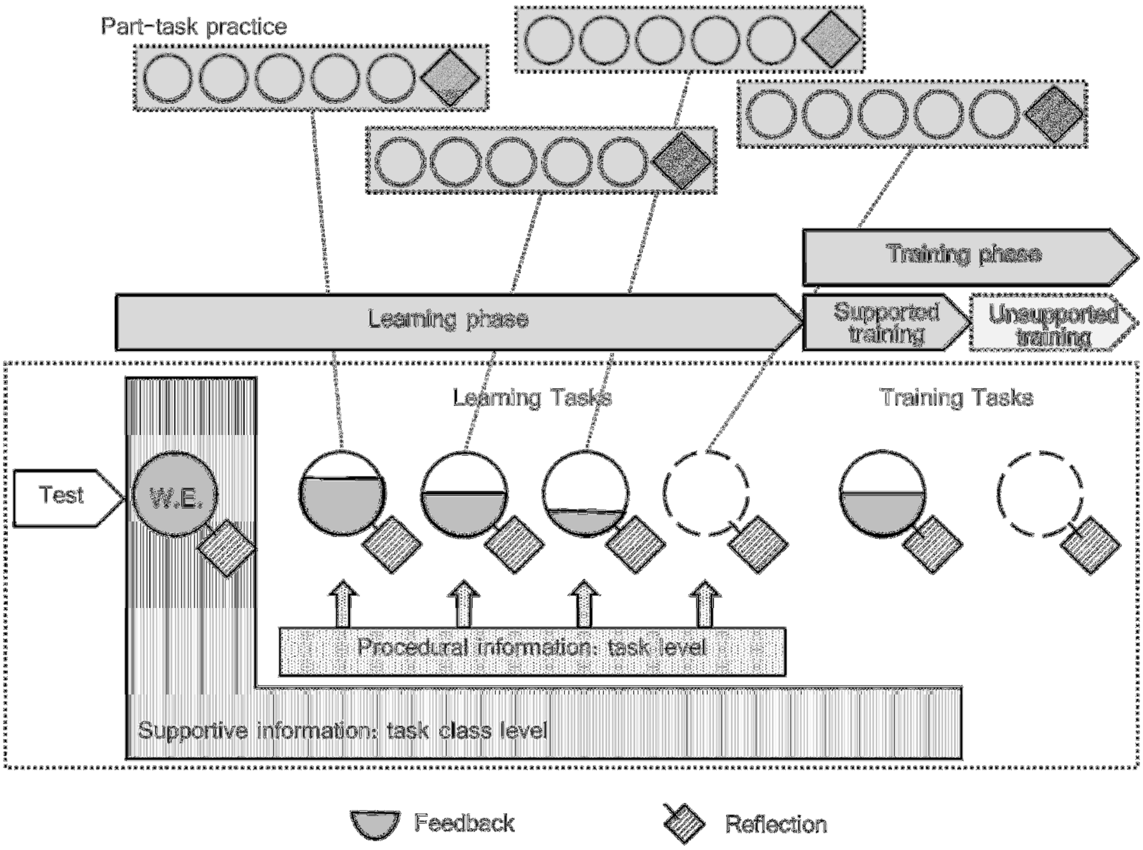
The 4C/ID model: from theory to practice

The model comprises four major components, all interrelated and each component uniquely contributing to the development of complex skills (see Figure 1). The four components that are identified are (1) learning tasks; (2) supportive information (the theory); (3) procedural information (the how to's), and (4) part-task practice (focused repetitive practice or 'drill').

In Figure 1, the *learning tasks* are indicated by the circles. They provide the backbone of the educational program. Learning tasks that are performed in the workplace are called training tasks. Often, learners will receive support and guidance when they are working on the learning tasks; this is indicated by the filling of the circles. Support and guidance will typically decrease as learners acquire more expertise. Moreover, learners will often be asked to reflect on the quality of their task performance, which is indicated by the diamonds connected to the large circles. The *supportive information* is indicated by the L-shaped figure. This information helps learners to perform non-routine aspects of learning tasks, that is, aspects which require problem solving, reasoning and decision making. The *procedural information* or *just-in-time information* is indicated by the rectangle with upward pointing arrows. This information is offered at the task-level and informs learners on how to perform ‘recurrent’ aspects of learning tasks, that is, aspects to be performed as routines after the educational program has been completed. The last component is the *part-task practice*, indicated by the small circles grouped in a rectangle. Part-task practice involves a lot of repetitive practice and is provided when a very high level of automaticity is required for a particular recurrent aspect of the task. Also, part-task practice can be accompanied by a reflection task at the end of the practice series (indicated by a diamond). The aim is to strengthen schema automation, and hence it typically involves extended repetitive practice. A last element that is represented in Figure 1 is the test (indicated by the right-pointing arrow). More than assessing a students’ already available relevant knowledge, this test informs students about the performance standards and introduces them to the topic and complexity of the learning tasks.

Figure 1.

General Practice 4C/ID model with the four main components



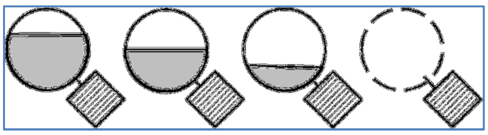
In order to transfer and organize learning materials into the framework of the 4C/ID model, identifying the four components is only one part of the design process. There are additional, auxiliary activities that support the good design of a 4C/ID-based learning environment. Together, these activities are described as the ten steps (to whole-task course development) or the ten activities that make up the design process (van Merriënboer & Kirschner, 2013). The work of van Merriënboer and Kirschner (2013) provides essential information and a more detailed elaboration on each of the ten steps described below.

In order to help the reader keep a coherent overview, these steps will be discussed in four sections, one for each respective component. Within each section, the reader will get some theoretical underpinning, as well as the relevant steps and illustrations using the General Practice 4C/ID course at the University of Leuven (KU Leuven).

In parallel with taking the ten steps for the development of the content of the course, it is recommended to draw a plan for the implementation of the course. The latter involves conceptual issues (software, design and structure of the learning environment), change management as well as the design of a system for quality control (how to manage and improve the quality of the course). These issues will be elaborated in the Discussion section of this Guide.

Ten steps to develop the content of the whole-task based medical course

Component 1: Learning tasks



The first component (indicated with large circles in Figure 1) comprises a sequence of learning tasks (van Merriënboer & van der Vleuten, 2012) which more or less mirrors the physician's professional tasks. They can be concretized in three steps.

STEP 1: DESIGN LEARNING TASKS

The **learning tasks** are chosen in such a way that they are representative for the physicians work. They are so-called ‘whole tasks’ or complex problems. In order to contribute to a higher transfer of learning, the tasks vary from one another as they would in a real-life situation. For example, when learning to assess the diabetic patient’s foot, tasks can focus on simple and complex situations; assessing the foot without or with neuropathy or ulcers; having little or much information about a patient’s health condition, and so forth. This ‘variability of practice’ greatly contributes to the transfer of knowledge, skills and attitudes to other, non-familiar situations (Norman, 2009). Most learning tasks include both routine and non-routine aspects. Routine aspects are, for example, asking a sequence of questions during history taking or a clinical examination of the diabetic’s foot; they are also called ‘recurrent’ aspects, in order to indicate that they will be performed as routine after students have completed the educational program. Non-routine aspects are actions that are rather new to students, require effort and have a problem-specific outcome; they are also called ‘non-recurrent’ aspects to indicate that they still require problem solving, reasoning or conscious decision making after students have finished the educational program. For example, combining information from various sources (history taking, clinical examination, blood test results) is a non-recurrent skill that requires the combination of cognitive schemata in order to engage in problem-solving behavior and the application of cognitive strategies (van Merriënboer et al., 2002).

Besides varying in their content and presentation, tasks may also vary in their instruction. Moreover, there is a decrease in support and guidance as the student proceeds through the program (see the filling of the circles in Figure 1) and for particular tasks, students are invited to reflect after task completion (see striped diamonds in Figure 1). This leads to several exercise or task types that can be offered in the educational program, like a mini-case diagnosis, patient stories, commenting on a scientific article, development of an information leaflet for patients, presenting work to colleagues, role play, discussion with patient, colleague or other healthcare professionals; reflection; peer feedback; expert assessment; spot diagnosis; filter case; reasoning case, and so forth.

(All types of learning tasks with indications on how they can be offered are listed in Appendix A of the AMEE published Guide)

Another variation in learning tasks is the distinction between tasks that can be completed during the course and **workplace-based learning tasks**. The latter are tasks that can be done during the internship of students, often in collaboration with medical experts who supervise the student. Examples of such tasks are: observing and reflecting on history taking; participating in a multidisciplinary team meeting, writing prescriptions and asking feedback from the physician or internship trainer.

STEP 2: DEVELOP ASSESSMENT INSTRUMENTS

As in any other competency-based curriculum, assessment instruments are crucial elements in the process of complex learning. They assess whether predefined standards have been met and to provide learners with feedback as to improve and guide their learning process. In the 4C/ID model, the main objective is the successful completion of a set of 'whole tasks' which requires the integration and coordination of knowledge, constituent skills and attitudes. To ensure that all constituent skills are represented in the assessment instruments, one could develop an assessment matrix representing whole tasks, (constituent) skills and interrelations between those skills. Subsequently, the skills can be linked with performance objectives that clearly describe what learners will be able to do after they finished the program. Parts of the objectives are standards for acceptable performance. These standards include relevant *criteria* (e.g. ‘without error’; ‘within ten minutes’), *values* (e.g. ‘taking into account the recent guidelines for diabetes management’, ‘in accordance with the electronic health record’), and *attitudes* (e.g. ‘giving relevant arguments for treatment’, ‘using active listening techniques in a conversation’). Performance standards are needed to distinguish acceptable from unacceptable performance and make it possible to inform students (and teachers) about the actual performance and the desired outcomes.

To inform students about the performance standards one could offer a **self-assessment quiz** at the beginning of a learning module. On the one hand, this test activates a students’ prior knowledge (Merrill, 2002); while on the other hand, students become familiar with the standards by which their performance will be evaluated. Doing so, a student can choose to remediate before starting the learning module or to, during task completion, focus more on the content that is not fully mastered yet.

One way to inform students about the performance standards linked to the desired professional behavior (‘to what standards will their performance be compared?’) is to use **worked examples**. A worked example can take the form of a video of a consultation, a step-by-step approach for taking a motivational interview from a patient, a knowledge test where the student is guided towards the most appropriate or correct answer by offering (parts of) a model solution, and so forth. Central in a worked example is that it reflects the ‘golden standard’, the expert behavior. As such, a worked example task becomes a modeling task where not only the solution is offered, but also the process to come to the solution. This helps students to recognize the standards for acceptable performance and to act accordingly to reach the outcomes. However, we cannot assume that all students are able to recognize the underlying standards, or that they can distinguish what is crucial in the expert’s behavior and what is not. Therefore, students can be asked to evaluate the performance of the expert according to the standards for acceptable performance by which they will be evaluated during or after task completion (Gulikers et al.; 2008, Fastré et al, 2010). By doing so, performance objectives and standards are introduced to students in a real context. A worked example ideally stays available as part of the supportive information (indicated by the lowest bar in Figure 1; WE stands for worked example). Students are thus able to consult the worked example and its accompanying standards on a self-directed basis.

In line with promoting self-directed learning, two types of assessments can be applied in the setting of medical education (van Merriënboer & van der Vleuten, 2011): (1) **supported assessment** in which students are assessed while all supporting materials are available and can be consulted in the learning environment, and (2) **unsupported assessment** in which support is no longer available in the learning environment and students have to seek information on a self-directed basis as in regular medical practice. By offering both types of assessment in the learning tasks, reflective practice is promoted. If necessary, students are instructed with part-task practice to foster automation of smaller parts of the task (e.g. practicing motivational communication skills)to deepen the understanding of parts of the task (e.g. how to distinguish the different phases in a motivational conversation with the patient) in order to improve their overall task performance. Also, immediate feedback is provided as well as the opportunity to repeatedly perform the part-task practice and smaller parts of the task. By doing so, students are supported in the development of their self-assessment and self-regulation strategies in order to reach expert performance. Expert performance only continues to improve as a function of more experience and deliberate practice (Ericsson, 2004).

STEP 3: SEQUENCE LEARNING TASKS

As described above, a sequence of varying tasks forms the backbone of the learning environment. This facilitates the integration of knowledge, skills and attitudes, hence the acquisition of competences (van Merriënboer & van der Vleuten, 2012). Therewith the 4C/ID model foresees to group learning tasks that have a similar complexity level and similar required knowledge in so-called *task classes*. Throughout the training program, learners will be guided from easy and simpler task classes to increasingly more difficult and complex task classes. In other words, learners will need increasing amounts of integrated knowledge as they go from one task class or level of complexity to the next one.

Task classes differ from each other in that they comprise tasks of a different complexity level requesting different knowledge or more elaborated knowledge for their successful performance. However, although tasks within one task class are similar with respect to complexity they may differ from each other on many other aspects. Ensuring task variability within a task class, i.e. taking into consideration many real world contexts that may be encountered by experts in the subject matter domain, should enable learners to develop rich cognitive schemata, which allow for schema-based transfer of learning (Paas & van Merriënboer, 1994). Tasks within a task class should therefore show variability of practice and, as will be discussed in the sections that describe component 2 (supportive information) and component 3 (procedural information), differ in the amount of support or guidance that is associated with the tasks. Within a task class, there is a decrease in the support offered to the learner: the first task is accompanied by maximal support, while the last task has no or minimal additional support (indicated by the filling of the circles in Figure 1). In the subsequent task class, then again, the first task is accompanied by maximal support. This process of providing support and guidance that is in accordance with the progress of the learner is also called (first-order) scaffolding (van Merriënboer et al., 2002).

Once the learning tasks and assessment instruments are developed and sequenced (summary see Table 1), further steps focus on the identification and development of information that supports the learning process. Steps 4 to 7 entail the design and development of supportive information and are discussed in the next section.

Table 1 summarizes the relevant principles for the development of learning tasks and lists the three steps that designers can take in order to develop a series of complex, authentic, whole tasks.

Table 1.

Relevant principles and auxiliary steps for the development of component 1: Learning tasks

Component 1: Learning tasks		
Principles		
	– Real-life, whole-task practice	
	– Organized in task classes	
	– Simple-to-complex sequencing of task classes	
	– Equivalent, within a task class, with respect to complexity and required knowledge	
	– High variability of practice within each task class	
	– Scaffolding: decrease of support and guidance per task within one task class	
Steps to take		
	1. Design learning tasks	*Set of typical learning tasks that represent the whole complex skill*
		Represents what the training program aims to achieve
	2. Develop assessment instruments	*Articulation of to-be-reached standards*
		In order to inform learners about the quality of their performance and to determine whether standards have been met
	3. Sequence learning tasks	*Order tasks in such a way that the learning*

	process is optimized – by increasing complexity and, at each level of complexity, by decreasing support and guidance

Illustration

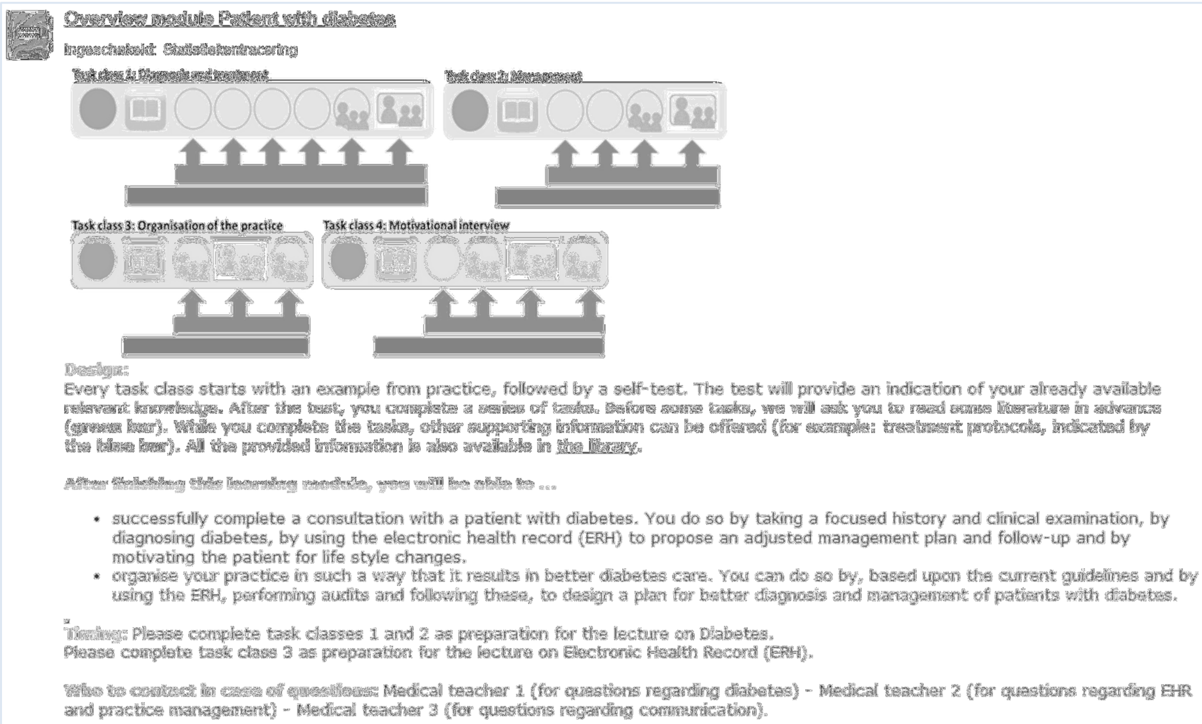
Learning modules. Within this Guide, the modules 'Patient with diabetes' and 'The young child with fever', both developed at the KU Leuven General Practice Department, are used to illustrate how one can develop and structure a 4C/ID-based learning environment.

Task classes. When students enter the learning module, they not only receive an overview of the structure of the module (task classes) and the amount of tasks, they are also informed about the performance objectives per task class (i.e., what they will be able to do after finishing the task class), the timing and deadlines and who to contact in case of questions about the content.

In the learning module 'Patient with diabetes' the tasks are ordered in four task classes, all presented graphically in Figure 2 showing the main screen of the learning module. Each task class focuses additionally on one of the CanMEDS roles and is more complex than a previous task class. The first task class of the learning module comprises tasks and case studies focusing on the declarative knowledge about diabetes (like diagnosis and treatment). The second task class also provides tasks on diagnosis and treatment but shifts the focus of the exercises to management of patients with diabetes, hence stressing the role of the doctor as a collaborator and professional. The third task class then provides tasks emphasizing the role of manager, while the fourth (and last) task class stresses the communicator's role. By adding foci (which each imply the acquisition of more domain knowledge) from one task class to the other, the complexity gradually increases.

Figure 2.

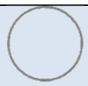
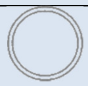
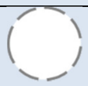
The learning module ‘Patient with diabetes’ with four task classes.



Tasks. Several tasks are offered in the learning environment. Table 2 provides the icons for different types of tasks.

Table 2.

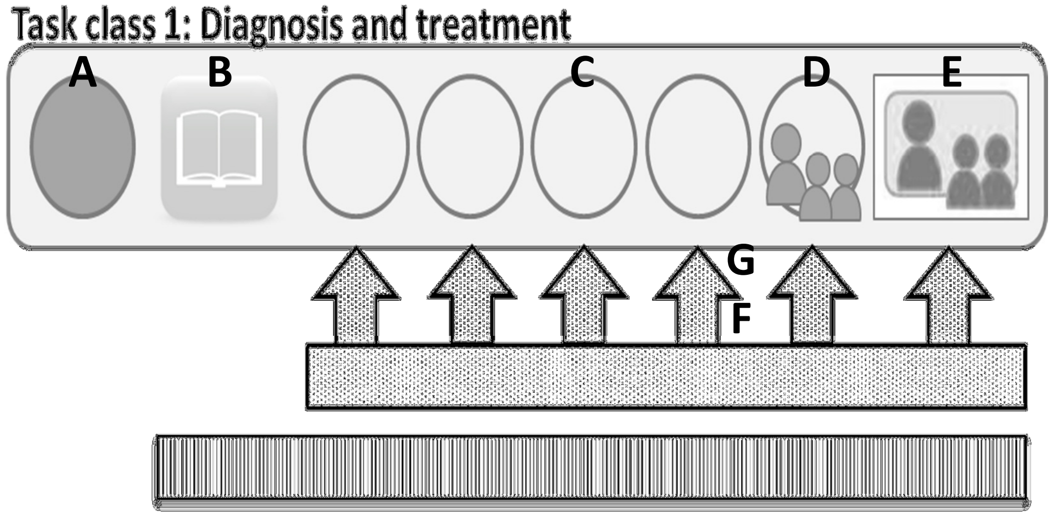
Selection of icons for different tasks.

	*Individual computer-based task* *e.g. Using a computerized test with individualized feedback, students practice the application of guidelines in the treatment of diabetes (all questions are case-based and include questions on communication skills, practice management etc.)*
	*Individual computer-based task to prepare for class(es)* *e.g. Using a short video introducing the mock patient and access to his electronic health record, the student has to propose an appropriate management plan. During the lecture, students will do role plays to practice how to explain this to the patient.*
	*Learning group activity* *e.g. Students have to reflect upon the indications of bariatric surgery for non-compliant obese patients.*
	*Training – workplace learning task* *e.g. Students have to perform a consultation with a real diabetic patient and record this on video. The video is discussed with the GP trainer.*
	*Optional task*

Each task class is represented by a series of icons, indicating how many tasks and what tasks are offered in the task class. For example, the first task class, Diagnosis and Treatment, consists of eight tasks, as presented in Figure 3.

Figure 3.

Content of task class 1: Diagnosis and Treatment (learning module 'Patient with diabetes').



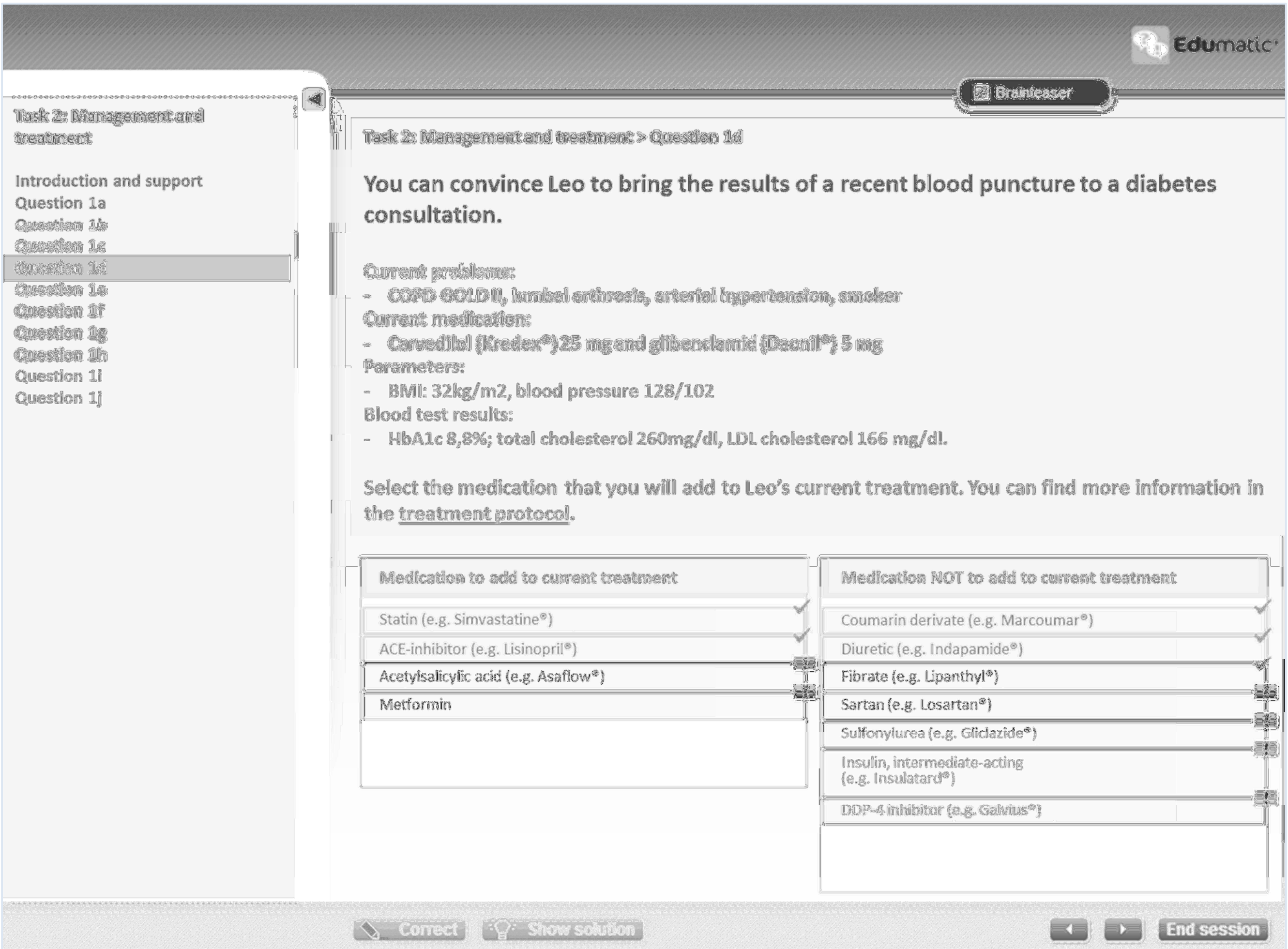
The **first task** (the large circle, see Figure 3, part A) for students to complete is a worked example, in this case a problem-based knowledge test. By answering the questions on this test, students obtain information about their knowledge, receive feedback on their answers and are provided with the expert's answer to the question and the reasoning process to come to the answer. Also, they are introduced to the content of the task class and what the standards are for acceptable performance. Hence, students are informed about what knowledge, skills and attitudes they are expected to demonstrate after completing the task class (i.e., the performance objectives).

The **second task** (the square with the book icon, see Figure 3, part B) represents the supportive information for the whole task class. Students are instructed to read the materials as to complete this task. These are provided by documents and web links focusing on theoretical overviews and course chapters. This supportive information is available throughout all tasks. This is also visually presented by the lowest bar (see Figure 3, part F). In the next section, the design of the supportive information is described in more detail.

After a student has read the supportive information documents as part of the second task, several **tasks** are offered (presented by the large circles, see Figure 3, part C). For example, the second task class in the module 'Patient with Diabetes' focused on management. The second task in this task class more specifically focused on the optimisation and update of management and treatment for patients with diabetes. To complete this task, students had to answer ten questions in different formats (multiple answer, sort, fill-in-the-blank, complete, etc.). Figure 4 presents an example of a question in drag-and-drop format.

Figure 4.

Example of drag-and-drop exercise with correct answer feedback.



All questions in this task had the same structure: a patient case is presented, or is presented in more detail (as compared to a previous question), or is presented with more elements to take into account (like previous treatments). (Appendix A presents an overview of all possible types of tasks in the learning environment and found in the AMEE Guide)

While the majority of tasks aims for individual completion, other tasks are **group tasks** or tasks that are completed or discussed during class hours. This is indicated by the circle with a people icon within (see Figure 3, part D, last circle). Examples of such group tasks are: the online preparation of a patient case followed by a group discussion during class hours, the group discussion of a patient case on the discussion forums with the instructor providing feedback during class hours, a collaborative writing of a treatment plan, and so forth.

A last icon that is depicted in Figure 3 (part E) are the **face-to-face classes**. During these classes, instructors can provide feedback on students' learning outcomes of the learning module; they can provide additional information if any gaps in knowledge, skills or attitudes were identified during task completion in the computer-based learning environment (based on computer-based correction of tasks), and they can elaborate more on certain topics that were discussed in the learning module (based on forum posts and discussion threads). The face-to-face class icon also indicates when students are expected to complete the tasks: before, around or after the class is organised.

A last type of tasks pertains to **training or workplace-based tasks**. For example, one of the training tasks in the learning module 'Care for the elderly' is the following: "During your internship you will meet older patients. Note the initials of one of those patients and discuss this patient with your training supervisor. How do you set up a long-term healthcare plan for the elderly? What is possible for you to do in your own general practice? What are the points that need attention? Please bring your report with you to class 3 of 'Care for the elderly'". Because of the increasing complexity of tasks within a task class, a student needs to integrate all knowledge and skills about elderly healthcare and should be able to take multiple roles as physician and more specifically, as a general practitioner (medical expert; communicator to and collaborator with patients, family, nurses, colleagues; health promoter towards patients and professional with respect to management and planning) to complete the training or workplace tasks. Moreover, the training tasks are accompanied with unsupported assessment (van Merriënboer & van der Vleuten, 2011). Unlike the (supported) assessment during task completion in the computer-based learning environment where all support materials were available and where the amount of support decreased gradually over tasks, students now have to seek information on a self-directed basis as they also should seek information in their future medical practice. This is in line with the principle of decreasing the amount of support and guidance for tasks within a task class. The last set of tasks has no built-in support hence providing minimal or no support to students. Questions such as: "What is possible for you to do in your own medical practice?" encourage students to engage in deliberate practice and to reflect on their own (future) performance. Moreover, students receive feedback from both the training supervisor (during internship) and the instructor (during class hours), again fostering deliberate practice. By explicitly considering the students' internship as the extension of their learning process, transfer between classroom learning and internship learning (and the other way around) is increased.

Component 2: Supportive information

Supportive information, traditionally called "the theory", helps learners with the problem solving and reasoning aspects of the learning tasks. Typically, supportive information is important for the fruitful completion of non-recurrent aspects of learning tasks, that is, those aspects that require problem solving, reasoning or conscious decision making even after the completion of the educational program. In order to develop the supportive information that needs to be incorporated in the learning environment, three steps can be taken. In Figure 3, supportive information is schematically shown by the lower bar and the booklet icon.

STEPS 4 to 6: DESIGN SUPPORTIVE INFORMATION

The supportive information provides the learner with new information that is needed to complete the non-routine aspects of learning tasks. The provided supportive information is hence tailored to the content of each task class and can be accessed in accordance with the learners' needs (already existing and yet to be acquired knowledge). It helps learners to construct cognitive schemata (e.g. illness scripts, treatment protocols, systematic approaches and rules-of-thumb for clinical reasoning or decision making), but it can also provide cognitive feedback, inviting the learners to critically compare and contrast their own schemata with those of experts or peer students.

The cognitive schemata, as reflected by the supportive information, come in two forms. First, there are the cognitive strategies (step 5), providing systematic approaches to problem solving (SAPs) in this domain, like heuristics and rules-of-thumb and second, there are the mental models (step 6) that reflect how the learning domain is organized and hence allow for reasoning within the learning domain. For example, treatment plans for patients with diabetes provide physicians with a systematic approach towards treatment and follow-up of patients with diabetes. Mental models, on the other hand, can be described as personal theories that are actively created and are informed by previous experiences with similar situations. Mental models can be extended with new experiences or they can be revised if one encounters a discrepancy between a real-life experience and the beliefs as represented in the mental model (Sandars, 2009).

Given the relevance of this supportive information for the different tasks within a task class, this information is offered at the beginning of a task class and should stay available during the work in a task class. A new task class will also request (partly) different or more elaborated supportive information.

Next to the provision of mental models and cognitive strategies, supportive information also encompasses cognitive feedback. This type of feedback is provided on the quality of non-recurrent aspects of performance (van Merriënboer et al., 2002). Because non-recurrent aspects of performance cannot simply be rated as 'correct' or 'incorrect', but rather as 'more or less effective', cognitive feedback stimulates learners to reflect on the quality of their approach to the problem-solving process. This can be done by debriefing sessions, peer or expert critiques, and group discussions (van Merriënboer et al., 2002). As such, cognitive feedback is best offered after learners have completed a series of tasks or have finished a whole task class (van Merriënboer et al., 2002).

Summarizing, supportive information helps the learner to carry out the non-recurrent or non-routine aspects related to problem solving, reasoning and decision making while completing the learning tasks. Units of supportive information are defined at the level of a task class (not at the level of single tasks). Table 3 summarizes the steps to be undertaken to specify the supportive information. When existing instructional materials are of sufficient quality, then the design of supportive information can be limited to step 4 by reorganizing the materials according to the task classes. However, when new or additional support needs to be developed, steps 5 and 6 will assist in this process.

Table 3.

Relevant principles and auxiliary steps for the development of component 2: supportive information.

Component 2: Supportive information	
Principles	
– *Provision of domain models and systematic approaches to problem solving*	
– *Cognitive feedback*	
Steps to take	
4. *Design supportive information*	*Connect units of supportive information to task classes; more complex task classes require more or more elaborated supportive information.* *If supportive information is not or not sufficiently available, then performing steps 5 and 6 is helpful*
5. *Analyze cognitive strategies*	*Identify the cognitive strategies that proficient task performers use to solve problems as presented in the task classes*
6. *Analyze mental models*	*Analyze the mental models that describe how the domain is organized*

Illustration

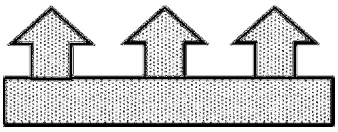
Supportive information (Figure 3, part F) is offered in several ways. First, at the start of the task class, students are informed about the **performance objectives** that are set for the task class (i.e., what they will be able to do after completing the learning tasks), and **performance standards** (i.e., criteria, values, attitudes that describe acceptable performance). For example, for the task class focusing on the management of a patient with diabetes the performance objective is as follows: “In preparation for a consultation with a diabetic patient, the student is able to perform a focused search for evidence-based literature, to faultlessly draw relevant conclusions, to use these to draw a management plan that aims at a better quality of care for his diabetic patient and that is in line with the ruling healthcare policy”. This performance objective entails several performance standards like criteria, values and attitudes. One criterion refers to the minimum requirements that a student must meet in terms of amongst others accuracy, time requirements and errors (e.g. ‘faultlessly draw relevant conclusions’; ‘in preparation for a consultation with a diabetic patient’). A value describes the rules, regulations or conventions by which a non-constituent skill should be performed (e.g. ‘to perform a focused search for evidence-based literature’; ‘implement a management plan that is in line with the ruling healthcare policy’). The attitude that is required for an acceptable management is a patient-centered attitude and patient-directed communication.

Furthermore, during the first task (**worked example**) students get feedback on their answer and are provided with the expert’s answer to the question and the reasoning process to come to the most appropriate or acceptable answer. In this way, students are encouraged to reflect on the cognitive strategies and mental models that are used by experts and they can strengthen their own models of how the domain is organized and strategies of how to systematically approach tasks in the domain.

After completing the worked example (first task), students are instructed to read a selection of **supportive materials**. Typically, these materials focus on the theory and comprise a lecture, a narrative presentation, course documents and research articles focusing on theoretical and practical insights that are relevant in the treatment of patients with diabetes. This information is divided into compulsory information (i.e. the student is strongly encouraged to read all documents) and optional information (i.e. the student can read the documents at a later time, while progressing through the tasks in the task class and learning module).

A last way by which supportive information is offered to students is by providing them **cognitive feedback** on task performance. This type of feedback comprises elaborated feedback on students' answers and solutions by providing the student with the correct answer and by presenting the problem solving approach to reach the (most) appropriate answer. As such, this feedback links to information that can be related to existing mental models and to a students' cognitive strategies for problem solving (like theoretical insights, exclusion and inclusion criteria) and eventually suggests students to consult or re-consult the supportive information. To encourage this consulting of supportive information, students are directly provided with links to the documents relevant for this task and task class. A specific form of cognitive feedback on task performance is provided by 'reflection prompts'. The use of such prompts can urge students to reflect on experts' or peers' performance or to self-reflect on their own performance (Paas & van Gog, 2009). From a practical point of view, reflection prompts can be given as side-tasks where students are encouraged to collaboratively discuss topics provided by the instructor or task solutions provided by peers. Based on this feedback from peers, students themselves are again prompted to reflect on their performance, encouraging the development of deliberate practice skills.

Component 3: Procedural information



In contrast to supportive information that focuses on non-routine aspects of tasks, procedural information or 'just-in-time information' provides information on how to perform recurrent aspects of learning tasks, that is, those aspects that need to be performed by the learner as routines after the educational program has been completed. The procedural information is schematically presented in Figure 3 by the rectangle with upward-pointing arrows.

The presentation of procedural information should facilitate schema automation and in order to do so, it should best be available during working on the task. This is information that learners need while performing a task, and hence it is best given exactly when they first need it to perform a task (i.e. precisely and just-in-time). This type of information is given step-by-step, since it constitutes the procedures and rules, facts and concepts needed to perform the routine; for example, it might be the support given while a student, for the first time, accesses a patient's electronic health record (e.g. "1/ click 'name'; 2/ Provide the patient's full name including middle names", or "1/click 'diagnosis'; 2/ double click the right clinical diagnosis"; etc.). The information is available throughout the whole task and gradually disappears or fades away as the learner's skill increases. One way to offer procedural information is corrective feedback. When learners do not correctly apply the rules that describe effective performance, it is said that they make an error. Immediately after such a misapplication of a rule is detected, corrective feedback should be presented (van Merriënboer & Kirschner, 2013). Then, a learner can compile a rule that attaches the correct action to its critical conditions.

STEPS 7 to 9: DESIGN PROCEDURAL INFORMATION

As in the development of supportive information, if there are already useful instructional materials available (e.g., manuals, checklists, quick reference guides, job aids etc.), then no further development is required and the materials can be linked to the appropriate learning tasks. However, if new procedural information needs to be developed, then steps 8 and 9 can be helpful. Table 4 summarizes the steps related to the procedural information.

Table 4.

Relevant principles and auxiliary steps for the development of component 3: procedural information

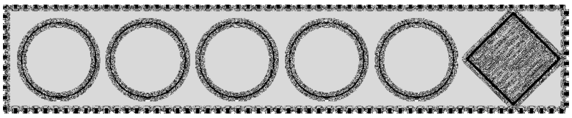
Component 3: Procedural information		
Principles		
– *Just-in-time information*		
– *Step-by-step directions*		
– *Fades away as learners gain more knowledge*		
– *Corrective feedback*		
Steps to take		
7.	*Design procedural information*	*Connect units of procedural information to tasks*
		Provide just-in-time how routine aspects of tasks need to be carried out
		Fades away over tasks within one task class
		If procedural information is not or not sufficiently available, then performing steps 8 and 9 is helpful
8.	*Analyze cognitive rules*	*Identify the condition-action pairs (i.e., cognitive rules) that drive routine behaviors*
9.	*Analyze prerequisite knowledge*	*Analyze the knowledge that is prerequisite to a correct use of cognitive rules*

Illustration

Procedural information (Figure 3, part G) is offered at the level of individual tasks, focuses on how to perform routine aspects of learning tasks and is therefore best provided just-in-time. A preferable way to present this procedural information is **step-by-step instruction**. For example, in the Diabetes learning module, the first tasks concentrate on guiding the students stepwise through the routine steps of a consultation. Tasks focused on questions like 'what is the reason for the visit?'; 'what is the key question in the history taking?'; 'what is the most likely diagnosis?'; 'what is the most suitable treatment?' Doing so, students receive step-by-step procedural information for fruitful completion of the consultation. Later tasks may then focus more on the non-routine aspects of consultation such as clinical reasoning strategies, dealing with additional information, and integrating evidence-based guidelines into the treatment plan.

Procedural information can also be offered in the form of **corrective feedback** during or after task performance. Tasks can be split up in several exercises or items as to be able to immediately detect misapplications of rules that could lead to less effective or non-effective performance on tasks. Consequently, corrective feedback can be offered after every exercise or item students solved within a task. However, as students progress through the tasks in a task class, procedural information gradually disappears or fades away. This is done by providing less elaborated corrective feedback, by providing links to information instead of presenting the information, by providing summaries of protocols instead of complete protocols, and so forth.

Component 4: Part-task practice



Part-task practice may be helpful when a very high level of automaticity is required for a particular recurrent aspect of the task. The aim is to strengthen schema automation, and hence it typically involves a lot of repetitive practice (see Table 5). Part task practice is not always part of the learning environment, but it may be necessary to include some additional part-task practice in a training program.

STEP 10: DESIGN PART-TASK PRACTICE

Within medical education, part-task practice typically will focus on to-be-automatized parts of a consultation like clinical skills (measuring blood pressure, liver palpation, auscultation) and technical skills (e.g., venipuncture, suturing, CPR) but also practicing spot diagnoses. When designing a learning environment on the consultation with a child with fever, one may choose to offer part-task practice on the diagnosis of prototypical examples of childhood infectious diseases (spot diagnosis). This skill of performing a correct spot diagnosis needs to be highly automatized because it requires that a student is able to quickly recognise the relevant symptoms, to exclude irrelevant symptoms and to identify the next steps for completing the diagnostic reasoning process. An online quiz with photos and immediate feedback on every question would be a good option.

Table 5.

Relevant principles for the development of component 4: part-task practice

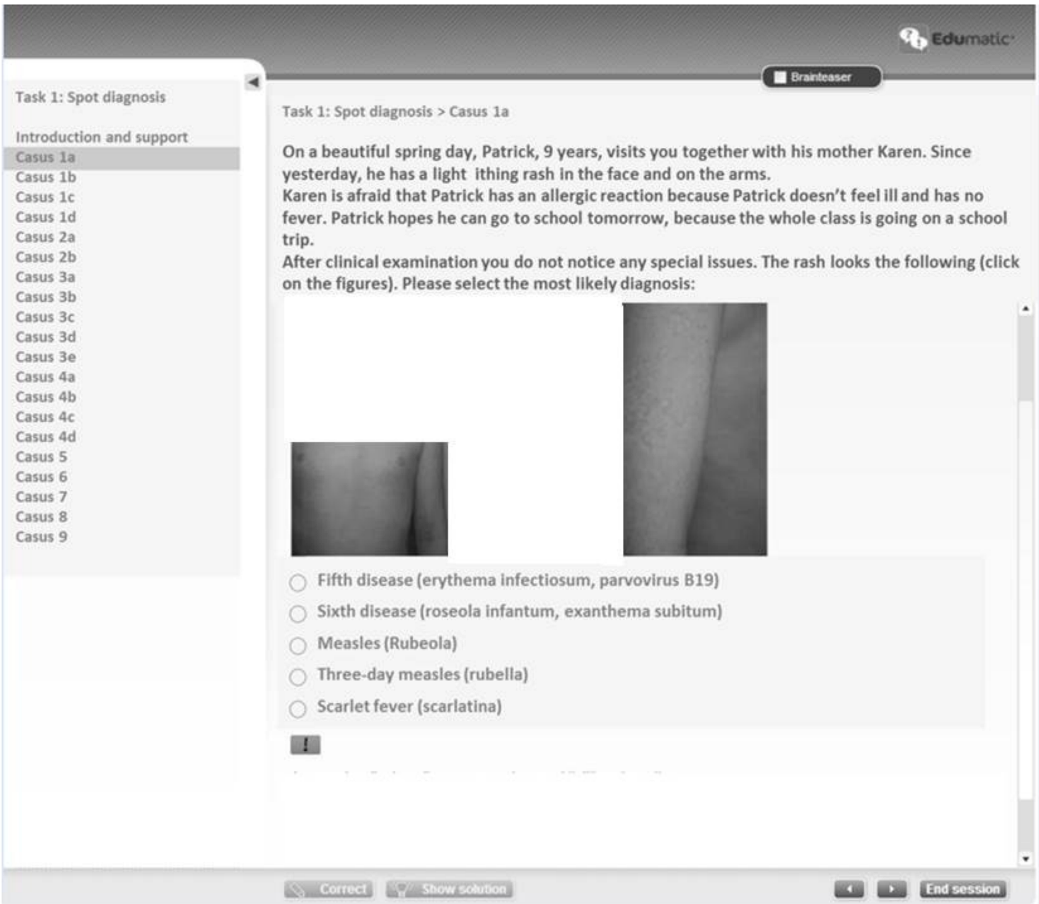
Component 4: Part-task practice
Principles – *Compilation and strengthening of rules* – *Promotes automaticity of particular recurrent aspects* – *Practice items with just-in-time information*

Illustration

Part-task practice, as applied in this learning environment, comprises several multiple-choice questions where students are introduced to a young child showing prototypical presentations of childhood infectious diseases (spot diagnosis). The feedback on the questions focused on supportive information that elaborated on protocols for correctly diagnosing the disease of interest and for correctly excluding other diagnoses. Figure 5 provides an overview of a set of part-task practice exercises in the multiple-choice format.

Figure 5.

Example of part-task practice: multiple-choice exercise with correct answer feedback.



Implementation strategy and management plan

Whilst guided by the ten steps for developing the content-related aspects of the 4C/ID-based learning environment, as described in the previous sections, several other issues arise and need to be handled. Although there is accumulating evidence that the whole-task approach is effective and efficient (van Merriënboer & Kester, 2008; Merrill, 2012), the development and implementation of whole-task models (like the 4C/ID model) is often inhibited, even restrained, by many practical, theoretical and technical issues. Therefore, it is advisable to have an implementation strategy and management plan. The change from traditional face-to-face education towards a blended learning environment starting from whole tasks implies big changes in educational practice and professionalism of teachers. Therefore, one could use a model for leading change, presented by Kotter (1995) and applied in medical education by Steinert and colleagues (Steinert et al., 2007). Kotter (1995) presented eight frequently made errors in the process of change and suggested an equal number of actions in order to increase the chance for successful change. In Table 6, the actions as described by Kotter (1995) are listed together with additional steps to be taken in the change cycle towards blended, whole-task learning in medical education. This is a cyclic process that might have multiple iterations in order to develop and optimize an evidence-based blended learning environment for whole-task learning.

Table 6.

Educational change cycle towards innovation: actions to take.

[a] Based on Kotter (1995) and Steinert et al. (2007)

Actions in the leading change process[a]	***Actions in the educational change process***
1. Establish a sense of urgency	*Identify what practices of (medical) education can and should be improved. Define short-term and long-term improvements.*
2. Form a powerful guiding coalition	*Identify the stakeholders: end-users of the learning environment, developers, teachers and management*
3. Create a vision	*Apply evidence-based principles*
4. Communicate the vision	*Communicate the instructional approach with all stakeholders*
5. Empower others to act on the vision	*Teach the teachers*
6. Plan for and create short-term wins	*a. Identify high quality learning materials;* *b. Prototype testing with small user groups*
7. Consolidate improvements and produce still more change	*a. Work future-oriented;* *b. Evaluate with all end-users;* *c. Document*
8. Institutionalize new approaches	*Disseminate and discuss*

Action 1: Establish a sense of urgency

Define what practices of (medical) education can and should be improved. Define short-term and long-term improvements. In our case, there was the observation that there was not sufficient integration of theory and practice and that there was also a lack of transfer from what had been learned during classes to what was seen during internship (and the other way around). However, as medical education increasingly stresses the integrated acquisition of multiple competences, there was a discrepancy between the way instruction was offered to students and the goals of medical education. This led to a raised awareness for adjusting the educational practice towards a higher standard.

Action 2: Form a powerful guiding coalition

Define the stakeholders: end-users of the learning environment, educational specialists familiar with (blended) learning environments, content developers, teachers and management. In line with the tips that Dolmans et al. (2013) provide, it is of utmost importance in this process to (1) form multidisciplinary teams comprising several medical disciplines (like communication experts, diabetes experts, medical imaging experts) and instructional designers, and (2) prepare and motivate team members to fulfill different roles (medical expert, content creator, content reviser, supervisor for training tasks, etc.) and to reflect on their methods of instruction. The first is crucial for the development of balanced, whole-tasks that integrate different aspects of authentic tasks; the latter is of added value when it comes to the development, successful implementation and follow-up of the learning environment. For example, once decided to use an instructional design model to support the re/development of a learning environment, the stakeholders need to assess every element of the model to its asset value. To illustrate this, in the General Practice 4C/ID model, the component of part-task practice was left out in some learning modules because high levels of automaticity for selected task aspects were not part of the objectives of that specific learning module. A powerful guiding coalition forms a counterbalance for instructional designers that consider all elements in the model as assets ("it is a validated model, after all"), and for teachers and content developers that consider only those elements that are easy and practical to implement.

Action 3: Create a vision

Apply evidence-based principles. Medical education research can genuinely evolve by investigating and applying empirically sound principles from instructional design research. Cognitive psychological research, for example, can be of great value for medical education (Schuwirth, 2010). An illustration of this value is given by van Merriënboer and Sweller (2010) discussing how cognitive load theory can be applied in health professional education. One principle that is highly relevant in this context is the expertise reversal effect indicating that principles that work well for novice learners are not always beneficial, and can even be detrimental, for more advanced learners. For example, a worked example that is offered at the beginning of a task class becomes redundant for more knowledgeable learners. Worked examples are initially introduced to reduce a (novice) learner's cognitive load by providing a full solution that needs to be studied carefully. Instead of investing effort in trying to generate a solution, learners can invest all effort to studying the expert solution and elaborating on the example. Irrespective of what instructional design principles are used to define the vision towards educational innovation, they will largely define the choices to be made in the design, development and implementation of the innovation. Hence, explaining and communicating this vision and its underlying principles will support all stakeholders to genuinely contribute in the process of educational innovation.

Action 4: Communicate the vision

Discuss the instructional approach with all stakeholders. This action is intended to make the vision, and its underlying principles, clear towards all stakeholders. In an initial meeting, the instructional design method (here, the 4C/ID model) can be introduced to and discussed with the instructors and content developers involved in the educational change. One can start from the original 4C/ID model but may need to make modifications based on the feedback of the stakeholders that is given during the initial meeting. In our specific case, teachers and students indicated that the structure and wording of the components in the 4C/ID model was not entirely clear to them. Consequently, the visual presentation of the model was made clearer with icons that were specifically developed for this application of the 4C/ID model in medical education. By consequently using these icons to label tasks, supportive and procedural information, worked examples and so forth, students, instructors as well as content developers became familiar with the structure of the learning environment and could easily find their way and navigate through tasks and task classes. Also, by indicating the total set of tasks and informing students of their progress through the task classes, students could easily manage the completion of tasks and tasks classes. Adding icons to make the approach more clear was a consequence of discussing the vision with the stakeholders at an early stage.

Action 5: Empower others to act on the vision

Teach the teachers. Roadmaps or templates guide the content developers stepwise through the development process and are built around the elements that are required per task class, providing additional information per element. To introduce the roadmap one could organize a hands-on session for teachers and content developers wherein the instructional approach is illustrated with practical examples. **(The roadmap as used for the development of the General Practice 4C/ID model is provided in Appendix B, as part of the AMEE Guide)**

For example, when a content developer starts a new set of tasks, the first question in the roadmap is to define the performance objectives and achievements of the set of tasks, or, in other words: what real-life tasks should medicine students be able to perform correctly in order to achieve what the program aims for (steps 1-3: Design learning tasks). This assists the developers in developing a varied set of tasks that jointly involve all performance objectives defined for that task class. The learning tasks need to be specified before the objectives, standards and assessment instruments in order to avoid that learning objectives are determined early in the development process with the risk of being abandoned or revised later on in the learning process to correspond more closely to the content that has finally been developed (van Merriënboer & Kirschner, 2013). Subsequently, the roadmap lists possible examples of supportive information (steps 4-6: Design supportive information), after which content developers can indicate what documents, links or resources they want to be offered to students. On the task level, a list is provided with exercise types and examples as to inform the content developers of the possibilities in task development (step 1: Design learning tasks). For all tasks, developers are requested to provide the reasoning process that results in the most optimal or correct answers (steps 4-6: Design supportive information) and to list the general (step 4: Design supportive information, cognitive feedback) and fault-specific (step 7: Design procedural information, corrective feedback) feedback that should be offered to students. This structured way of content development allows both instructional designers and content developers to develop the learning environment efficiently.

Action 6: Plan for and create short-term wins

a. Plan for short-term wins: use or reuse learning materials of high quality. In the development of a (computer-based) learning environment for the acquisition of medical knowledge, skills and attitudes, all available learning content should be viewed at from three angles:

(1) Are the existing learning materials of sufficient high quality to foster the integrated development of knowledge, skills and attitudes, taking into account the different roles a physician should be able to take in his/her practice?

(2) Is there sufficient variability in task type and interactivity within the learning modules? To assure high variability and a range of interactivity, existing learning materials can be categorized into the way they are presented (see roadmap in Appendix B, AMEE Guide) as to identify the degree of variability and interactivity that is already present. To foster variability and different forms of interactivity, one could create an overview of several types of learning tasks (see Appendix A, AMEE Guide), and indicate for all types in what context the task can be offered (training task in internship, task in course class, online text questions, online video), what interactivity was possible (student-student; student-environment; student-instructor; student-class), and how student performance could be evaluated (step 2: Develop assessment instruments).

(3) Are the (existing) learning materials suitable to be offered via computer-based instruction? This question stems from the notion that the effectiveness and efficiency as obtained by the use of paper-and-pencil materials does not necessarily hold when this content is offered in an online content management system (CMS) as the infrastructure for the learning environment. Not only is this due to the nature of the learning materials, but also to the technical characteristics and restrictions of the environment in which the content is offered.

b. Create short-term wins: prototype testing with end-users. The contribution of students and teachers as future end-users should not be underestimated when it comes to receiving feedback on the environment's strengths and weaknesses (Dolmans et al., 2013). A major pitfall in the design, development and testing phases is not making use of future users' insights. In this case, both instructors and students were considered as end-users of the learning environment and already in the conceptual design phase they were involved to critically reflect on the elements in the learning environment. In line with the suggestion by Dolmans et al. (2013) to explain the ideas behind the innovative whole-task approach, user groups were organized in which the principles and structure of the learning environment were presented and discussed. The discussions in the user groups provided valuable information to further refine the learning environment. By continuously involving the users in the process of design and development, at first sight critical users may become the best advocates of the new approach. Moreover, students become familiar with the instructional methods and the expected learning approaches.

Action 7: Consolidate improvements and produce still more change

a. *Work future-oriented.* With respect to future development and sustainability of the learning environment, learning materials can be provided with metadata. Metadata can label learning materials with values for subject, education level, performance objectives, intended users, number of roles to integrate, and so forth. The added value of metadata is that they allow for searching repositories of learning materials in order to find content that meets the required criteria (Ellaway & Masters, 2008), but they also foster reuse of learning materials in other environments. In this Guide we have proposed a first attempt to a metadata overview by describing the criteria and their parameters by which learning materials are categorized.

b. *Evaluate with all end-users.* After students complete all tasks in the learning environment (including internship tasks), both qualitative and quantitative evaluations can be performed. Three end-user groups need to take part in the evaluations: students as they can be considered as the primary end-users of the learning environment; teachers as they have used the learning environment as a tool in their educational practice; and developers or educational specialists as they likely have encountered technical and practical issues that need to be dealt with in a future cycle of innovation. Evaluations may focus on the quality of the content as well as on the user-friendliness and functionality of the learning environment. For example, rating scales that indicate the satisfaction of students with the overall structure of the learning environment, the quality of the tasks and support materials, the practical organisation of classroom instruction and computer-based instruction, interface design, the interaction with teachers and other students, etc. provide input for further improvement of the learning environment. Open-ended questions on what end-users would improve or change can also form the basis for future changes in educational practice.

c. *Document.* In the progressive process of developing and implementing a learning environment, documenting what has been developed, what steps have been taken, what issues have been dealt with and how, may seem like a rather disturbing task that interrupts the flow wherein all team members are. However, documenting offers great advantages as it is one of the backbones of the next successful educational innovation. There are a number of reasons why one could decide to spend enough time on documenting: it keeps all team members on track, it keeps the stakeholders informed; it provides a back-up for the team members; it provides clarity and traceability; it provides a starting point for dissemination and with good documentation, the time needed to support and train teachers is reduced. When deciding what to document the following elements should be included: risks and technical issues that were encountered and how they were dealt with; all re-usable materials like icons, videos, pictures; identification of educational materials on websites; reports on development and implementation; reports on testing by small user groups; suggestions made by stakeholders and a separate document where do’s and don’ts are listed for future end-users of the learning environment.

Action 8: Institutionalize new approaches

Disseminate and discuss. As a last step in the change process, Steinert et al. (2007) suggested to anchor the new approaches in the culture of the institution. For this anchoring, dissemination is needed in order to create a widespread support for endorsement of the new approach in the medical curriculum. By disseminating the process of development and implementation, one gets feedback from peer researchers, peer teachers and peer designers, which again provides input for optimization of the current and future learning environments. Moreover, dissemination allows to discuss what successful elements in the change process can be transferred to other parts of the medical curriculum as to further stimulate innovation in medical education.

Conclusion

In this Guide, the reader was introduced to the 4C/ID model, an instructional design model that supports complex learning. The model was illustrated with an example of a blended learning environment in a general practice curriculum. The learning environment, as proposed in this Guide, is in accordance with the whole-task approach, where a learning domain (i.e. general practice) is considered as a coherent, integrated whole and where teaching and instruction start with relatively simple, but authentic tasks and gradually proceed to more complex tasks.

As van Merriënboer and Kirschner (2013) describe, the 4C/ID model and its accompanying ten steps to complex learning can form the basis for designing educational tasks with established and well-known educational approaches such as problem-based learning (Norman & Schmidt, 2000) and constructivist learning (Jonassen, 1999). The 4C/ID's four main constituents can be incorporated throughout all instructional design models that promote effective learning.

The tens steps to complex learning (as described by van Merriënboer & Kirschner, 2013) provide a good starting point for the design of powerful learning environments that promote complex learning. The steps and underlying theoretical assumptions can be considered as guidelines and markers in developing or optimizing a learning environment as described in this Guide. Depending on the already available knowledge about instructional design in the institution, the existing good practices and practical issues to deal with (like time efforts and available support for teachers) the 4C/ID model can be implemented in several gradations, varying from the enrichment of existing complex learning tasks with part-task practice where deemed relevant, or providing worked examples at the beginning of a set of learning tasks, to reforming whole courses or even the curriculum of medical education based on the 4C/ID principles. The 4C/ID model is based on a broad range of evidence-based principles from research on instructional design, cognitive psychology and information processing theories, hence implementing parts of the model in accordance with the steps as described by van Merriënboer and Kirschner (2013) and in this Guide, is likely to improve the instructional design.

Parallel with the decision to start implementing (parts of) the 4C/ID model, practical and technical issues should also be taken into account. In this Guide, Kotter's (1995) actions to prevent frequently made errors in the process of change are listed together with the steps to increase the successful implementation of a blended, whole-task based learning environment for medical education.

Concluding, two major tools were provided in this Guide. On the one hand, based on the 4C/ID model, there are Ten Steps for the development of whole-tasks that can be offered in a blended learning environment for medical education. On the other hand, the actions to be taken in order to ensure successful (long-term) implementation were discussed. With these tools, medical teachers and instructional designers in medical education are well equipped to further introduce the whole-task approach in medical education and to deal with practical, theoretical and technical issues. In addition, new research lines can be developed wherein the effectiveness of the whole-task approach is sketched in a variety of learning situations, for a variety of medical students, hereby strengthening the validity of the whole-task approach.

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The following will appear only in the Hard copy of the Guide, the above material refers only to what will appear within Medical Teacher

Looking for failures and inspiration

In an ideal world, a worked example would have preceded this AMEE Guide on the 4C/ID learning environment. Such worked example would have provided the reader the golden standard for developing a whole-task based environment. However, even evidence-based guidelines from educational theory require some trial-and-error to be properly implemented into educational practice. As a result, worked examples only become available after years of experience. Therefore, it is worthwhile to share failures and difficulties experienced during the process of medical innovation. This prevents others from making the same mistakes or at least increases the attention to avoid similar mistakes, coming closer to the golden standard for whole-task based learning environments in medical education. This is discussed in the next section 'A look back'.

To conclude this Guide we look forward to what is up next: after taking 10 steps to innovate medical education, it requires a little additional walk in order to guarantee a long-lasting and qualitative innovation that gives rise to a new whole-task based approach in medical education and inspires research on medical education.

A look back

The whole process from starting with an idea, proceeding through development and implementation and finishing with an evaluation of the product (the learning environment) and the development process, is also to be considered as a learning curve for all stakeholders. Since reflection is without doubt crucial for the advancement of any learning process, a selection of outcomes of our reflections are listed here. The reader should be aware that, although some points may sound very familiar, the listing below is context-specific and non-exhaustive and should therefore work inspirational rather than normative.

- *Stakeholders say "yes" and think "what are they talking about?"*

  Imagine the maximal distance that is possible between a teacher explaining a concept and a student trying to understand this. This is likely only half of the distance that can be experienced between an instructional designer trying to explain the 4C/ID model and his/her audience –a mix of medical teachers, general practitioners, students and a project manager– trying to figure out what is actually said. A consequence of this is that all who are involved in educational innovation should go beyond their regular reference framework, and talk beyond the vocabulary of their own profession. The fact that medical teachers agree to co-design learning tasks does not mean that they know how to design such tasks; it only indicates that they are supporting the idea, are willing to invest effort in it and believe that their help can be of added value if only they could experience some learning-by-doing and support to successfully complete that tasks to which they said "yes, of course, no problem".
- *If the will to work with technology would equal the skills to work with it, then we would have perfect educational practice.*

  This relates to all stakeholders involved in educational innovations that are supported by technology. Even if everyone in the team is strongly convinced of the benefits and added value of using videos, automated feedback, adaptive instruction and interactive learning tasks, then still nothing has been developed. The skills to work with educational technology often are developed in line with the needs of the project. Moreover, the one that delivers the content (e.g., medical teacher) is not necessarily the one who developed it which may cause problems after the project has finished and the learning environment needs further support or follow-up. One way to deal with this is to provide hands-on training sessions to a selection of the stakeholders and to make the documentation for these training sessions available to all stakeholders. Related to this is documenting every major step that is taken. In fact, from the start of the process of educational innovation, a diary should be kept in which all major actions are listed, documented and accompanied with overviews or manuals of how the steps were taken, how content was developed. During the project this might be the least concern, however, imagine that you are the one who will need to further support a learning environment for which no documentation is available.

- *The strongest critics might become your biggest fans (students/teachers)*

  Let your end-users formulate their thoughts, worries and perhaps even irrational critics. Students might be very reserved towards the innovation that is announced. Be not surprised when you hear urban legend-like stories about what the change will be, stories based on other stories from so-called well-informed students amidst your team of stakeholders. Embrace the worries and critics from your end-users, let them formulate suggestions and assure them that they are heard. However, it is important to keep in mind the original goal of the educational innovation, and not to radically change means, methods and goals based on thoughts from less informed stakeholders. Let criticism work inspirational as in the end, when a good product is delivered, the most skeptical people will become your biggest fans.

- *Make other people jealous… and then let them join the team.*

  Expectations of a whole teacher team that supports the innovation will likely result in disappointment. Expecting that all teachers are equally involved and equally contribute to the process of innovation is also not realistic and even unnecessary. Starting with a small sample of teachers who are willing to invest time might be the preferred way for developing and pilot testing the innovation. If it goes wrong, then it is only a part of the team that should re-invest in the process, or more negatively formulated, it is only a part of the team that might lose the motivation. If it goes well, then the early involved teachers are the best advocates of the new approach and innovations. Let them talk, spread the word, and in no time, other teachers will be asking to take part in the process.

- *Humans can learn, technology doesn't, technology developers might.*

  Technical problems with e-learning platform and software issues is something that humans can overcome and solve, with or without additional support from within or outside the institution, school or university. While humans become more skilled in dealing with technological difficulties or software-related issues, the technology itself does not change. However, between the phases of an innovative idea and plan on the one hand, and the phases of implementation and evaluation on the other, technology developers might provide updates to the software. Procedures that worked well before (e.g. steps to enter learning tasks in a CMS; procedures to provide fault specific feedback) might then become ineffective resulting in more time and efforts that need to be spent in the development phase.

A look forward

In this section we describe the next steps to take. In line with action 8: Institutionalize new approaches of the implementation strategy and management plan, the method as described here was transferred to other curricula. New courses, based on the 4C/ID model and the steps as described in this Guide are currently developed in the Masters curriculum of Youth Healthcare (Master to be followed after obtaining the degree of medical doctor; Dutch website: http://onderwijsaanbod.kuleuven.be/opleidingen/n/CQ_50268989.htm), and in the third year of the Bachelor in Medicine. With respect to the latter, a new course has been developed that integrates four courses (Clinical consultation; Primary health care; Quality of care and patient safety; and Internship in a general practice). All four courses are offered in an integrated way, using four didactical methods: interactive lectures; workshops (of which some are led by peer tutors); online exercises as to prepare for the lectures, workshops and internship or to deepen and broaden the knowledge and skills after the lectures and workshops; and an integrated online assessment. The whole course starts from multiple patient cases that will be handled by the different teachers, all viewing the cases from different angles and adding multiple viewpoints to the cases. As students proceed through the course, tasks will become more complex and the available support will decrease. For the design and development of this course a joint workforce was set-up with about 45 medical teachers willing to take part in it.

However, based on the lessons learned, parts of the approach are different. Instead of expecting that teachers will be able to design 4C/ID-based learning tasks, now, teachers are asked to handle all relevant learning materials after which the team starts to make proposals on content and method. The proposals are then discussed and refined with one or two medical teachers (who are then introduced to the 4C/ID model) after which the content and approach is presented to the steering committee in order to get feedback. Also, usability tests with students will be done at a much earlier stage of development. Doing so, technical issues and problems with usability and clarity of the structure will be defined before the implementation starts. Moreover, in order to answer the call for more theory building in medical education, multiple measurements will be taken prior, during and after the implementation stage. Prior measurements include the students' knowledge and (clinical reasoning) skills, motivation and perceptions of the courses in the curriculum as is (control group). During the implementation, students will also be asked once a week to indicate their perceptions of the tasks, satisfaction with the new course, the study time invested in preparing and attending lectures and workshops, and the study time invested in processing the learning materials and completing the online tasks. After the course is completed, students' scores on the tasks and the assessments will be registered. In doing so, the effectiveness and efficiency of the new course can be sketched (as compared to the traditional courses), taking into account learning process variables (like study time) and student characteristics (like perceptions and motivation).

While the research design described here can already partially answer the question whether students learn to reason in a more integrated matter, no answer can be given to the question whether they also become better doctors. This requires longitudinal research designs that investigate the long-term effects of implementing educational curricula based on whole-tasks. However, as part of the curriculum's quality control, additional measurements on clinical reasoning skills can be taken once students are graduated and are employed as a medical doctor. To do so, a sample of students from the new and traditional curriculum can be selected and followed after graduation. Every two years, the sample will be offered a set of whole tasks that need to be completed. By comparing the used knowledge and skills and by sketching the attitudes of the two groups in an ecologically valid setting, in the long run, there might be clear evidence that whole-task based medical education is an effective and efficient way to provide better healthcare professionals.

Further reading

Readers may benefit from visiting the following web-site: www.tensteps.info.

The book, Ten Steps to Complex Learning (van Merriënboer & Kirschner, 2013), presents a path from a training problem to a training solution in a way that students, practitioners (both instructional designers and teachers), and researchers can understand and easily use. Practitioners can use this book as a reference guide to support their design of courses, materials, or environments for complex learning. Students in the field of instructional design can use this book to broaden their knowledge of the design of training programs for complex learning.

Appendix A: Possible tasks.

What? This list provides a not-exhaustive overview of possible tasks for medical education, aiming to provide inspiration to content developers as to provide a rich and varied set of tasks. Below the list, the table overviews in what forms tasks can be offered to students. For example, a mini-case study of diagnosis and follow-up can be offered in the e-learning environment (through a video or text description); can be offered as a task in class; but is less suited as a training task.

Table A1. Learning tasks and context in which they can be administered

Learning tasks	Case with patient (text - computer)	Consultation with patient (video - computer)	Training task (internship /workplace)	Class/college task (blended)
Mini case	x	x		x
Patient story	x	x		x
Simulation		x		
Article reading + argumentation statement	x	x	X	x
Preparing presentation for a patient group			X	x
Preparing presentation for colleagues			X	x
Role-play		x		x

Discussion with patient	x	x	X	x
Discussion with colleague-	x	x	X	x
physician				
Discussion with third party	x	x	X	x
Reflection	x	x	X	x
Peer feedback	x	x		x
Expert assessment	x	x	X	x
Completion problem	x	x		
Cheat case	x	x		x
Self-assessment	x	x	X	x
Filter case	x	x		x
Non-analytical reasoning	x	x	X	x
Analytical reasoning	x	x	X	x
Design of care/treatment plan	x	x	x	x
Participation in multidisciplinary			x	
team		x	x	x
Observing and reflecting on		x	x	x
history taking			x	
Writing prescription				
Asking feedback from				
physician/clerkship trainer				

1. Mini case diagnosis and/or follow-up:

What? Short introductory video, question from patient; student indicates what needs to be observed and registered in a first consultation or in a follow-up consultation.

Evaluation? Evaluation can be done with computer-assisted feedback (informative).

2. Patient story:

What? Short video, patient tells story/complaints. Question is whether there is (for example) evidence for a diabetes diagnosis? Is more research feasible or advised? Why?

Evaluation? Evaluation can be done with computer-assisted feedback (informative) or feedback by teacher.

3. Simulation:

What? Virtual patient, video, depending on the answers of the student, other video parts are shown. Simulations are useful to exercise communication skills and diagnostic reasoning.

Evaluation? Evaluation can be done with computer-assisted feedback (informative).

4. Article reading + argumentation of statement:

What? Student reads one or more scientific papers related to a statement, offered by the teacher. The student needs to discuss the statement and construct an argumentation (not) in favor of the given statement.

Evaluation? Evaluation can be done by the medical teacher, peer student(s), during college, student compares with expert argumentation (computer-based).

5. Preparing a presentation for a patient group:

What? Student describes diabetes: what is it, how to avoid, how to deal with it, etc. The student prepares a presentation for a fictional group of people (group of elderly, teachers: how to deal with children with diabetes in school; employers of a rehabilitation center, etc.).

Evaluation? Evaluation can be done by the medical teachers, by the clerkship trainer or by peer student(s).

6. Preparing a presentation for colleague-physicians:

What? Student prepares a scientific presentation about diabetes for a fictional group of colleagues-physicians.

Evaluation? Evaluation can be done by the medical teacher, by the clerkship trainer.

7. Role-play:

What? Role-play with other students; with clerkship trainer or with medical teachers. Can be done during class hours or in workshops.

Evaluation? Evaluation can be done by peer student(s), medical teacher or clerkship trainer. Delayed evaluation is possible of the student uploads the video recorded role-play and provides this to who's responsible for feedback.

8. Discussion with patient:

What? Student reads the case of a 'difficult patient' (non-compliance, low motivation, denial), and notes how (s)he would deal with this.

Evaluation: Evaluation can be done with computer-based feedback or by teacher or peer student(s).

9. Discussion with colleague-physician:

What? Student reads the statement of a colleague-physician and has to disagree with it. The student writes down the argumentation.

Evaluation? Evaluation can be done with computer-based feedback or by teacher or peer student(s).

10. <u>Discussion with third party:</u>

What? A third party (e.g. mother, partner, child) is involved in the consultation between the student-doctor and patient, the third party can be a threat to the successful treatment. The students arguments how to deal with this situation.

Evaluation? Evaluation can be done with computer-based feedback or by teacher or peer student(s).

11. <u>Reflection:</u>

What? After completing a task or series of tasks and after having read the feedback, a student reflects on his/her answers. The practice or reflection is guided by the assessment criteria.

Evaluation? Self-evaluation, student notes this in a portfolio.

12. <u>Peer feedback:</u>

What? This task involves providing feedback to the completed tasks of peer students. Feedback can be provided in role-play, argumentations, during class, etc. This requires that a student is able to compare the outcome of his/her peer to the assessment criteria and provides appropriate feedback.

Evaluation? The medical teacher evaluates the quality of the feedback as provided by the student; the student that receives the feedback can provide an answer to the feedback (added value, quality and relevance of the feedback for the learning process).

13. Expert assessment:

What? A student grades expert behavior according to prior defined criteria. This involves, for example, evaluating an expert's treatment plan or care plan; evaluation an expert's reasoning strategy to come to a diagnosis; evaluating the interaction between expert-doctor and patient.

Evaluation? Evaluation can be done with computer-based feedback or feedback provided by the expert him/herself (medical teacher or clerkship trainer).

14. Completion problem:

What? A task that is provided at the beginning of a series of tasks (task class). The student gets an overview of the steps needed for a successful performance on the task, but some steps are not provided. The student needs to decide which steps are missing (and in what order).

Evaluation? Evaluation can be done with computer-based feedback.

15. Cheat case:

What? A task from which the subject does not belong to the topic(s) that is(are) central in the series of tasks. This task is given in order to foster the student's critical information processing and reasoning strategies and to teach students how to look for arguments again a diagnosis. The task involves providing a case or a situation based on which the student needs to assess what other diagnoses are likely or possible and why.

Evaluation? Evaluation can be done with computer-based feedback, peer feedback (as a task) or feedback given by medical teacher.

16. Self-assessment:

What? This entails self-tests, which can be offered prior or after each task class. With the self-assessment, including feedback on the results, deliberate practice is fostered. Self-assessment can comprise a computer-based quiz, but also evaluating one's own role-play or describing and evaluating one's interaction with a patient during internship.

Evaluation? Evaluation can be done with computer-based feedback, or with feedback from medical teacher.

17. <u>Filter case</u>

What? A case where a patient show multiple and varied symptoms; the student needs to filter the relevant symptoms and reason further based on that selection.

Evaluation? Evaluation can be done with computer-based feedback; feedback by medical teacher or peer student(s).

18. <u>Non-analytical reasoning:</u>

What? A student reads a patient case (text or video) and is asked to provide answers to the case by means of a non-analytical, holistic reasoning process. The task can be offered in a quiz format and is similar to an on-the-spot diagnosis.

Evaluation? Evaluation can be done with computer-based feedback.

19. <u>Analytical reasoning:</u>

What? A student reads a patient case (text or video) and is asked to provide answers to the case by means of an analytical, stepwise reasoning process. A student is fostered to search for and against evidence that support the reasoning process.

Evaluation? Evaluation can be done with computer-based feedback, also expert (medical teacher, clerkship trainer) feedback can be provided.

20. Design of care/treatment plan:

What? A student reads a patient case (text or video) and is asked to design and write down a care or treatment plan.

Evaluation? Evaluation can be done with computer-based feedback, also expert (medical teacher, clerkship trainer) feedback can be provided.

21. Participation in multidisciplinary team:

What? This internship task focuses on the students' participatory behavior in a multidisciplinary team during internship. A student needs to focus on the different team members, their job function and role in the treatment plan of a patient. A student needs to reflect on his/her own behavior as a team member and collaboration skills.

Evaluation? Evaluation can be done with self-assessment. A student is given reflection prompts to foster reflection on his/her behavior in the team.

22. Observing and reflecting on history taking:

What? Already in an early stage of internship, this task can be offered to train history taking. The task is to observe the experts' history taking and to reflect on what was observed and link this with the theory that was offered during classes.

Evaluation? Evaluation can be done with self-assessment, also, peer feedback is possible.

23. Writing prescription(s):

What? Parts of this task focus on the automation of certain elements (like indicating dosage and duration) in writing prescriptions. Other parts then focus on the non-routine aspects of the task in that content, form and amount of prescriptions will differ along patients and situations.

The to-be-automatized parts can be exercised by means of computer-based instruction, as a preparation for the whole task which can then be completed during internship.

Evaluation? Parts of the task can be evaluated with computer-based feedback; the whole-task is to be evaluated by the clerkship trainer or the medical teacher.

24. <u>Asking feedback from physician/clerkship trainer:</u>

What? This task is an internship task that focuses on fostering deliberate practice, not only to acquire expertise, but also to develop the attitude of lifelong learning and deliberate practice.

Evaluation? By means of computer-based instruction, feedback prompts can be sent to the student, after which a student asks for feedback. The feedback is then given by the medical teacher or the clerkship trainer after which the student is again prompted to reflect on this and to integrate the feedback in future behavior.

Appendix B: Roadmap for whole-task development.

Step 1: Define the tasks of a general practitioner

How? Based on the medical curriculum's goals, indicate the most important components, tasks or actions for a general practitioner (GP) within this learning module (Patient with diabetes). These components will give an indication of the number of task classes.

Please note here the most important components within this learning module (Patient with diabetes):

Component	More specifically
☐ Illness forms	patient with diabetes
☐ Communication	motivational interview, compliance
☐ EBM	0
☐ Diagnostic strategies	diagnosis and policy
☐ Practice management	Audits
☐ Clinical-technical skills	foot examination, insulin
☐ Psychosocial and diversity	0
☐ Other	Please indicate:

…………………………………………………………………………..

→ **Are there any components that can be merged, or that are very interrelated with each other?**

If not: the number of components = number of task classes

If yes: what components can be merged? Define the number of task classes as the number of related components within this learning module.

The indicative number of task classes in this learning module is: …….

Additional remarks:

Step 2: Define performance objectives of the learning module.

How? Have a look at the ECTS (European Credit Transfer System) files of the courses in the curriculum. What are you aiming for in this learning module? What should students be able to do fruitfully after completion of this learning module?

Please note here the objectives for this learning module:

After completion of this learning module, the student is able to …

Additional remarks:

Step 3: Define performance standards.

How? What standards should a student reach in order to complete a task class, module or course? Please take into account all components in the learning module (step 2) and the complexity of the task classes (step 3). The standards, as listed here, will also be announced to students. Doing so, a student knows on what aspects his or her performance will be evaluated and what he/she needs to focus on.

Examples of performance standards: *the student reflects on a given diagnosis; the student is able to argue against a diagnosis; the student is able to correctly search information in order to complete a diagnosis, the student knows the different elements in the model of communication; the student knows how to work with the electronic health record; etc.*

Additional remarks:

Step 4: Define the complexity of task classes – sequencing tasks.

How? Task classes are formed based on increasing complexity. The first task class contains the most simple tasks, with only one or two GP actions to be acquired. The last task class contains the most complex tasks where all relevant GP actions for this learning module are to be acquired. Next to the number of GP actions offered in a task class, different complexity between task classes can also vary along the following parameters.

Please indicate how you would like to define the complexity of the task classes.

Parameter	Least complex	Most complex
☐ Nature of the complaints	*clear complaints*	*vague complaints*
☐ Accessibility of information	*Direct access*	*Indirect, difficult access*
☐ Patient requests/needs	*Low*	*High*
☐ Duration of consultation	*Unlimited*	*very limited*
☐ Other (additional) complaints	*None*	*Multiple*
☐ Actors in the consultation	*doctor-patient*	*doctor-patient-family-employer*
☐ General Practice actions/components	*1-2 actions*	*all actions*

Additional remarks:

Step 5: Define the supportive information per task class.

How? Supportive information is available for all tasks and exercises within one task class. Overall, this type of information can be described as ‘the theory’. The information can be organized in three groups:

(1) Descriptive domain knowledge (e.g. form and functions of human body systems, functionalities of the electronic health record, method to have an intake conversation, etc.)

(2) Systematic approaches to problem solving (systematic approaches to problem solving; e.g. systematic approach for the clinical reasoning process)

(3) Cognitive feedback (e.g. answer and fault specific feedback with externalization of the reasoning process behind it)

Concrete examples of supportive information per task class are: a reference manual, theoretical course chapter, presentations, websites, web lectures, wiki’s, glossaries and multimedia sources. Summarized: all content from which the instructor rates that it contributes to the domain knowledge and problem solving skills of students, specifically for the tasks within a task class.

This information can be offered in the learning environment where a student goes through the information individually, or it can be offered during classes.

Information for task class x:

GP actions for task class x	Supportive information
- treatment and policy	Theoretical chapter [put file path here]
- [add content]	[add source]
- [add content]	[add source]

What will be discussed in class?	*[describe content here]*

Information for task class x+1:

GP actions for task class x+1	Supportive information
- treatment and policy	Theoretical chapter [put file path here]
- motivational interview	Video of motivational interview [put file path here]
- [add content]	[add source]
What will be discussed in class?	*[describe content here]*

Additional remarks:

Step 6: Define the worked example(s) per task class.

How? A worked example illustrates to student how certain aspects of a task should be executed. Worked examples differ between task classes and also function as supportive information. In line with the variety in tasks; also different worked examples from different settings can be offered to students. Students are asked to have a detailed look at the worked example as to be able to identify the 'golden standard' behind it. It is not aimed for that a whole consultation is offered in a worked example, but only that the elements that are central in the task class are demonstrated by an expert (in different settings; with different patients). A worked example can take the form of a video consultation (fragments), a written-out motivational interview, a tutorial on how to use the electronic health record, etc.

Worked example(s) for task class 1:

Form	Content
☐ Video fragment consultation ☐ Text ☐ Screen capture ☐ Demonstration/Tutorial ☐ Other: [please specify]	*Please describe here the content of the worked example(s).*

Additional remarks:

Step 7: Define the learning tasks per task class.

How? Learning tasks within the same task class have a similar degree of difficulty. However, they vary in surface and structural characteristics and also vary in the degree of support that is offered in a task.

(1) Surface features: features of tasks that are deemed to be irrelevant when it comes to clinical reasoning and diagnostic decision making. For example: for the diagnosis of diabetes, some elements are rather irrelevant like gender, partner involved, previous illnesses, etc.

(2) Structural features: features of tasks that do make a difference in the processes of clinical reasoning and clinical decision making. For example: high or low blood pressure, cardiovascular problems, etc.

(3) Support: in the first task of every task class there is maximum of available support. Typically, this entails strong linkage to procedural information (i.e. how to) and strong, elaborated corrective feedback.

For every task, we ask you to fill in the other parameters that are especially relevant for the practical organization of the learning environment.

An overview of possible tasks (for inspiration and certainly not exhaustive) is given in Appendix A.

The questions below will assist you to define the tasks within a task class. Please repeat this step for every task class.

Task class x

Task x.1

1. Describe the task:

Focused questions with respect to problem specification and treatment plan based on a case study.

2. What should students know or be able to do before they start this task (e.g. knowledge of electronic health record; experience with electronic health record; knowledge of diabetes pathology, etc.?

Students should have completed all the tasks from the first task class of electronic health record and should therefore be able to work with an electronic health record.

3. Will you refer to this task in class? Should this task be completed before or after a class? For example: students prepare a diagnosis which will be discussed afterwards in class.

No

4. How do students complete this task? Individually, in learning groups, free to choose, etc.? Is the task computer-based or pen-and-paper?

Individually, computer-based

5. What are the instructional materials for this task? How will the instruction for the task be offered to the students? For example: patient description in text; video of patient, etc.)

Patient information will be offered in a text. Some additional pictures to illustrate the foot of het patient.

6. How should assessment take place?

☐ Computer-based

☐ Feedback of instructor

☐ Peer feedback

☐ Feedback in class

☐ Other, [please specify]

7. Are there multiple correct answers/solutions possible?

☐ no

☐ yes, *please specify*

8. Describe the feedback (including references to educational materials) that should be presented after a correct answer or solution.

[Add text]

9. Describe the feedback (including references to educational materials) that should be presented after an incorrect answer or solution.

[Add text]

10. If students give an incorrect answer, could it be required that additional exercises should be offered in order to foster fruitful completion of the task?

☐ no

☐ yes, more specifically when this type of error(s) is(are) made: *[add text]*

Then adding the following exercise(s) is of added value: *[Describe exercises, materials, support and feedback]*

11. Can/must this task be completed during internship?

☐ no

☐ yes, *please specify*

Step 8: Define the self-assessment at the beginning of a learning module.

How? Providing the opportunity for self-assessment at the beginning of a learning module serves two goals: on the one hand students' already available relevant knowledge is activated; on the other hand students get an indication of their prior knowledge level and the criteria by which he/she will be evaluated during task completion. Doing so, a student is informed of the focus in the learning module and can compare this with his/her own knowledge.

The self-assessment comprises questions on all elements included in the learning module.

1. What is the format of the self-assessment?

☐ Text-based instruction with questions

☐ Video-based instruction with questions

☐ Electronic health record data file(s) with questions

☐ Other: *[please specify]*

2. Does a student have access to the theory documents (and other educational materials) while completing the self-assessment?

☐ no

☐ yes, more specifically these documents can be provided: *please specify*

3. Questions in the self-assessment can be in different formats. Please take a look at Appendix A for different exercise types. Please add below, per question, the exercise type, instruction (with media if any), answer possibilities (if any), correct answer and the feedback that should be offered.

Question 1	Label:	Type:

Instruction:
Media to use:
Answer possibilities (put the correct answer(s) in bold:
Feedback:

Additional remarks:

Step 9: Define the evaluation.

How? Evaluation can take place on multiple levels: after one task, after a set of tasks in the learning phase or during internship, or after all tasks in a learning module.

(1) **Evaluation after a task**: a student is invited to evaluate his/her own performance (reflection) or needs to evaluate another students' performance (via peer feedback). A student can keep track of this in his/her portfolio. With this evaluation on the task-level, a student can create to-do-lists of what needs to be read; what additional information needs to be searched for or what skills and knowledge needs to be exercised and learned.

Please indicate the (numbers of the) **tasks** for which an evaluation is preferred:

[*Add text]*

(2) **Evaluation after a set of learning tasks**: once all learning tasks are completed (this does not include the training tasks), the students is invited to reflect on his/her performance on all tasks. This can be done with a personal (online) survey, that stays available for the student as a part of his/her portfolio.

Please indicate the **task classes** for which an evaluation of the **learning process** is preferred:

[*Add text]*

(3) **Evaluation after a set of training/internship tasks**: this evaluation entails evaluating the completed tasks during the internship. By means of a personal (online) survey, a student acquires more knowledge and insights in his/her weaknesses and strengths with respect to the successful completion of the training tasks.

Please indicate the **task classes** for which an evaluation of the **internship/training tasks** is preferred:

[*Add text]*

(4) **Evaluation after all tasks in a learning module**: in this evaluation a student evaluates all completed tasks, both from the learning phase as from the training phase. This evaluation can only be done after all tasks in the module have been completed. Again, this can be done with a personal (online) survey, that stays available for the student as a part of his/her portfolio.

Please indicate if you would prefer an evaluation on the level of the module

☐ yes

☐ no

Additional remarks: *Add text*

Step 10: Define the training or workplace-based learning tasks.

How? When specifying the tasks in the previous steps, for some tasks you might have indicated that they should be performed during internship. In this step, you can provide more details about the training tasks and specify the requirements for the workplace and for the student.

Task:	*[please provide the task number as used in step 7*]
Workplace requirements:	*[e.g. private practice space for student; practice makes use of electronic health record, etc.]*
Student requirements:	*[e.g. student has completed all tasks in the learning phase; student completed task x.x successfully; etc.]*
Other requirements:	*[e.g. student has access to electronic health record; student is able to collaborate with other student or with trainer; etc.]*

Additional remarks: