Medical Teacher, Vol. 28, No. 5, 2006, pp. 447–452

Design of integrated practice for learning professional competences

AMEIKE M.B. JANSSEN-NOORDMAN[1], JEROEN J.G. MERRIËNBOER[2], CEES P.M. VAN DER VLEUTEN[1] & ALBERT J.J.A. SCHERPBIER[1]
[1]University Maastricht, The Netherlands; [2]Open University of The Netherlands

ABSTRACT *To acquire professional competences that entail performance of complex skills, an authentic learning environment is required focused on the integration of all aspects of competences. However, most educational programmes offer separate building blocks, such as separate modules for knowledge and skills. Students accumulate what they have learned in these modules as they progress through the curriculum. In this paper the authors advocate the Four-Component Instructional Design model (4C/ID), which offers a whole-task approach to course design for programmes in which students learn complex skills. The four core components of this approach are: learning tasks, supportive information, just-in-time information and part-task practice. A concrete example from medical education will be presented to clarify both the general ideas behind this approach and the differences between the whole-task approach and conventional educational designs.*

Practice points

- The Four-Component Instructional Design approach to educational design differs from conventional educational approaches in that, from the *start* of the educational programme, the use of whole learning tasks stimulates students to integrate knowledge, skills and attitudes and encourages them to integrate and coordinate different problem solving and routine aspects of competences.
- The four components of the Four Component Instructional Design approach are: whole learning tasks, which serve as the backbone of the programme, supportive information, just-in-time information and part-task practice.
- Variability in learning tasks and repetition in part-task practice are critical factors in facilitating transfer of learning.
- The Four-Component Instructional Design approach is not a ready-made educational method, but an approach to educational design that can be used in a variety of educational models and environments.

Introduction

In undergraduate clinical training, medical students often have difficulty performing complex tasks (Prince *et al.*, 2000). For instance, when they have to examine a patient with back pain, students may find it hard to combine correct performance of physical examination skills with an appropriately attentive attitude towards the patient even though they have learned the pathology of the spine, what tests to perform and the correct attitude towards patients. Clinical supervisors explain this problem as follows: 'Students are unable to hook up their pathological knowledge with physical examination.' Students have acquired considerable knowledge and many separate skills, but they have not learned how to integrate and coordinate them into smooth performance of complex tasks. Students have been reported as saying that the various aspects of complex skills were dealt with in a *fragmented* way (Perotti *et al.*, 1998) and that they had little opportunity to master coordinated performance of the knowledge and skill components of complex tasks. Ideally, students should learn professional competences in a powerful learning environment where complex tasks can be performed and practised as integrated units. When students learn complex tasks in an integrated manner, it will be easier for them to transfer what they have learned to the reality of day-to-day work settings. Although there are results from research in the domain of learning and instruction that support the effectiveness of integrated learning environments, systematic models for this type of instructional design are scarce (Harden *et al.*, 1984; Clark & Estes, 1999; Harden *et al.*, 1999; Harden, 2002). One of these models is the Four-Component Instructional Design Model (4C/ID model) (Van Merriënboer, 1997), which has been used successfully in recent years in higher education and other educational settings (Hoogveld *et al.*, 2002). In this paper we present the 4C/ID model and illustrate its use by a concrete example from medical education, i.e. a patient with back pain who consults the general practitioner.

Professional competences, what are they?

Within the context of the 4C/ID model, professional competences are defined as meaningful whole tasks that are performed in professional practice. Whole tasks, such as a consultation with a patient with back pain, require coordination and combination of a complex set of skills. Professionals must be competent to work in different settings and circumstances. A closer look at a consultation in general

Correspondence: Ameike M.B. Janssen-Noordman, MSc, Department of Educational Development and Research, University Maastricht, PO Box 616, 6200 MD, Maastricht, The Netherlands. Tel: +31 43 3884175/3881119; fax: +31 43 3884140; email: ameike.janssen@educ.unimaas.nl

practice reveals the following aspects: the general practitioner (GP) greets the patient, observes the patient (gait, stance), interprets findings, asks questions, decides which examinations or tests to perform, performs these her/himself as appropriate, interprets findings and informs and advises the patient. When a patient presents with back pain, GPs have to combine communication skills with theoretical knowledge of the pathology of the spine and procedural skills, such as straightening a patient's leg to elicit Lasègue's sign (if the leg rises the sciatic nerve is involved). A distinction can be made between recurrent and non-recurrent aspects of tasks. Recurrent aspects are performed in the same way in different situations and thus can be turned into a routine, whereas non-recurrent aspects require a variety of performance modes depending on the situation. Furthermore, non-recurrent aspects typically involve problem-solving and reasoning. For instance, the decision on which test to perform next in a patient with back pain is a non-recurrent aspect. Subsequent performance of the selected test, for instance Lasègue's sign, is a recurrent, routine action, whereas interpretation of the findings of the test is a non-recurrent aspect, etc. Reasoning, interpretation and decision-making are non-recurrent task aspects, which vary with individual patients' needs (different uses of the same knowledge). A test like Lasègue's sign, on the other hand, is a recurring sequence of actions that is identical for every patient (identical use of identical knowledge). Consultations in general practice follow different patterns depending on the patient and the complaint. For instance, when the patient with back pain is a young girl with a sports-related back problem, the GP–patient encounter will unfold according to a different pattern from when the patient is an elderly man who has been carrying shopping bags that were much too heavy for him. In conclusion, the professional competences that a GP displays in an encounter with a patient with back pain involve performance of a variety of interrelated skills in a coordinated fashion. This requires integration of knowledge, skills and attitudes, which combine recurrent and non-recurrent task aspects.

How are professional competences acquired?

The best way to determine how professional competences can be acquired is to observe experts in the domain of interest. Experts are professionals who are recognized by their colleagues as performing at a very high level (Ericsson, 2004). GPs who are able to conduct consultations efficiently while being sensitive to the needs of individual patients have acquired a variety of aspects of complex skills that are stored and held together in cognitive networks (schemata). The advantage to GPs of having at their disposal such integrated networks is easy access to complete packages of interrelated task aspects that are appropriate to both the complaint and the individual patient. Combinations of knowledge, skills and attitudes organized in schemata are easier to retrieve and apply than chunks of information about different aspects of complex tasks stored in memory in a distributed manner (Regehr & Norman, 1996). The key challenge for designers of educational programmes is to create a learning environment that helps students to construct well-functioning networks of packages that compris integrated knowledge, skills and attitudes. First and foremost, educational designers should strive to preserve the coherence of whole tasks. This means that students should be asked to perform meaningful whole tasks in authentic situations. In the 4C/ID model such tasks are called learning tasks. Initially, students are offered relatively simple, but nevertheless authentic, tasks. Such tasks comprise all the key aspects of the complete task. As students progress through the curriculum, they are required to perform tasks of increasing complexity in more and more complex situations, which increasingly approximate the reality of professional practice. From the very start of their training, students should learn how to combine and integrate different aspects of complex tasks by performing whole tasks. A task may entail: 'seeing patients in a GP surgery', where students can 'smell, see and feel' the authentic context of that task.

Many traditional educational programmes, however, teach skills, knowledge and attitudes in isolation in separate modules. Courses focus on single components of complex skills and students are not required to integrate and coordinate what they have learned into coherent, authentic whole tasks. Such programmes are based on the premise that, when confronted with a patient in clinical practice, students who have successfully completed all the relevant blocks will automatically and spontaneously select and combine the appropriate components of what they have learned to deal competently with the patient problem in hand and even be able to transfer this competence to new problems and circumstances. A number of empirical studies have demonstrated, however, that effective competence-based learning is not achieved by offering students separate building blocks, because this does not facilitate transfer of what students have learned (Van Merriënboer, Clark & Croock, 2002). There is sufficient evidence that effective learning of complex skills and the ability to develop effective networks will only be achieved when students are given ample opportunity to manipulate, i.e. to combine and integrate, the building blocks in different ways instead of merely collecting blocks of knowledge, skills and attitudes and stacking them into a pile (Gick & Holyoak, 1983; Paas & Van Merriënboer, 1994).

What are the consequences?

The preceding has far-reaching implications for education. We will clarify this by comparing the traditional, block-based approach with the integrated approach (Whole Task Practice). In order to illustrate the comparisons we give examples derived from the complex task of a GP who examines a patient with back pain.

Traditional educational approach

Many traditional educational programmes break complex skills down into separate components, which are offered to students more or less separately (Jones *et al.*, 2001). We call this the stacking model. Educational designers who use this model ask themselves the question: 'What should students be able to do after completing the course and what knowledge and skills do they need to accomplish that?' The answers to this question direct the construction of suitable building blocks. A subject tree is constructed to provide an overview of themes and subjects to be included in the course. This is the blueprint. The subjects are placed in a logical sequence and appropriate educational formats are selected. Knowledge of subjects such as pathology and kinesiology may or may not be integrated into a theme. Skills, such as how to approach a patient (attitude, communication skills) and the physical examination of the spine are taught as much as possible in parallel with theory. The way a subject is presented to students is guided by the principle: from easy to difficult. The programme consists of at least two streams, a theoretical stream and a practical stream. These streams contain stacks of separate building blocks. Individual blocks are offered in a meaningful context. The sum total of building blocks is assumed to provide students with a set of tools that will enable them to perform complex tasks. Students are given little opportunity to practise complex task performance extensively, however. Admittedly, many successful attempts have been made to strengthen the connections between streams and building blocks, for instance by more integration and more contacts in professional practice. Basically, the idea of separate blocks that can be stacked has remained unchanged, however. In many complex domains this approach has proved to be ineffective (Clark & Estes, 1999), simply because performing complex skills will always require more than simply adding (stacking) the necessary constituent parts. In order to learn to perform complex tasks, students should practise coordinated performance of the parts in different combinations as dictated by the varying demands of clinical practice. The key concept is that (re-)integration and coordination of the parts of complex skills is a process that is non-trivial and needs attention and repeated practice if true competence is to be attained. In summary, it is of the essence that the process of integration and coordination of the constituent parts of complex tasks is repeated time and again in a process of deliberate practice (Ericsson, 2004). Not only does competence learning require that subject material is organized in a different manner, it also requires different learning processes from the ones we are familiar with. That is the fundamental difference between the traditional, stacking model and the integrative model advocated in this paper.

Whole Task Practice approach

The core issue in Whole Task Practice is: 'How does a student master a professional competence?' Whole Task Practice does not start from a blueprint consisting of different subjects or themes (building blocks), but from the complex task as a whole and how the constituent skills and their interconnections are arranged within this task. This is called a skill hierarchy. All the important constituent skills that might be included in the behaviour of an expert who is performing the task in question are given their appropriate place in the hierarchy. From the outset of their education, students learn by performing meaningful, authentic tasks in situations resembling professional practice. Situations are offered integrally (whole task) in the form of assignments, cases, tasks, problems or projects. One context is used for the acquisition of a network of knowledge, skills and attitudes needed to perform a certain task. History-taking, physical examination, knowledge of pathology and communication skills in the patient encounter are viewed as an integrated whole. The educational programme is composed of a multitude of different learning tasks, each requiring students to combine and coordinate all the task aspects involved. The learning tasks are classified from simple to complex. There are no separate parts that can be 'summed': the whole is always more than the sum of the constituent parts. Basically, the curriculum consists of a sequence of learning tasks, which converge in one stream or integrated learning trajectory. All other educational components are derived from this programmatic backbone.

How is this to be achieved?

The Whole Task Practice approach provides guidelines, suggestions and advice on how to design a competence-based educational programme. The 4C/ID model is not a new educational model or a new method. What the model furnishes is an approach aimed at enhancing the development of expertise. The 4C/ID model offers a blueprint for educational design. It consists of the following four components: Learning tasks, Supportive information, 'Just-in-time information (JIT)' and Part-task practice.

The learning tasks form the core of the 4C/ID approach. From the start of their education students learn by performing authentic tasks, presented in their entirety, which are nevertheless not too difficult. A common reaction to the idea that students should be offered whole tasks (learning tasks) is: 'Whole tasks are far too difficult and complex; students should first have a firm grounding in the basics; they don't know anything yet!' This comment is based on the presupposition that students need to lay a firm foundation of theoretical knowledge before they can be allowed to perform real tasks. The sequence 'first thinking then doing' is not a prerequisite for a good educational programme, however. There is no hard evidence that students learn to perform complex tasks more effectively when they are not allowed to perform these tasks until they have demonstrated mastery of all the separate facts and rules. On the contrary, there is evidence that the reverse is true: facts and rules are learned more easily in a dynamic cognitive context in which students actually need to learn the facts and rules so as to be able to perform meaningful actions (Regehr & Norman, 1996). Working with integrated, whole tasks in real or simulated task environments is also expected to facilitate 'transfer' of learning (Maran & Glavin, 2003), which means that students are able to apply what they have learned with flexibility and in different authentic situations. We will now go into some of the details of the different components of the 4C/ID model.

Component 1: Learning tasks

The learning tasks are the backbone of the educational programme. Working on learning tasks, students amass concrete experiences that enable them to construct and automate cognitive schemas. However, we should realize that not every authentic situation offers suitable material for an effective learning task. Students need support and structure in the learning tasks they are offered. Without support and structure, meaningful results are hard to achieve and motivation is likely to suffer. Teachers should be mindful of some essential factors in learning tasks. We will illustrate this

Table 1. Example of a sequence of task classes—from simple to complex—for the complex skill of 'encounter with a patient with back pain'.

	Task Class 1	Task Class 2	Task Class 3
Presenting complaints	Clear, largely standard	Less clear	Vague
Availability of information	Readily available, easy	Less readily available, incomplete	Difficult to obtain
Patient's demands	Low	Realistic	High
Available time	No limit	Limited	Extremely limited

by a description of the task: 'a complete consultation with a patient with back pain'.

The consultation must be arranged in a sequence *'from simple to complex'*. The problem that faces educators in placing tasks in order of increasing complexity is how to simplify an authentic practice situation without sacrificing 'authenticity'. In order to resolve this, factors should be identified that determine whether practice situations are more simple or more complex. The best way to go about this is to consult experts in the workplace. The complexity of the consultation may depend on (a) the patient's complaints (ranging from a straightforward, more or less standard complaint to very vague symptoms), (b) availability of information from examination, tests and documentation (readily available or hard to come by), (c) demands made by the patient (undemanding or very demanding) and (d) the amount of time available. The first class of tasks, that is, a category of tasks with a particular degree of difficulty, may consist of learning tasks that involve only straightforward consultations with simple, clear complaints, information that is easy to obtain (recurrent tests like Lasègue's sign), patients with reasonable demands and no time pressure. The classes of tasks listed in Table 1 contain situations that are progressively less simple and straightforward and the last class consists of situations that are highly unusual or uncertain and in which GPs know that errors can easily occur.

Second, students must be offered several different learning tasks within each class of tasks. Tasks in one class are equally difficult and require the same basic knowledge, but within these constraints they may differ on all the dimensions that can also vary in real practice. The back problem may essentially be the same, but patients can differ in age, in (standard) presenting complaint and in gait. The student then has to find different explanations, which have to be tested using different standard tests in order to arrive at the correct diagnosis and management strategy. A *variety of different combinations* should be offered. Practising with a combination only once or twice will not yield results, for it is variety that facilitates transfer (Paas & van Merriënboer, 1994; Quilici & Mayer, 1996). Third, programme designers should take account of students' existing knowledge. For the first tasks within a certain class, students are given extensive guidance but when they have come to the final task they are expected to be able to perform the task independently without any guidance (Van Merriënboer, *et al.*, 2003). Guidance is gradually reduced as students progress through a task class. Most teachers automatically decrease the amount of guidance as students progress in their learning. In the 4C/ID model, however, the *decrease in the amount of guidance is explicitly incorporated* into the structure of the programme. For instance, the first learning task in class 2 may consist of a 'modelling example' of a GP consultation of a patient with back pain. The complaint is more complex than those in task class 1 (see Table 1). The GP gives detailed comments on all the steps in the consultation. This type of guidance enables students to study concrete solutions and ways of dealing with certain situations and to identify and master the relevant characteristics of those situations. In the next learning task students may be asked to use guidelines that direct the course of action. And in yet another learning task students may be confronted with the problem in reverse order, i.e. students are presented with the GP's advice and students are required to work out for which complaints and symptoms this advice is appropriate. Working backward from advice to symptoms is easier for students than working from symptoms to advice. Nevertheless, it helps them to master the task. The final learning task offers no inbuilt guidance and presents an authentic patient problem. In fact, the last learning task in a task class is the final test of students' competence (performance assessment). Students who have demonstrated adequate competence are allowed to proceed to the next class of learning tasks. It should be noted that the test at the end of a task class is not the final test on a particular subject for students. The tasks in this class will return in subsequent, more complex, task classes. Students do not work through themes or parts consecutively, in the way that they do in the stacking model.

Component 2: Supportive information

Supportive information is knowledge that may be helpful for students in working on non-recurrent, problem-solving and reasoning aspects of learning tasks. When working on a task, students may need information that explains why the patient is in pain or shows a particular gait. This information resembles the 'theory' in educational programmes where students are expected to learn theory before they are asked to apply it in practice. Supportive information comes in two forms: descriptive models of how the knowledge domain is organized, for example form and function of systems in the human body, and prescriptive models relating to how to tackle problems in the domain, e.g. a systematic approach to diagnosis. Students can find this information in readers, textbooks, lectures, videotapes and multimedia resources.

Component 3: Just-in-time information

This refers to any information that is needed to learn and perform recurrent aspects of a learning task. Suppose a student is working on a learning task and decides to test the range of motion of the lower back or use Lasègue's sign. In order to proceed with the task, students need immediate information on how to perform those tests. This is Just-in-time information (JIT). Preferably, this information is offered at the very moment a student needs to use it. It makes no educational sense to offer such information—for instance the protocol for performing Lasègue's sign—in advance in a lecture.

Component 4: Part-task practice

Part-task practice involves certain recurrent aspects of complex tasks that students who have successfully completed the educational programme must be able to perform automatically. Educational designers may think that learning tasks alone do not afford students sufficient opportunity to build up the required degree of routine, for instance in the examination of the back. In that case, students should have additional opportunities for practising a certain skill. The important thing is that this type of practice should not precede the learning task of which it is an integral part, for only if practice is firmly embedded in the task will students understand how a particular aspect fits within the whole of the task. Thus, whilst traditional educational approaches have students progress from separate components of tasks to whole tasks, the 4C/ID model always *starts* with—initially simple versions of—whole tasks and only uses components of tasks for building up automated routines for selected recurrent aspects of whole tasks.

Conclusion

With this paper we wanted to show that the traditional approach to competence-based learning, i.e. the approach based on separate building blocks, is not the preferred approach to educational design, because it does not take sufficient account of integration and coordination of all the skills that constitute a competence. The building-block approach obscures the clear overview that students should have of whole tasks and hampers effective transfer of what has been learned to the varying situations students will face in professional practice. We have described the 4C/ID model and illustrated it with concrete examples. The 4C/ID model should not be seen as a new, ready-made educational model or a new educational method (Merill, 2002). The learning tasks of the model can be incorporated into different educational models, such as thematic education, project learning, case-based learning, problem-based learning (PBL), etc. Not every guideline of the model will be applicable in every context. Rather the model offers directions for improvement in any educational situation or setting. Educational teams do not have to adopt all the aspects of the model. Using parts of the model may suffice for improving educational programmes. It will be evident that this paper does not offer sufficient information to satisfy readers who would like to try and use the 4C/ID model to design their own courses. To those who want to take up the challenge offered by the model, we would recommend two articles, one by Van Merriënboer, Clark & De Croock (2002) and one by Van Merriënboer & De Croock (2002).

Notes on contributors

AMEIKE M.B. JANSSEN-NOORDMAN, MSc, is an educational consultant, Expert Centre for Active Learning (ECAL), Department of Educational Development and Research, University Maastricht.

JEROEN J.G. VAN MERRIËNBOER, PhD, is a professor of Educational Technology, Educational Technology Expertise Center (OTEC), Open University of the Netherlands.

CEES P.M. VAN DER VLEUTEN, PhD, is a professor and Chair of the Department of Educational Development and Research, University Maastricht.

ALBERT J. J. A. SCHERPBIER, MD PhD, is a Professor of Quality Advancement in Medical Education and Scientific Director of the Institute for Medical Education, Faculty of Medicine, University Maastricht, the Netherlands.

References

CLARK, R.E. & ESTES, F. (1999) The development of authentic educational technologies, *Educational Technology*, 39(2), pp. 5–16.

ERICSSON, K.A. (2004) Deliberate practice and the acquisition and maintenance of expert performance in medicine and related domains, *Academic Medicine*, 79(10), pp. S70–S81.

GICK, M. & HOLYOAK, K.J. (1983) Schema induction and analogical transfer, *Cognitive Psychology*, 15, pp. 1–38.

HARDEN, R.M. (2002) Learning outcomes and instructional objectives: is there a difference? *Medical Teacher*, 24(2), pp. 151–155.

HARDEN, R.M., CROSBY, J.R., DAVIS, M.H. & FRIEDMAN, M. (1999) AMEE Guide no. 14: Outcome-based education: Part 5—From competency to meta-competency: a model for the specification of learning outcomes, *Medical Teacher*, 21(6), pp. 546–552.

HARDEN, R.M., SOWDEN, S. & DUNN, W.R. (1984) Educational strategies in curriculum development: the SPICES model, *Medical Education*, 18(4), pp. 284–297.

HOOGVELD, A.W.M., PAAS, F., JOCHEMS, W.M.G & VAN MERRIËNBOER, J.J.G. (2002) Exploring teachers' instructional design practices: implications for improving teacher training, *Instructional Science*, 30, pp. 291–305.

JONES, R., HIGGS, R., DE ANGELIS, C. & PRIDEAUX, D. (2001) Changing face of medical curricula, *Lancet*, 357, pp. 699–703.

MARAN, N. J. & GLAVIN, R. J. (2003) Low- to high-fidelity simulation: a continuum of medical education? *Medical Education*, 37(1), pp. 22–28.

MERILL, M.D. (2002) A pebble-in-the-pond model for instructional design, *Performance Improvement*, 41(7), pp. 39–44.

PAAS, F.G.W.C. & VAN MERRIËNBOER, J.J.G. (1994) Variability of worked examples and transfer of geometrical problem solving skills: a cognitive load approach, *Journal of Educational Psychology*, 86, pp. 122–133.

PEROTTI, V.S., GUNN, P.C., DAY, J.C. & COOMBS, G. (1998) Business 20/20: Ohio University's Integrated Business Core, in: R.G. MILTER, E. J. STINSON & W.H. GIJSELAERS (Eds) *Educational Innovation in Economics and Business III: Innovative Practices in Business Education* (Boston, Kluwer).

PRINCE, K.J.A.H., VAN DE WIEL, M.W.J., SCHERPBIER, A.J.J.A., VAN DER VLEUTEN, C.P.M. & BOSHUIZEN, H.P.A. (2000) A qualitative analysis of the transition from theory to practice in undergraduate training in a PBL-medical school, *Advances in Health Sciences Education*, 5, pp. 105–116.

QUILICI, J.L. & MAYER, R.E. (1996) Role of examples in how students learn to categorize statistics word problems, *Journal of Educational Psychology*, 88(1), pp. 144–161.

REGEHR, G. & NORMAN, G.R. (1996) Issues in cognitive psychology: implications for professional education, *Academic Medicine*, 71(9), pp. 988–1001.

Van Merriënboer, J.J.G. (1997) *Training Complex Cognitive Skills: a Four Component Instructional Design Model for Technical Training* (Englewood Cliffs, NJ, Educational Technology Publications).

van Merriënboer, J.J.G. & de Croock, M.B.M. (2002) Performance based ISD: 10 steps to complex learning, *Performance Improvement*, 41(7), pp. 33–38.

van Merriënboer, J.J.G., Clark, R.E. & De Croock, M.B.M. (2002) Blueprints for complex learning: the 4 C/ID-Model, *Educational Technology Research and Development*, 50(2), pp. 39–64.

Van Merriënboer, J.J.G., Kirschner, P.A. & Kester, M. L. (2003) Taking the load off a learner's mind: instructional design for complex learning, *Educational Psychologist*, 38, pp. 5–13.