Expertise development:
The transition between school and work

Inaugural Address

Expertise development: How to bridge the gap between school and work

Henny P.A. Boshuizen, Open Universiteit Nederland

Conference

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To ‘my’ MHPE students,
lifelong learners par excellence
and great gap-bridgers.

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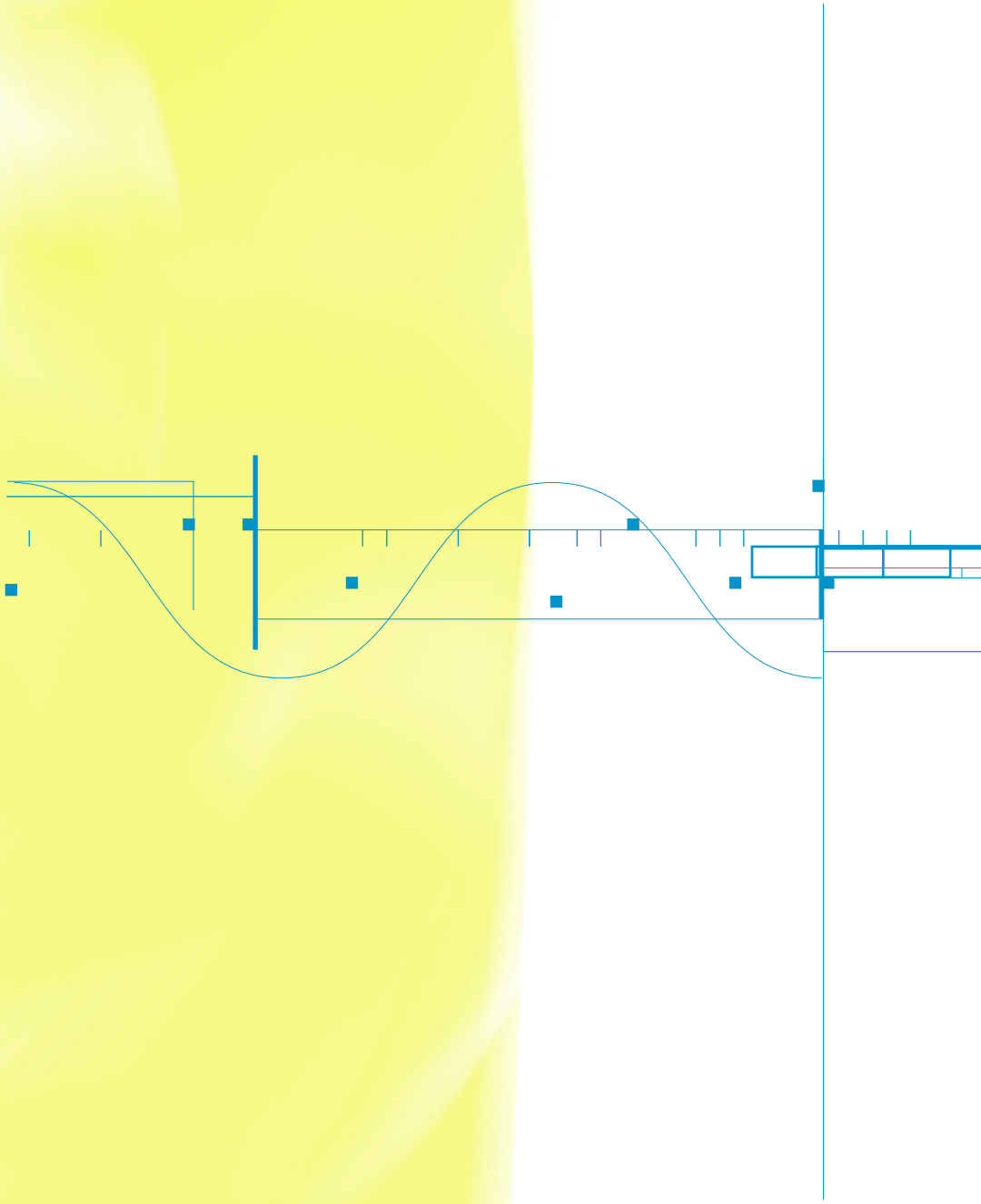

Expertise development: How to bridge the gap between school and work

Inaugural Address

spoken upon the public acceptance of
the professorship in Educational Technology,
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on Friday, January 31, 2003

by prof. dr. H.P.A. Boshuizen

Expertise development: How to bridge the gap between school and work

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Dear rector and other members of the Executive Board,
Colleagues and invited guests,
Family and friends,
Ladies and gentlemen,

Expertise and experts: what is that, and what kind of people are we talking about? Are the people who are asked for comments on the news and who we can see on television daily experts? What about the specialists who assess and evaluate objects of art in programme like Antiques Roadshow, are they experts?[1] Or is it better to stay closer to everyday life and ask the same question about the educational designer, the plumber or the doctor?

Years ago (Boshuizen, 1989), when I wrote the introduction to my doctoral thesis, I asked a rather select group of colleagues, friends and acquaintances the same question. They told me the following: an expert is someone who is very talented in a specific domain, has a lot of experience, has a very extensive repertoire of knowledge but also knows his or her limits, has good or even excellent skills in his or her domain, delivers quality work and quickly and purposefully finds a solution to a problem or designs and delivers a product that meets the requirements. Another aspect of experts is that they have spent thousands of hours developing these skills; they have acquired only some of them in formal education, and the rest through self-directed learning in other environments and by deliberately practising[2], sometimes starting at a very young age in the case of computer skills, sports and art, but also in the case of history, biology or science. More recently the discussion of expertise has extended to topics such as the ability to develop professionally, the flexibility to remain on top even in a changing environment, and to social recognition (being recognised as an expert by superiors, colleagues within the same or in other professions, and/or the clientele, Van der Heijden 1998).

I am not sure whether it is a typically Dutch characteristic to have an ambivalent attitude toward expertise and experience. On the one hand, expertise is very much valued; on the other, it is very difficult to judge someone's expertise. The very nature of expertise implies that those who are able to judge the quality of experts' work probably don't need them, whereas those who need them most cannot evaluate it (Brown & Duguid, 2000). Things get even more complicated when we are dealing with a very

dynamic field like computer sciences or financial estate management, and when the field the expert is involved in directly influences our health or well-being. To make this horror story complete, Weggeman (2000) claims that there is a natural process of development among professionals in business in which an 'over the top' stage can be discerned. Professionals in this stage work on the basis of routine, no longer incorporating new developments in their work. These professionals have standard solutions that may no longer match the new problems surfacing in society, or that do not conform to recent insights in the field[3]. It is not surprising that people sometimes prefer newcomers who have just graduated, because they 'know all the latest insights and standards and have everything fresh in their memory'. The latter sentence encapsulates everything I want to deal with here this afternoon. It can be broken down into the following elements:

- Expertise and its development
- The transition from school, college or university to work and the problems that may accompany this transition
- How learning in school, college or university may affect expertise development
- How experience and learning in practice affect expertise development
- And opportunities and threats in this process from the perspective of learning and education.

These are the topics we are going to deal with for the rest of the time available.

Expertise and its development

We expect experts to be better in their domain than novices and laypeople. Is that indeed the case? I will give you a couple of examples of research revealing different outcomes.

The first is a very recent study by Jos Arts and colleagues in Maastricht that has not yet been published (Arts, Gijselaers & Boshuizen, in preparation). A total of 115 (!) subjects participated, representing nine different levels of expertise ranging from younger novices to older experts in business administration with more than 25 years of experience. They analysed a business case and one of the measures derived from these analyses was the quality of the solution. Except for a delay around the time of the transition from education to work, we found a continuous improvement in performance over the whole period of thirty years encompassed by the results. More detailed analysis also showed that the number of mistakes decreased and that particularly during formal education, the number of partially correct solutions increased, mostly because students could not adapt their solutions to suit the context of the case. Only after graduation did the number of partially correct solutions decrease.

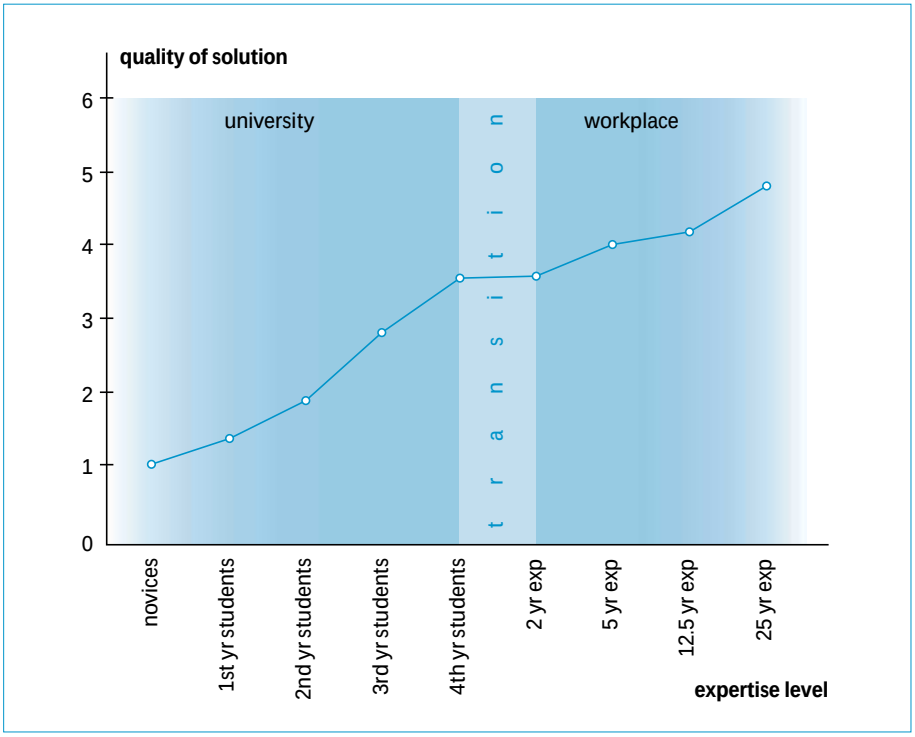

Figure 1 Quality of the solutions of a management case by students and experts in the domain. Derived from Arts et al. (in preparation)

Another example is from research done by Hofstra and Hobus et al. in 1988. This study involved family physicians who had between three and thirty years experience. These physicians saw 18 incomplete cases and were asked to give the most likely diagnostic hypothesis. Here again, we see a continuous improvement in performance.
However, there are also studies that show a less rosy picture. For instance, Krol, De Bruyn and Van den Bercken (1992) compared students and experts in the classification of dysfunctional behaviour in children. They did not find any significant differences between the groups. They even questioned whether one could speak of expertise, since the classification structures of some so-called experts' could not stand up to comparison with epidemiological findings (Krol, 1992).
Finally, again in the domain of family medicine, Yvonne van Leeuwen (1995) compared students, interns and experts (the most experienced had been in practice more than 20 years). She used a more conventional knowledge test and found that the state-of the-art knowledge of the diagnosis and treatment of conditions and diseases was at its best

at the time students graduated as family physicians. The more experienced the physician, the lower his or her score.

What can be concluded from this? For now I will go no further than to say that in some domains and on some measures we see that more experienced people perform better than less experienced ones and than those still in training. However, in other cases we see that recent graduates perform better. Why that should be so is a question I will return to later. First I want to look more closely at a couple of related factors .

From novice to expert

Let me start with the following claim, which is not a very surprising one given the amount of evidence supporting it and the length of time this evidence has been around. The claim is that, in medicine at least but probably in the many other diagnostic professions, differences between experts and novices cannot be explained by differences in reasoning (see Elstein, Shulman & Sprafka, 1978; in the domain of accountancy, Bédart, 1989, is a good example). Everyone, novice and expert alike, generates hypotheses in diagnostic reasoning and tests these hypotheses by gathering discriminatory information that either confirms or denies them[4]. Despite the overwhelming evidence it is important to bear this in mind, since many educators in medicine see students' problems in clinical reasoning as a lack of general skill, as a lack of proper training in this area, or as a competence that students have not yet mastered completely. Contrary to this view, I claim that building up domain knowledge, in combination with learning the required skills, is the key (see Boshuizen & Schmidt, 1992; Schmidt et al., 1990, 1992; Schmidt & Boshuizen, 1992). In this sense, acquiring medical expertise is no different a process than acquiring expertise in other, non-diagnostic domains (e.g., in chess: De Groot, 1965; engineering: Ackermann & Barbichon, 1963; statistics: Allwood & Montgomery, 1981, 1982; mathematics: Bloom & Broder, 1950; physics: Chi et al., 1981). I therefore use the novice-to-expert learning process in medicine as a prototype in order to derive hypotheses for other domains.

Medical knowledge consists of thousands of concepts, principles, rules, skills, procedures, patterns and so on that are not learned for their own sake, but with the aim of diagnosing and treating sick people. It is therefore necessary for this knowledge to be organised in a way that it can be verified, easily activated in relevant contexts, easily applied in reasoning, et cetera. There are a couple of learning processes that guarantee that this goal is reached. One of these consists of knowledge accretion, validation and integration, a process that takes much more time than teachers might expect. The integration and integrated use of knowledge from different domains (e.g., biochemistry, pathophysiology or microanatomy integrated with the clinical sciences) are particularly tricky (see Boshuizen & Van de Wiel, 1998; Groothuis, Boshuizen, & Talmon, 1998). This kind of learning takes place mostly in the first years of training, when the student's

clinical reasoning process is characterised by lines of reasoning consisting of chains of small steps commonly based on detailed, biomedical concepts, sometimes supported by notes and sketches. These kinds of exercises result in a well-integrated, validated knowledge network.

Once the student has acquired these well-integrated networks, he or she can make direct lines of reasoning between different concepts. The more often these direct lines are activated, the more the concepts they include cluster together and the more student is able to make direct links between the first and last concepts while skipping the intermediate ones. This is the second learning process we have discerned. We labelled this process 'knowledge encapsulation', a term that refers to the clustering aspect of the process and accounts for the automation involved (e.g., Boshuizen & Schmidt, 1992; Schmidt & Boshuizen, 1993; Margje van de Wiel's PhD thesis was devoted to this topic, 1997). As a result of this encapsulation process, the level of granularity in clinical reasoning protocols increases and such supporting tools as sketches are no longer necessary. A new type of clinical or semi-clinical concept appears in the protocols, such as micro-embolism, aorta-insufficiency, forward failure, or extra-hepatic icterus, providing a powerful reasoning tool.

The third learning process is illness-script formation. Scripts are based on experience. They are knowledge structures that describe stereotyped sequences of action (Schank & Abelson, 1977). The archetype of a memory script is the restaurant script, which describes the procedure of eating in a restaurant, the roles of the different participants and their actions, the objects involved, et cetera. Scripts also indicate where variations are allowed and what is really necessary. The restaurant script requires that food is served and that the guests pay for it. Scripts can form families with a common structure but with different combinations of variables, such as fast-food restaurant, Chinese take-away, sushi bar, and so on. Likewise, illness scripts describe the process of contracting a disease: the conditions or constraints under which a disease occurs (the Enabling Conditions), the pathophysiological process that takes place (the Fault, represented in encapsulated form) and the signs and symptoms caused by a specific disease (the Consequences). Illness scripts also include the course a disease may take and the kind of action required to cure it. Physicians have scripts similar to restaurant scripts for all the disease and patient types they commonly see in their practice (also see Feltovich & Barrows, 1984, who introduced this theoretical notion).

There is a big difference between clinical reasoning based on networks of concepts and clinical reasoning based on illness scripts. Network-based reasoning is done step by step. In the case of encapsulated networks, these may be big steps, but they are still taken one at a time. Illness scripts, on the other hand, are activated as a whole. Once an illness script has been activated, the other elements of the script are also activated, immediately and automatically. People whose knowledge is organised in illness scripts

therefore have an advantage over those who have only semantic networks at their disposal. While solving a problem, a physician activates one or a few illness scripts. The illness script elements (Enabling Conditions and Consequences) are subsequently matched to the information provided by the patient. Not only do illness scripts incorporate matching information volunteered by the patient, they also generate expectations about other signs and symptoms the patient might have. Hence, activated illness scripts provide a list of phenomena to look for when taking the patient's history and during his or her physical examination. In the course of this verification process the script is further instantiated, i.e. expected values are substituted by real findings, while scripts that fail in this respect are de-activated. The fully instantiated script yields a diagnosis or a differential diagnosis when only a few competing scripts remain active. For the sake of completeness we must add a fourth learning process. Diagnosing and treating patients leaves traces in the memory. These traces can be used later and function as a shortcut to activate relevant knowledge (Kolodner, 1993).
These changes in the organisation of knowledge not only bring about changes in the appearance of clinical reasoning but also in the amount of control required and, hence, in the demands made on cognitive capacity (see Table 1)[5]. I will not go into further detail at this point, but will return to this idea in my discussion of the implications for education and research.

Table 1 Knowledge structure, learning and cognitive demand in problem-solving at subsequent stage of expertise development

Expertise level	Knowledge structure	Learning	Problem solving	Control required in clinical reasoning	Demand on cognitive capacity
novice	networks (incomplete and loosely linked)	knowledge accretion, integration and validation	long chains of detailed reasoning steps through networks	active monitoring of each reasoning step	high
intermediate	networks (closely linked)	encapsulation	reasoning through encapsulated network	active monitoring of each reasoning step	medium
expert	illness scripts	illness script formation	illness script activation and instantiation	monitoring of the level of script instantiation	low
	memory traces	instantiated scripts	automatic reminding	check relevance	low

Place and source for learning

The knowledge and skills we are talking about are partly built up within the context of formal education and partly later, in actual practice , when one works independently or under supervision. At which point in time this transition should take place can be the subject of serious dispute.

It is often thought that, ideally, graduates should only enter the labour market as a 'finished product', as someone who is ready for work and who can function independently from day one. This opinion is the logical end result of a trend that started in the Netherlands in the 19th century and that made labour and education increasingly separate and independent. Education and training could no longer take place on the job due to several processes: the introduction of new techniques required knowledge that could no longer be learned at work; precious materials and expensive, complex and heavy machinery increased the risk of accidents, so that new workers had better build up skills first before they were allowed to operate or even come near this equipment; rationalisation of labour processes interfered with supervision of apprentices; and a long period of schooling and training raised the status of a profession or vocation (De Vries, 1992). There is another view, however, which is that young adults or adolescents should start working and be economically productive as early as possible. Though very outspoken, this view does not tell us where one best learns specific content and skills. Instead it seems to be the product of economic circumstances, industrial development and a general perception of man and society.[6]

Although the topic of this address is expertise development, I want to take you on a short excursion to the economics of education and the labour market to show that changes in the economic climate have an impact on educational strategies and the choice of place and time best suited to learning a specific competence. The central issue in this economic debate is the question of the shelf life of knowledge or its half-life, as it is often called. Neither term refers to the normal decay of knowledge and memory ('forgetting' in the vocabulary of psychology and everyday life or 'technical skills obsolescence' in terms of labour market economy, De Grip and Van Loo, 2001). What is meant is that technical and scientific knowledge and standards develop so rapidly that, depending on the field, someone's body of knowledge can become obsolete within only a couple of years. Den Hertog and Huizenga (1997), for example, claimed that over a period of ten years the half-life of knowledge in the field of engineering was reduced from ten years to five. This means that half of the knowledge of an engineer who graduated five years ago is probably now outdated. According to Weggeman (2000), two factors have contributed to this shorter life cycle: the tremendous advances in several fields[7] and the enlargement of our environment from local to global. The latter is leading to a sort of absolute benchmarking affecting the way businesses as well as professionals work and are evaluated. Physicians, for instance,

are increasingly confronted with clients (especially patients with a chronic disease) who are very well informed about the most recent breakthroughs in diagnosis and treatment in countries as far away as Canada, Brazil, India or Australia.
The preferred educational strategy to prepare people for work in such a field will depend largely on its pace of development. In fields with a knowledge half-life that is virtually eternal, a 15-year course of study does not give rise to any problems in terms of the practical usefulness of the knowledge acquired in education. How different is the case of a student of information science. This field sees a paradigm shift every ten years. Such dramatic changes have two implications for the training of software engineers. One is that students should not be kept in schools or universities so long that by the end of training the content and principles learned in the first years of study have become completely outdated. The other is that the students must learn how to handle these paradigm shifts: which principles remain, which move to the background, and how to integrate new developments with existing skills and knowledge.
Not only can discipline knowledge develop at an unexpectedly rapid pace, but society itself is also susceptible to change, and so are the boundary conditions that must be observed when applying the skills and competencies that someone may still be acquiring. In addition to national and global economic and technological trends, the ageing population and the expansion of the EU will have a major impact on society in the near future.
In domains and disciplines undergoing rapid development, the question as to whether a graduate must be 'ready' for the labour market, or a 'finished product', is irrelevant; instead the question should be whether a student has enough stock-in-trade to get a job and start working as an apprentice or as a young professional and – possibly– continue to develop his or her competencies at the same time, either with the help of a coach or supervisor or independently, not only during the first few years after entering the labour market, but for the rest of his or her professional life. If we also give credence to the idea that few communities and societies can afford to exempt their young generations from being economically productive[8] (e.g., in order to study something exotic for 15 years like old Assyrian), then it will be evident that the wish to deliver or receive a 'finished product' is unrealistic in most cases, if not undesirable. And if learning should take place at least partly in practice (which is my claim), we must take care that the conditions for learning are optimal.

The transition from school to work

In our present society, pupils and students are exempted from work. In this period of their lives, which they spend in schools or other educational institutions, they have the opportunity to learn large amounts of knowledge and skills without that learning process being embedded in work. However, the result must be such that they are

capable of applying the knowledge and skills they learn flexibly and adequately. Students and recent graduates are expected to master their skills and knowledge to such an extent that they know when to use them and when not. They should be able to recognise application conditions, and to flexibly apply their knowledge and skills by adapting them to the characteristics of a specific situation. Examples of this adaptive use of knowledge can be found everywhere: children of a certain age should be vaccinated against several infectious diseases, but not if they have a condition that increases the risk of their suffering side-effects beyond the risk of their catching the disease; reasonable wishes of a client should always be satisfied, but not if that brings one in conflict with other clients or tasks; et cetera. This adaptation sounds easy, but it is left to the student to decide which of the two applies, the rule or the exception. However, at the point of transition from school to work this is not the 'only' thing. The students should also be ready for further professional and self-development. For instance, the software engineer who graduated five years ago must have remained up to date by learning java and must also be prepared for the next paradigm shift and be capable of adapting to completely new concepts and technologies.

How does one go about doing that? Are such attempts successful? I have to say that this transition is an uphill battle. Even those who indicate that they were looking forward to leaving their student days behind them agree that the transition from school to work is a hard one. What kind of problems do they face? To answer that question, I will restrict myself to the findings of research I was myself involved in during my previous job at Maastricht University.

The first project is one in which I found an unexplained dip in the development of students (Boshuizen, 1996; in preparation). It was the most extensive study of its kind ever conducted and the only study that zoomed in on the moment of transition from pre-clinical education in medicine to clinical education. The phenomenon I was interested in was an earlier finding by Henk Schmidt and myself that fifth-year medical students (i.e. shortly after they have entered their clinical clerkships) applied hardly any biomedical knowledge during clinical reasoning, but that the biomedical knowledge they used in their post hoc explanations did not show a corresponding dip. The knowledge was therefore accessible and they could have used it afterward, but they did not apply it during clinical reasoning. Other observations suggested that the biomedical and clinical knowledge bases were not yet integrated (Boshuizen & Schmidt, 1992). Subjects in the 1996 study were fourth- fifth- and sixth-year medical students. A reference group of a sample of experienced physicians (gynaecologists) was also included. Subjects were asked to diagnose two paper cases while thinking aloud.[9] What I found was a profound dip in the performances of the fifth-year students in virtually every aspect measured: in the extent of the protocol, in number of knowledge

application propositions in the protocols, in the number of biomedical concepts used and in the auxiliary lines of reasoning. The only measure that did not show a clear drop was the accuracy of the diagnosis, but that did not significantly improve either during the same period, a finding similar to the plateau revealed by Arts et al. (in preparation). Given the large number of participants in the study and the combination of cross sectional and longitudinal comparisons, it seems unlikely that student selection can explain this phenomenon.

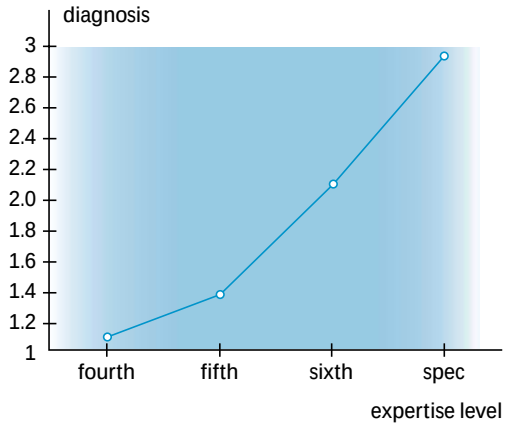

Figure 2 Diagnostic accuracy of subjects of four expertise levels. Derived from Boshuizen (1996)

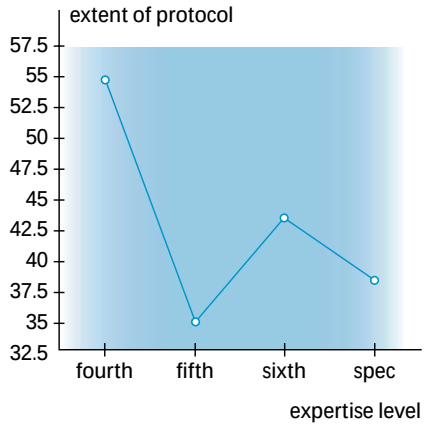

Figure 3 Extent of the protocols (number of utterances) generated by subjects of four levels of expertise. Derived from Boshuizen (1996)

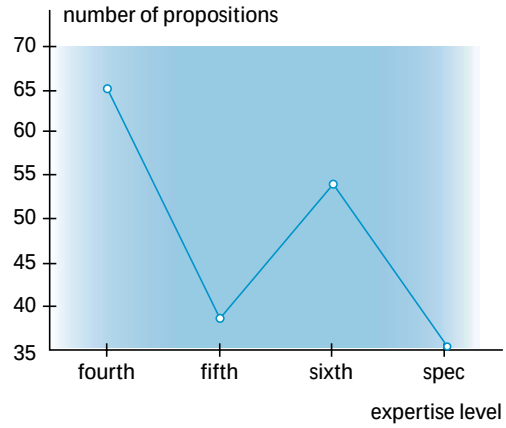

Figure 4 Number of knowledge application propositions. Derived from Boshuizen (1996)

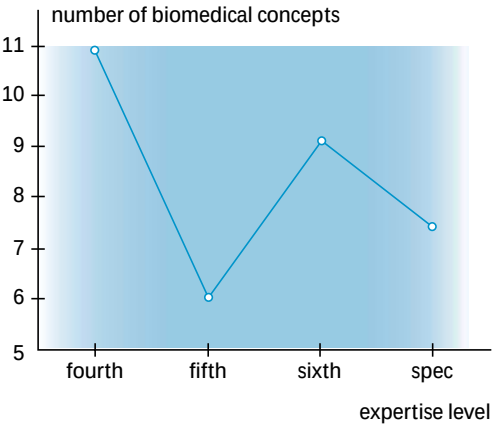

Figure 5 Number of biomedical concepts. Derived from Boshuizen (1996)

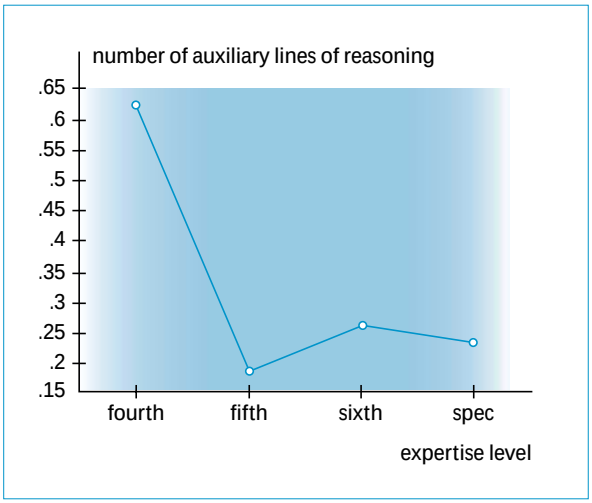

Figure 6 Number of auxiliary lines of reasoning. Derived from Boshuizen (1996)

Another phenomenon was found by Prince et al. (2000). They did a focus-group study with medical students at the start of their fifth year, soon after they had begun their clinical training. This study showed that the students were quite confident about their clinical skills, but felt very insecure about how well they had mastered the biomedical basic sciences, especially anatomy and pharmacokinetics. These basic sciences form the scientific foundation and legitimisation of the applied clinical sciences (see Bouman & Snellen-Balendong, 1996). There is also, however, a strong claim that biomedical knowledge is needed to interpret complex cases appropriately (see, for instance, Feltovich & Barrows, 1984; Patel, Cytryn, Shortliffe, & Safran, 2000).[10] So the students' discomfort about their situation should not be slighted. Another thing the students observed was that in practice they had to think the-other-way-round from what they were used to in their Problem-Based Learning sessions; the strategy they were used to applying when dealing with a clinical case was to find the clue for the diagnosis (e.g., chest pain radiating to the chin or the arm → heart attack) and to reason back from this assumed diagnosis to the case findings to see whether they fit. In real life things turn out differently. Key findings can hardly ever be found and normally a hypothesis is based on a combination of findings that make one more probable than another. These students consequently felt a lack both in terms of available knowledge and clinical reasoning. This was not a long-term problem – the clerkships were meant to help them through this difficulty – but that was definitely not the case when it came to their knowledge of the basic sciences.

Finally, research by Agnes Wagenaar et al. (2001), carried out in co-operation with Master's students Kathelijne Dik and Crista van Oosterwijk, was another heroic attempt to find out which knowledge and skills are applied in diagnostic action. This time no paper cases were used, but a 'real' simulated patient, with the participants' task being to perform an intake on this patient, who had been referred to an ambulatory mental care setting by his GP. The 44 (!) participants varied in level of expertise (thirteen health sciences students prior to their practical internship, thirteen students during their internship, five who had recently graduated and were specialising as mental health care psychologists, and thirteen experienced therapists). The method used was video-stimulated recall, which entails that the student or therapist and the client first had a 30-minute intake interview immediately followed by a session in which the experimenter and the student or therapist viewed the video with the aim of making the therapist's thoughts during the interview explicit. Of course this procedure has many disadvantages, but it is the only way to acquire some insight into the therapists' dynamic use of knowledge, and that was what we wanted to unearth.
What did we find?

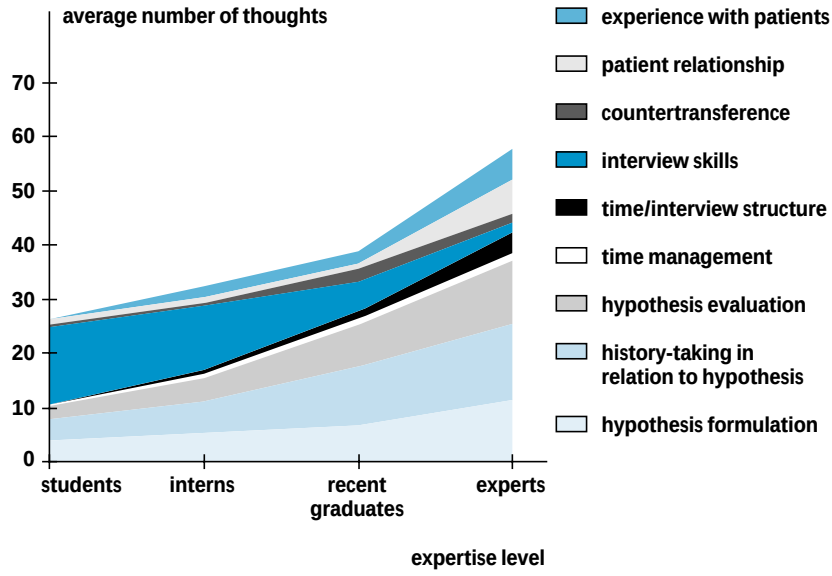

Figure 7 Thinking in action. Average numbers of thought spent on different topics in a video-stimulated post hoc protocol of an intake interview with a simulated patient. Derived from Dik, 2000

We found an increase in the number of thoughts reported by the therapists. The more experienced the therapist was, the more ideas crossed his or her mind. That was not the most interesting part of the story, however; far more interesting was what thoughts occupied them. More than half of the students' thoughts concerned the interviewing process itself: how to ask questions (open, non-leading questions for instance); in many cases they expressed some worries about their ability to handle the case. The experts' thoughts, on the other hand, mostly concerned hypothesis generation and evaluation; they were very aware of conducting the interview so as to collect the information necessary for that purpose efficiently.[11] As they did so, the experts were very conscious about building or at least enabling a good therapeutic relationship with the client, taking into account the hypotheses they had in mind.[12]

What we see here is that the students had a level of mastery in which their main interest was to conduct an interview that was technically okay. The interview lacked focus and structure, however, and like the medical students they failed to integrate the knowledge they had about relevant conditions into their clinical reasoning. The more experienced the subjects were, the more hypothesis-driven. Once they had graduated and were working as therapists, they developed the skill to monitor the interview in terms of relationship-building and process efficiency.

What can we conclude so far from these studies? Based on their outcomes, the image emerges of a graduate who has the relevant knowledge but perhaps not enough of it, in his or her own judgment; who feels s/he has adequate technical and social skills, but fails to integrate these skills in problem-solving, probably due to a lack of integration and contextualisation of knowledge (assuming that his or her knowledge is otherwise sufficient, which is probably not the case). When we combine that with the outcomes of the follow-up studies one year after graduation (Ramaekers, 2002)[13], we have to add a lack of leadership and management skills, communication skills (especially at the 'other' Dutch universities, but also at the UM), computer skills, and a lack of preparation when it comes to dealing with change. All this leads us to conclude that the gap between education and work is considerable.

Learning from practice

Concluding that there is a gap or a mismatch does not automatically imply that we have a real problem on our hands. Such a problem only emerges when students and graduates are unable to learn while in practice and from it, and when the environment in which they work does not offer a good and safe place for learning. In other words, there is a problem when students and graduates are not prepared for learning in a way that is very different from what they are used to[13] and when the working environment does not see them as trainees, but expects that they can function as full-fledged professionals.

The goals of a clerkship or internship may vary widely, depending on the field and the student's progress. Clerkships can have as a goal that students see in practice what cannot be learned from books (ranging from what patients, clients, buildings and business processes look like to how professionals work together and cultural issues in working environments) and practise skills that they are already supposed to have at a more rudimentary level. Some of these goals are very explicit and sometimes students are given all sorts of help and guidance to reach them. For example, at Salford Hospital, one of the teaching hospitals associated with the University of Manchester, students use a sign-up system that shows them which clinics, teaching, et cetera will be available for them in the coming week. Depending on the specific activity, they can perform simple procedures or observe. In combination with the intended learning goals made available at the beginning of the clerkship, students should be able to plan their learning experiences.[15] That may look straightforward, but it is not.

This brings us to a point with many unknowns. One of these unknowns is the role of and the optimal conditions for implicit learning, a way of 'unconscious' or at least undirected learning that happens as a by-product of action or experience.[16] The very nature of implicit learning makes it hard for learners or even teachers or coaches to plan. The only possibility is to offer or seek out opportunities. All an individual can do otherwise is try to make the best of it. This, however, requires students to at least understand what their experiences entail and what it is that they have come across. Better students know in advance what they might see and experience in an upcoming situation.[17] Without an interpretation frame and without preparation, students may completely overlook essential aspects of a situation they observe. For example, a student told us that he had been sitting in with a psychotherapist who had told him that his plan was to tell a client that it was about time to pick up the thread of her life again and get a job. The student had been rather sceptical about this plan and was very surprised that it worked out the way the expert had told him it would. Without knowing this plan in advance, the student might not have even known that something remarkable, at least by his own standards, had taken place before his eyes. Now he was aware that he had witnessed something very instructive, and afterward he was able to identify the critical elements that had contributed to this positive outcome. Having an interpretation frame (developed by the student him or herself or passed on by an expert) and planning and preparing for experiences contribute to learning results. The question is whether students do this routinely as a strategy for learning from experience.

Another strategy that is supposed to be effective in learning from experience is the action-reflection-action cycle that we find in many different forms in the work of such authors as Boud, Keogh, and Walker (1988), Korthagen (1992, 1999), Kolb (1984), and Schön (1987). These authors assume that reflecting on experiences plays a critical role in learning from these experiences. Reflection should lead to plans for new actions in which novel approaches and ways of dealing with problems can be tested. Again, the question is whether students do this.

A study undertaken by Wagenaar et al. (2002, in press) showed that students (again medical and health science students during their clerkships) thought that they learned mainly by doing, which is an implicit way of learning, and a little bit by observing or from preparation and reflection (see table 2). No student reported full cycles of action-reflection-action. Korthagen (1999) found similar results, i.e. that novice teachers display little continuity in their reflection-based learning process. This means that novice teachers may well come to conclusions about the good and less optimal aspects of their behaviour and problem solutions, but they then fail to draw conclusions on how these could be improved, never draw up concrete action plans for future situations or, if they do, don't implement these concrete plans. Korthagen also investigated barriers to reflection in beginning teachers, who evidently hold beliefs about learning that reflect the passive 'hand over' view of learning. In regular sessions with a coach, the subjects of the study frequently tried to tempt the coach to make statements about what is good and what is not, and how it should be changed, instead of reflecting on their own behaviour and generating possible alternatives.[18]

Table 2 Learning from experience; learning processes described by medical and health sciences students during a practical internship or research training

Learning process	MHS students research	MHS students practice	Medical students
Information processing			
– by seeing things in practice	–	4	5
– direct teaching	–	–	1
– actively overcoming gaps in knowledge and skills (SDL)	2	2	5
Performing tasks			
– learning by doing	18	23	20
– learning through preparation and evaluation	–	3	1
Total	20	32	32

So far we have only spoken about newcomers and their learning. However, learning is not expected exclusively from novices and intermediates in the field. To prevent skill obsolescence, every professional and every employee must remain up-to-date. Ilse van Eekelen investigated how experienced teachers learn, under which conditions, from whom and with whom, et cetera. She also investigated what and how much teachers learn, apart from implicit learning. She found four categories of teachers in her sample, varying in their will and ability to learn, with the same kind of behaviour, the same lack

of reflection and planning and the same inability to see the others' perspective as in the student sample, at least with respect to those whom she characterised as not-willing-to-learn (see Van Eekelen et al., in preparation).

To conclude this section on learning from experience, I would like to mention a couple of features of the workplace that can have a major impact on how fruitful actual practice is as a place for learning. The first feature relates to the learning strategy of preparation and trying out new action. The better one can predict and control situations, the easier it is to use this strategy. However, in many domains an experience does not consist of discrete episodes. An experience can be hard to prepare for in the way the student did who witnessed a client being helped back on her feet again. For newcomers in particular, many real-life tasks can be quite unpredictable. It is hard for them to see when and in combination with which other competencies a specific competence should be applied. In such situations deliberate action is the exception, not the rule. Teaching is a good example once again. Teachers have to apply multiple competencies simultaneously, depending on the emerging situation, for example teaching the subject matter, monitoring the students' understanding of it, monitoring and evaluating student behaviour and acting on it, taking the person of the student into consideration, and all this in real time. Eraut (2002) calls this a situation in which routines are punctuated by rapid decisions. Learning in these situations will require whole-task approaches to make sure that the student learns the conditions under which things can happen and the rhythm of the situation. Situations may be simplified (e.g., schools should not give the most difficult groups to newcomers), support and scaffolding may be offered, but the tasks cannot be reduced nor can the rapid decisions be practised and prepared for in isolation. Training isolated subtasks is only relevant for tasks that can be routinised independently (Van Merrienboer, 1997).

Finally, let's return to Krol's remark about 'expertise' in diagnosing dysfunctional behaviour in children. Supposed experts had knowledge structures that were a poor match with the epidemiology of the field. There can be many reasons for this. One of them might be that implicit learning is not an effective tool in this field. A professional may not see this kind of patient frequently enough or not be given feedback on the quality of the diagnosis or only after a very long delay. The bureaucracy of the field is a contributing factor. It would be very tempting to say more about this issue, but this is not the time or place to go into it at great length. I will therefore confine myself to saying that it is the task of professional or trade representative organisations, or of the government if these organisations do not or cannot take the responsibility, to guarantee the quality of the services provided.

How to bridge the gap

Let's summarise what we have so far. Expertise development goes through several stages in which three learning processes play a role: knowledge accretion, validation and integration, knowledge encapsulation and script formation. At the same time, the amount of cognitive control required in learning and problem-solving decreases. All processes are based on formal teaching and shaped by the tasks students perform. The more authentic these tasks are, the more the learning results fit the contexts and tasks of the field. Scripts are largely affected by the experiences the learner has.

Real work experiences and episodes are the most authentic tasks one can imagine. Learning from experience includes implicit learning. More advanced learning requires planning and preparing for an experience, which in turn requires that one can predict to a certain extent what is going to happen, and can reflect on the experience. This is how an extensive, integrated, flexible and adaptive body of knowledge is formed that allows pattern-based retrieval. This, and not excellent problem-solving skills, is the core of expertise. Learning from experience requires different, self-directed learning strategies than does learning from the official media and applying what has been learned in problems and exercises. It also requires an environment that provides feedback and a learner who can anticipate, generate and use that feedback to adapt his or her future performance and to learn.[19]

Certification must take place at some point along the road to expertise; it cannot be postponed till someone has reached the expert level. Neither can practical experience be postponed until after certification. The educational institution is responsible for the competencies for which the graduate is certified. These competencies include the tasks expected of a new professional, as well as the ability to develop further, especially under changing circumstances. Businesses, professional organisations and/or the government are responsible for an environment that provides all the elements required for further learning.

This state of affairs has several implications for the Open Universiteit Nederland. Some of these implications apply to all educational institutions, some are unique to the OUNL and are related to the kind of students catered for and the present concept of competency-based education delivered by means of distance teaching.

- The Open Universiteit offers its educational products by means of distance education. This implies that the choice of methods and media tips the balance between implicit and explicit teaching and learning towards the familiar explicit side: books, multimedia kits, explicit assignments are the main learning tools, used by the students at home and on their own. The more implicit methods such as modelling (especially the supported and guided forms), projects and academic

discussions and forums with experts are used less often, but when they are used the more asynchronous and place-independent methods areapplied. The introduction of CSCL tools can support these processes, and it seems even improve them (see Kirschner, Buckingham Shum & Carr, 2003).[20] On the other hand, what is lost on the implicit side should be reconsidered. As the OUNL is a distance education institution, implicit learning is not a major vehicle for learning. And yet, academic values, a sense of the direction in which new scientific advances are moving, the pros and cons, ethical issues, and imminent paradigm shifts are often picked up by students implicitly, by being around, sharing a lunch table, overhearing or participating in discussions after presentations, and so on. Where possible these elements should be brought back, for example by organising conferences with renowned experts on topics at the cutting edge of development, by fostering student-student contact, by teaming up more experienced students with less experienced ones, et cetera.

- The Open Universiteit caters for students who are on average more than ten years older than the students at 'normal' universities in the Netherlands and Flanders. Many of these students take courses or enrol in a complete course of study to improve their working and personal lives. Nevertheless, many of the students make slow progress compared with part-time students at a 'face-to-face' university. Most of them do all their studying in their 'own' time and take about twelve years to complete a programme that would normally take four years full-time. Adult students are more likely than younger students to demand that what they learn is directly relevant to the goal which they are studying to achieve.
- As an educational institution, the OUNL's first concern is the pre-certification part of the road to expertise, rather than post-graduate development in the workplace, although educational institutions should be very aware of what the workplace offers and requires (see Eraut, this volume). This pre-certification part entails levels of expertise appropriate for the novice and intermediate. At present there are four levels of course difficulty plus a thesis requirement representing a fifth level of difficulty linked to these expertise levels. Level of expertise and the related learning processes and required cognitive control are not accounted for in the design. More research is needed to develop design guidelines.
- Most programmes offered by the Open Universiteit prepare students for a scholarly profession or for other work that requires academic competence in environments that can be described as fast-changing. The shelf life of the knowledge taught varies (information science and law are fast-changing, the humanities seem quite stable). The OU has so far come up with two ways of dealing with changes that arise in a domain during the average length of time

that OU students customarily spend in a programme. One way is to limit the period of validity of exams. The other assumes that students learn general competencies that can be used in other settings and under other paradigms. In this view it is not necessary to limit the validity period. If that option is chosen, the graduates' adaptability and preparedness for change should be guaranteed.

- When the aim is the integration and contextualisation of knowledge, this goal should be made explicit in the course or courses in which that knowledge is acquired. That means rethinking the competencies a student must have upon graduating and how these can be built up and warranted. Since competence-based education is the core of the educational concept at the OUNL, this rethinking could have far-reaching consequences. One of the major points of this address is that the core of expertise development is the development of a well-integrated, validated, well-connected, flexible or adaptive body of knowledge. I seriously doubt whether that should be considered a competency. And if it is, it is a huge one. The only way to learn this 'competency' is to apply every bit and piece of knowledge in relevant, authentic contexts in which knowledge integration and enrichment of scripts can take place. Educators and students should not fall into the trap of thinking that they are training skills in such a case, and that having done three or four of these exercises should be enough. The challenge will be to develop tasks to assure integration and contextualisation that do not take much time to work out, that are adapted to the students' level of mastery (including in terms of cognitive load) and that have environmental and cognitive authenticity.

These factors alone make teaching at the Open Universiteit a challenge. However, the particular combination of factors complicates things even more.

In my view, the most serious problem is that the following factors coincide: a short shelf life of knowledge associated with frequent paradigm shifts; the necessity of knowledge integration; and the extended period of enrolment of OUNL students. This combination of factors requires a new way of looking at the curriculum and at the competencies to be acquired.

Curricula are traditionally organised in the following way: starting with the basic sciences and followed by the applied sciences, knowledge is built up, integrated and contextualised, slowly but steadily. The emphasis is on theory first, with practice being gradually integrated, in turn leading to script formation and refinement. Simultaneously, self-directed and lifelong learning skills are supposedly accrued. This situation is depicted in Figure 8. The left axis reflects the growing level of expertise that extends far beyond graduation, while the right axis reflects the emphasis on theory that is later (partly) replaced by practice as a context for learning, coinciding with the increased authenticity of the learning environment that is required.

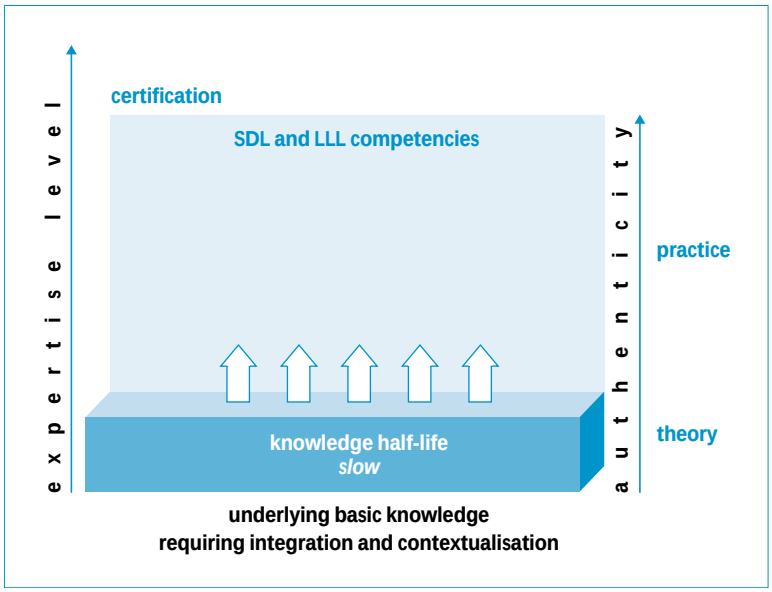

Figure 8 Model of a curriculum applicable for knowledge with a long shelf life. See text.

However, when knowledge has a short shelf life relative to a long period of student enrolment, this bottom-up approach does not work, since students will never reach the level of mastery at which they can independently use the new knowledge as a tool. When a programme involves knowledge with a very short shelf life, it is important that students quickly reach a level of expertise in subdomains that allow them to develop that skill further in practical situations in their daily work.[21] To be able to continue developing such skills independently, students also need to develop self-directed and lifelong learning skills at a very early stage of their academic career. That is not as obvious a progression as it may sound, and I will therefore return to this topic later. Figure 9 shows a diagram representing a curriculum approach of this kind; it depicts a 'lateral' procedure in which all-round expertise is developed per domain. It is not unthinkable that such an approach would work in fields like the management sciences.

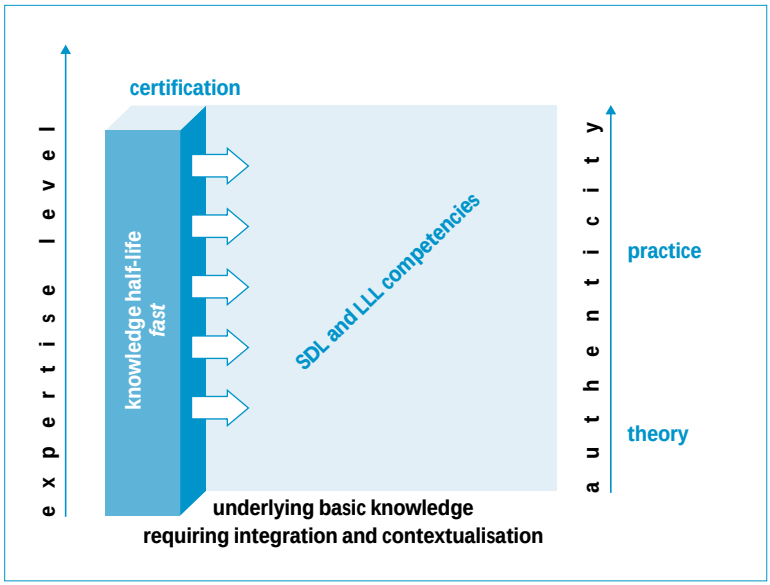

Figure 9 Model of a curriculum applicable for knowledge with a short shelf life. See text.

A comparison of these two extremes soon leads to a mixed proposal in which students work on a broader range of basic knowledge from the start, but develop one aspect of this knowledge to the level of complete mastery. Again, self-directed and lifelong learning skills should be developed at an early stage of their programme. Both in the lateral and in the diagonal approach, it is important to investigate whether the students' own needs should determine which aspect is developed first (see Figure 10).

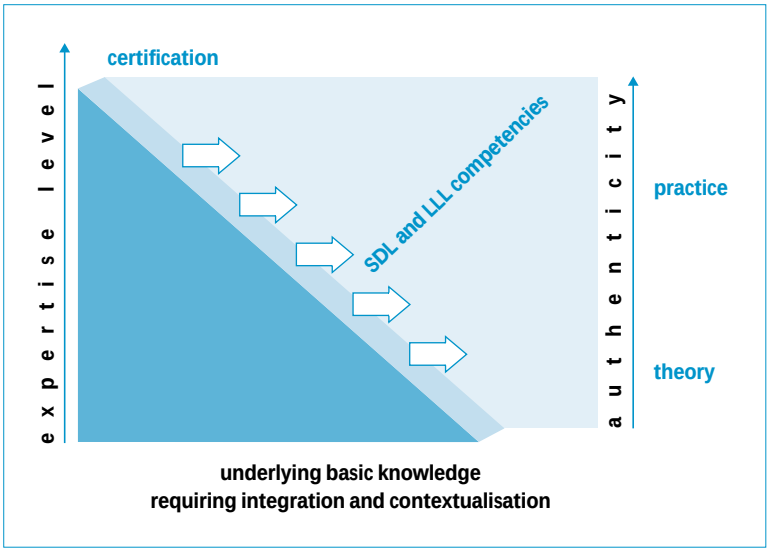

Figure 10 Model of a curriculum, which is a mix of the two previous, assumed to be applicable for knowledge with a short shelf life. See text.

As I said, the development of learning strategies is not a self-evident process. That is true of the self-directed and lifelong learning strategies mentioned, but also of more basic learning skills. For example, knowledge application in the context of new, authentic situations should be considered a learning strategy that a student must acquire, and not just a task that he or she has to fulfil. Learning strategies are like all other skills. They can be practised and it is very helpful when learners have some meta-cognitive understanding of their usefulness and the conditions for their application. It is worth our while to work this out and experiment with different kinds of instructions.
Another learning skill that students must acquire long before graduation is learning from experience. Research (Wagenaar et al. 2002 in press; Van Eeekelen et al., in preparation) has shown that most students do not plan and reflect spontaneously or do so infrequently. However, when we organise their environment in such a way that these steps are part of the process, much ground can be gained.
The combination of a short shelf life of knowledge and adult students who study to improve in their work cries out for the introduction of real tasks in Open Universiteit courses. Why should we wait to have students apply knowledge and skills until they have achieved the required level of expertise? Why should we use the workplace only to maintain and update competence? Why shouldn't students instead work on projects in their own workplace as much as possible? Where applicable, the Open Universiteit and the students' employers could form a partnership in which the Open Universiteit adopts suitable projects, in which other students may also participate, that can lead to at least three kinds of results: learning outcomes for the participating students, a completed project for the employer, and organisational learning in terms of feedback and altered working procedures. In our plans for the new Master's programme Educational Design for Active Learning, we plan to investigate the possibility of such partnership projects.
Before I conclude, I would like to mention one more aspect that deserves attention, an aspect that lies hidden in the terms of 'practice' and 'authenticity'. Most practical situations and workplaces require co-operation with other disciplines and/or other branches of the same discipline. Even a soloist physician works with an assistant, a nurse, a pharmacist, a dietician, the public health services, the social services, the police, financial and administrative specialists, et cetera, and has patients of many different ages and cultural and social backgrounds. Similarly, architects work with specialists in the field of civil engineering, draughtsmen, contractors, project developers, financial planners, specialists in logistics, municipal services, city planners, and they may also have to deal with pressure groups focusing on environmental protection or sustainable building, landmark protection and more. Authentic tasks will always include the participation of other disciplines. Students have to learn to co-operate with others, and to co-operate with people who have different kinds of expertise. At the beginning of this address I discussed in more general terms how difficult that may be.[2]

Bridging the gap – do we have the material to do that? Maybe we are asking too much. What we do have is a better idea of the gap and where it is located. We also have a better idea of what is or should be on the other side of the divide. We have identified strategies to narrow the gap and to bridge it. But as yet we do not have the material to do so. There is as yet much to be developed, tried out, rethought, investigated, in a field that itself requires further exploration. I would love to be part of that expedition.

Reflections

I am coming to the end of my inaugural address and would like to reflect for a moment on what brought me here, on my own developmental process. Much of what I have considered here is based on work I did with Master's and PhD students, colleagues, and supervisors. To mention a few: Hanneke Duijkers, Nathalie Ummels, Geert van de Brink, Arno van Rooijen, Ameike Janssen, Marleen Gulikers, Ilse van Eekelen, Tim Dornan, Katinka Prince, Agnes Wagenaar, PJ Beers, Piet van den Bossche, Margje van de Wiel, Rina Vaatstra, Maureen Machiels, Willem de Grave, Eugene Custers, Remy Rikers, Metta Hofstra, Pie Hobus, Hein Claessen, Jan Vermunt, Mien Segers, Wim Gijselaers, Paul Kirschner, Jan van Bruggen, Iwan Wopereis, Cees van der Vleuten, Albert Scherpbier, Henk Schmidt, Jan Elshout and Nico Frijda. Although more than 20 years have passed since I completed my own formal education, much of what I do now is rooted in what I learned at the Psychological Laboratory of the University of Amsterdam, where the project 'Thinking and Memory', initiated by De Groot and Frijda, and of which Jan Elshout was one of the directors, provided the focus for a lot of research. I even witnessed a real paradigm shift there, and saw how the concept of learning changed its shape completely, without which my later study of expertise would not have been possible. It was also there in my job as a student assistant that I acquired many of my research skills.

The former Rijksuniversiteit Limburg, now Universiteit Maastricht, where I did my PhD, gave me the opportunity to learn from experience in research, education and management. This is where I worked with most of the people I have just mentioned. I want to thank Wynand Wijnen, Henk Schmidt, Arie Nieuwenhuijsen Kruseman, Karl Dittrich, Gerjo Kok, Ed Sprokkel and Cees van der Vleuten for the opportunities they gave me.

This brings me to my most recent milestone, Heerlen and the Open Universiteit Nederland. You probably think that the distance between Heerlen and Amsterdam is the same as the distance between Maastricht and Amsterdam. I can assure you that for me it is not, academically speaking. At ETEC, my new workplace, I met a couple of people who have the same background as I do, people with whom I could easily pick up on some 'old' but still very worthwhile stuff relating to domain-dependent

reasoning. It was almost waiting there to be integrated into my thinking on expertise in different domains, and it is one of the things I would like to pursue in the future, if we can find funding for it.

The biggest challenge here is, however, of a different order. We have to bring the old programme in Education to a good end and start a new Master's programme in Educational Design for Active Learning. The team working on this project is very dedicated and I am happy to be able to work with them: Henk Münstermann, Arjan Dieleman, Marion de Bie, Marcel van de Klink, Ad Schellekens, Olga Firssova, Linda Luchtmans, Miriam Goes, Carlien Erens and the others who are about to join us. I thank the Open Universiteit's Executive Board, especially President Thijs Wöltgens and Rector Fred Mulder, and ETEC's Management Team for giving me this opportunity. ETEC is a workplace that has not disappointed me. The quality of the people and the structure provided are a blessing. Wim Jochems, Freek Gastkemper, Jos van de Broek and Jeroen van Merriënboer are my closest colleagues; thanks very much. Fellow educational deans and Alexander Udink ten Cate: my appointment to ETEC means that our working relationship is not as self-evident as it might have been if I had taken a position within the Directorate of Education. I take it for granted and see it as the best of both worlds, and I hope that we can work with one another to improve education, and go together on the expedition I just described.

Back to my daily environment, at work that is: Marina Pongraz and her colleagues, Ingrid, and all the others, thanks for all your support.

Having lavished so many words on work, management and colleagues, I want to end with the most important persons, my family: my grandparents, my parents and their brothers and sisters and my stepfather. They saw that I grew up healthy and happy, and they also provided the climate of trust and expectations that made it possible for me to find my way. I particularly want to thank my mother for her patient and non-interfering support during my academic career. You never tried to push me, and to my great fortune only told yourself that it would not matter if the child that I was at the time became a professor one year later. I am glad that you did not voice those expectations until I received my PhD. Finally, the home front: Hein, Rogier and Louise, you help me keep my feet on the ground. You help me to reduce work and science to their normal proportions. The three of you are so important and at the same time so natural and obvious a part of my life that most of the time I do not even think about it. To you as well, thanks so much.

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Notes

1 The Dutch equivalent of these TV programmes is *Tussen Kunst en Kitsch*.

2 The term 'deliberate practice' was coined by Ericsson, Krampe and Tesch-Römer (1993) and refers to self-organisation and strategies in practising the skills and subskills necessary for (excellent) skilled performance. Initial research on this concept was carried out in the domain of sports and the arts, but it was extended to the field of teaching (Dunn & Shriner, 2000), insurance (Sonnentag & Kleine, 2000) and is presently being carried out in the domain of management as well, where Van de Wiel, Szegedi and Weggeman (in preparation) are investigating differences between top and subtop managers with respect to deliberate strategies of self-improvement.

3 To prevent these effects, professional organisations may require their members to participate in continuous education and may develop evidence-based standards of dealing with specific problems.

4 I do not claim that this is also the case in other kinds of argument structures, such as reasoning based on examples and counterexamples, investigation of extremes, reduction ad absurdum proof, or formal logic.

5 Cognitive demands play a major role in instruction theories such as Sweller's (1988).

6 Even in highly industrialised societies, one will find groups and communities that have a different economic organisation. Examples are the Amish in the USA or communities of circus performers or showmen and owners of fairground attractions.

7 Technology, information science and the life sciences are at the forefront momentarily.

8 This does not only apply to the poor, but also to communities with a skewed age distribution.

9 An elegant design with parallel cases presented in balanced order was used, making it possible to gather 184 analysable protocols, 59 of which were produced by fourth-year students, 66 by fifth-years, 43 by sixth-years and 17 by medical specialists.

10 In addition, laboratory research currently being conducted at McMaster University, Hamilton, Ontario, by Norman, Brooks and colleagues suggests that knowledge of underlying mechanisms leads to better recall of clinical knowledge. Personal communication.

11 Experts felt real time pressure. Normally they have an hour for an intake interview, whereas in the experimental session they had no more than 30 minutes. The students found it hard to fill this time, since they were very dependent on what the patient volunteered.

12 The patient was a quiet man who had had very little schooling, was probably dyslexic, and showed signs of depression and hypochondriac tendencies with headaches and a fear of cancer. Dealing with such a patient can be difficult because of the demands they make on their environment, the discrepancy between their own interpretation of pain and other physical complaints and the therapist's and referring GP's interpretation ('I am not crazy!'). It requires the therapist to build trust and motivation and acknowledge the patient's interpretation without complying with it. Experts were aware that the intake lays the foundation for the success of the therapeutic relationship.

13 ROA, the Research Centre for Education and Labour Market, routinely collects data about the labour market position of graduates of all Dutch universities, 1, 5 and 10 years after graduation. Graduates are asked to choose no more than three out of fourteen competencies that they believe have not received enough attention: knowledge, technical methods and skills, *computer skills*, numeracy, *social skills*, working in a team, *management skills*, *leadership*, independence, creativity, initiative, *dealing with change*, accuracy, international orientation. The italics indicate the competencies mentioned most often.

[14] Even a transition from one school to another, either within a single educational level or from primary to secondary education, can have tremendous effects on pupil learning and performance. For example, in the UK it was found that about 40-50% of the pupils in the first class of secondary education had not improved on English, reading comprehension and math. The authors concluded that this should be mainly attributed to variation in the teaching approach and the failure of pupils to account for these differences in their learning strategies (Galton, Morris, & Pell, 2000).

[15] Research on the feasibility of the system is presently being carried out by Tim Dornan, Albert Scherpbier and myself.

[16] Script enrichment and refining are probably the results of implicit learning, as is link strengthening in knowledge networks.

[17] Similar situations can be identified in perceptual learning, where advance knowledge of a certain phenomenon can be a great help to students. Learning support of this kind is called 'cueing' (Patrick, 1972).

[18] Other findings by Korthage (1999) were that novice teachers often tended to search for solutions without thoroughly exploring the real problem, a tendency they share with novices in many other fields. Furthermore, novice teachers were very self-centred and had problems seeing the perspective of others and their interpretations of a situation. This phenomenon resembles Wagenaar's finding that Mental Health Care students were mainly concerned about asking the right kind of questions and did not monitor the relationship they were building up with the client.

[19] Some of these points were also mentioned by Robert Glaser at a symposium during the annual AERA conference in 1995.

[20] This book includes many experiences in different settings with software tools and infrastructures that help communities to better tackle problems they are dealing with. The book has a website with links to on-line resources www.visualizingargumentation.info.

[21] The assumption here is, of course, that once a certain level of mastery has been achieved and when students use that knowledge and skill in their work, they will be able to maintain and develop that competence further. The analysis in this adress shows that this does not happen as a matter of course when the workplace fails to provide feedback.

[22] It is very tempting to go into detail here. Instead, the reader is referred to Boshuizen and Tabachneck-Schijf (1998), and to Van Bruggen, Boshuizen, and Kirschner (2003), for an analysis of the difficulties that may arise when people with different forms of knowledge which are represented differently, different argumentation styles and different assumptions of what makes a valid line of reasoning work together.