

[Back](#)**23 page(s) will be printed.**

Record: 1

Title: The design of a study environment for acquiring academic and professional competence.

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Source: Studies in Higher Education; Jun97, Vol. 22 Issue 2, p151, 21p, 2 diagrams

Document Type: Article

Subject Terms: *EDUCATION
*PERFORMANCE
NAICS/Industry Codes611699 All Other Miscellaneous Schools and Instruction
611710 Educational Support Services
923110 Administration of Education Programs

Abstract: Proposes a framework for the design of a learning environment which encourages the acquisition of academic and professional competence. Definition of knowledge, cognitive skill and competence; Acquisition of competence; Designing an environment for competence acquisition; Implementation of study environments within education.

Full Text Word Count: 11025

ISSN: 0307-5079

Accession Number: 9707174825

Database: Academic Search Elite

THE DESIGN OF A STUDY ENVIRONMENT FOR ACQUIRING ACADEMIC AND PROFESSIONAL COMPETENCE

ABSTRACT This article sets out, by incorporating notions drawn from cognitive, constructivist and action psychology, a foundation for the design of a learning environment for the acquisition of competence. It does not make exclusive use of any one school of thought, but synthesises a number of notions and insights from each of the schools into an integrated approach to the education of competent professionals. The outcome of this synthesis is a model for a study environment which is composed of a knowledge environment and a task environment. The model aims to sensitise teachers and educational designers and developers to the various elements that distinguish training in competence from mere 'skills training'.

Knowledge, Cognitive Skill and Competence

The subject of this article is the design of study environments aimed at the acquisition of competence. We define competence as the whole of knowledge and skills which people have at their disposal and which they can use efficiently and effectively to reach certain goals in a wide variety of contexts or situations. We begin by distinguishing clearly between knowledge, cognitive skill and competence, as such a distinction will make it possible to formulate concrete proposals for the design of study environments for acquiring competence.

Knowledge

Knowledge is referred to variously as 'knowing that' (Olson, 1976; Salomon, 1981),

'declarative knowledge' (Anderson, 1980; Dillon, 1986), 'conceptual knowledge' (Posner & Keele, 1973), 'propositional knowledge' (Greeno, 1980), 'verbal knowledge' (White & Mayer, 1980) and 'substantive knowledge' (Gardner, 1975). What all of these terms have in common is that they are concerned with the representation of the facts, concepts, principles, procedures and/or theories in a certain domain (subject or discipline). Although the breadth and nature of the different types of knowledge (i.e. facts as opposed to procedures) vary, they are both characterised by learning, remembering and/or reproducing and not by the carrying out of higher order processes upon them or with them. Knowledge is the substantive (content-specific) element of that domain. One unique characteristic of knowledge is that it is easy to demonstrate whether or not someone possesses it in an educational setting. A simple test can make clear whether or not someone possesses a specific form of knowledge or specific insights. Another striking characteristic of knowledge is that it can be learned or acquired 'in one go'. This is not to say that this is always the case with all students, but knowledge acquisition can be achieved in a single try. Even after its acquisition, it does not require fundamental refinement or adjustment. At best knowledge can be reorganised or absorbed in more effective, more efficient, and/or more encompassing schemata for quicker, better and simpler use. For example:

A chemistry student is asked to separate a mixture consisting of two pure liquid substances, each of which has a different boiling point. She knows the boiling points of the two substances. She also knows that she can use different heating techniques to reach different boiling points and to heat substances at different speeds. And she also knows whether heating will result in certain (unwanted) chemical reactions.

The presence of such knowledge (for example, about techniques, boiling points, etc.) does not automatically mean that the student will actually be able to make use of that knowledge (e.g. by realising that distillation might be a suitable technique and by applying it). In addition to knowledge, the student in question also needs skill.

Cognitive Skill

Like knowledge, the literature also refers to cognitive skills in a variety of different ways, for example: 'operations on knowledge' and 'operations with knowledge' (Crombag et al., 1979), 'knowing how' (Salomon, 1981), 'procedural knowledge' (Dillon, 1986; Anderson, 1980), 'intellectual skills' (White & Mayer, 1980), 'mental process or operation' (Snow, 1978), 'executing function of our anticipatory schemata' (Neisser, 1976), 'strategic knowledge' (Posner & MacLeod, 1982; Cohen, 1983; Renner & Marek, 1990), 'cognitive strategies' (Gagne, 1977; White, 1988), 'structure-of-intellect problem solving' (Guilford, 1979), and 'syntactical knowledge' (Gardner, 1975). Although there are specific differences between many of the terms used and some of them even contain the word 'knowledge', common to all of them is that the learner must carry out higher order processes with or upon the knowledge gained. It is beyond the scope of this article to discuss the differences between the terms. Unlike knowledge, however, cognitive skills are often difficult to identify--and hence to test--in an educational setting since the operations take place 'in the mind' and are therefore scarcely, if at all, visible. Often the only way of testing them is to elicit a display of behaviour showing whether the specific skill has been acquired. Another salient difference between knowledge and skill is that a skill can hardly ever be acquired in one go (Posner & Keele, 1973; Neves & Anderson, 1981; Newell & Rosenbloom, 1981). A skill can be refined, speeded up and altered by practice and by receiving enough feedback--extrinsic, from others, or intrinsic/mental, i.e. 'cognitive monitoring of one's own actions'--on the results (Anderson, 1982; Eylon & Linn, 1988). We will take a closer look at this later in the article.

Of the various definitions of skill, we find the one proposed by Crombag et al. (1979) the most useful. A skill consists of operations (or actions) and is measured according to how well a person is able to carry out these operations (speed, accuracy, and so on). Every operation has an object and a goal: the operation is carried out on or with something, to ensure a certain result. As mentioned above, Crombag et al. identify two types of cognitive skill, namely operations on knowledge and operations with knowledge.

Operations on knowledge, the first type, take knowledge as their object; the operations are performed on knowledge. These operations lead to new knowledge or new cognitive representations of previously acquired knowledge. In other words, the goal of the operations is to effect a reordering or restructuring within the existing cognitive structure. Operations on knowledge are related to virtual products, to the ability to handle knowledge 'in the mind'. One simple operation on knowledge is memorisation; more complex operations on knowledge can be categorised according to Bloom's (1956) taxonomy: analysis, synthesis and evaluation. These operations have in common that they only exist within a particular field of knowledge, and that their results (or products) also only exist within that field. The goal of the operation is to arrive at knowledge at a higher aggregate level. For example:

A chemistry student must separate a fluid consisting of two pure substances. She knows that each substance has a different boiling point. She proposes to heat the compound slowly and carefully, so that the liquid with the lower boiling point vaporises, leaving only the liquid with the higher boiling point. 'But how do I collect the vaporised substance?' she wonders. She realises that it would be necessary to cool down and collect that substance elsewhere.

Operations with knowledge, the second type of skill, also take knowledge as their object, but are aimed at reality ('outside the mind'), i.e. at verifiable results or products. Such operations are also carried out to some extent within the relevant field of knowledge, with use being made of any knowledge stored and present there, such as a knowledge of procedures. The effect of carrying out these operations can ultimately be demonstrated in reality.

The actor intervenes in reality and does so by making use of any knowledge available about that reality and carries out planned operations, moving between action and reflection. As a rule this process produces new experiences and new knowledge about that reality. Writing a research report is an example of an operation with knowledge. Conducting a chemical experiment, building a desk out of wood, composing a summary of a text, and drawing up a statistical analysis are just a few examples of such operations. They are comparable to the third category in Bloom's (1956) taxonomy: 'application':

The boiling point of the more volatile liquid is 122 degrees C, but the boiling point of the less volatile substance is only 5 degrees higher. At around these temperatures the substances will not react with each other, eliminating the danger of explosion. The student puts together an oil bath to heat the mixture slowly and performs a distillation.

Both operations on knowledge and operations with knowledge lead to new knowledge, but there are notable differences.

Operations on knowledge enrich or deepen knowledge by arranging, analysing and combining. New relationships emerge, cross-connections are established, derivations and contradictions are detected. The processes at work are always internal ones. The (re)arrangement of previously acquired knowledge is the most important result of operations on knowledge.

Operations with knowledge encompass both the cognitive component of something

as basic as 'do a long-division problem' and as complex as 'write a research paper' where operations on knowledge are a prerequisite for the task of communicating one's research efforts, which is, in fact, an operation with knowledge. Operations with knowledge often lead to new, empirical information. New experiences are created in reality, leading to an increase in the knowledge available.

Competence

In the previous two sections we differentiated between the dimensions of knowledge and skill. These two dimensions can be defined respectively as 'knowing' (knowledge) and 'performing' (skill). As we studied the literature, it struck us that, in addition to knowledge and skill, researchers are on the lookout for 'something extra' to help them explain effective and efficient behaviour. Kirby (1988), for example, makes a clear-cut distinction between skills and strategies: 'Skills are existing cognitive routines for performing specified tasks, and strategies are the means of selecting, combining, or redesigning those cognitive routines' (p. 230). Strategies determine which skills should be used, and skills influence the strategies that are applied (Kirby, 1988).

In his *The Conditions of Learning*, Gagne (1977) uses cognitive strategies as an umbrella term for complex, acquired skills. Cognitive strategies become manifest in the way people think, in the way they analyse problems, in their approach to problem-solving, and so on. Gagne believes that the term strategy means selecting a 'skill' from among a number of available suitable actions aimed at achieving some goal. Ferguson-Hessler (1989) takes this a step further. In addition to declarative, procedural and strategic knowledge, she identifies situational knowledge: the ability to recognise relevant elements of a given problem situation, analyse the situation and predict how it may develop in due time. Going back to the chemistry problem, Ferguson-Hessler's ideas imply the following. Situational knowledge is knowing that there are certain limiting conditions (time, equipment and/or requirements such as the purity of the distillation and the limits on the consumption of energy) which must be taken into account.

Skilled behaviour requires only that declarative and procedural knowledge be applied. Competent behaviour transcends this in that it apparently must also involve strategic and situational knowledge. Ferguson-Hessler's definition both confuses and makes an important contribution to the discussion. The confusion is that she describes knowledge of the situation as a separate form of knowledge. To analyse a situation, students need procedural knowledge. As soon as they perform operations with this knowledge (i.e. analyse the situation), new knowledge is added to their own store of knowledge. Situational knowledge, then, is really the result of operations with knowledge. The contribution is that Ferguson-Hessler insists that the situation determines what competent behaviour is. When a person 'forgets' to take account of the circumstances in which (s)he must act, (s)he is not capable of behaving competently. The ability to access and use all four forms of knowledge can be viewed as a necessary precondition for competence. Kurt Lewin saw human behaviour (B) as the result or the function of personality (P) and situation (S), represented by the formula $B = f(P,S)$. Following Lewin's example, we could conceive of competence (C) as a function of knowledge (K), skill (Sk) and situation (S), i.e. $C = f(K, Sk,S)$.

Bloom et al. (1956,p. 39) alluded to this when they discriminated between skills and abilities. They defined (cognitive) skills as 'competence [sic] in using a generalized method of operating or dealing with a new problem situation' and abilities as 'situations in which the individual is expected to bring specific technical information to bear on a new problem'. Spitzberg (1983) goes a step further in that he sees competence as related to '... a broader set of concerns entailed in motivation, knowledge and skills as they relate to functionally effective behaviour

appropriate to its context', as do Wiemann & Backlund (1980, p. 198), who make the point that competence is the ability to choose among available behaviours in order to accomplish goals successfully within the constraints of the situation.

Barnett (1994) in *The Limits of Competence* also stresses this idea of situation in defining competence. He cites Jessup in defining competence as something that is not concerned with predictable behaviours in predictable situations. The unexpected may require the use of new configurations of existing skills--or the development of completely new skills. Coping with the unexpected and unpredictable in a creative way is, according to Barnett, a critical part of the concept of competence.

Stephenson & Weil (1992) more broadly define 'capability' as an integration of confidence in one's knowledge, skills, self-esteem and values. They state that capable persons '... have confidence in their ability to take effective and appropriate actions, explain what they are about, live and work effectively with others, and continue to learn from experiences'. They emphasise that it is not the mere possession of skills alone, but the self-confidence in knowing how to use skills within unfamiliar and changing circumstances that really matters. Like Barnett's use of the term 'competence', the term 'capability' is used for the ability to '... cope with unpredictability and even allow for creativity' (Barnett, 1994, p. 73).

Our definition of competence is very close to Stephenson & Weil's definition of capability and Barnett's definition of competence:

the ability to make satisfactory and effective decisions in a specific setting or situation.

Apart from taking effective and appropriate actions within unfamiliar or changing circumstances, it involves judgements, values, self-confidence to take risks, and a commitment to learn from experience. For example:

A laboratory technician in a chemistry laboratory is asked to separate a mixture which is composed of two different liquids, each one having a different boiling point. To do this competently, she must possess knowledge about the various separation techniques, the boiling points of the two substances, the limitations of the various heating techniques, the dangers involved in heating the different substances, and so on. Based on this knowledge she can determine a whole range of possible techniques. Given the limiting conditions, she must be able to select the appropriate technique. Finally, she must be skilled at using this technique.

If the chosen action does not result in the intended goal, even though it is carried out correctly, then there can be no question of competent behaviour. That means that a person may possess the correct skills and still not be competent. Conversely, it is not possible for a person to be competent without possessing the necessary skills. The difference is therefore that competence requires the use of situation-specific information, whereas skills do not.

Acquiring Competence

A proper conclusion after the first section of this article is that competence as a dimension is defined by the situation. In the following section we discuss several learning theories that eventually bring us to our design of a study environment for acquiring competence.

Discovery Learning and Modelling: some shortcomings

In our work in higher education, we have frequently come across the idea that students will acquire competence later on when they practise their profession or during a traineeship, either by 'learning by doing' or by 'watching others and doing as they do'. The paradigms underlying this idea are those of discovery learning and

modelling. The former assumes that learners in a novel situation will have their curiosity aroused, will have an increased motivation to learn, and will be able to translate that which they have seen into meaningful insights into the subject matter. The last assumes that learners, by watching others perform, will model their behaviours after those of the expert and will then be able to perform in a similar manner.

It is doubtful whether the principles of discovery learning and modelling should set the tone for education in which the aim is to acquire competence (Ausubel, 1964; Wellington, 1981). We have noted the following four problems.

1. If learners do not know what they should be watching out for either in their own behaviour (discovery) or in the behaviour of others (modelling), there is little chance that they will notice what they are supposed to notice, and even less chance that they will interpret what they notice in the correct manner--if they are capable of interpreting at all! Suchman (1966) suggested that the meaning that a person attributes to a certain observation depends on the relevant information already available to that person. Someone who knows a great deal about geology will notice features of a hill that will elude a botanist or cyclist. What you know determines what you see, and not vice versa. Concepts are used to understand new phenomena and to solve problems (Hewson, 1980).
2. Researchers such as Woolnough & Allsop (1985) emphasise the messy and confusing nature of reality. Students who work or take up a traineeship become so bogged down in details that they fail to recognise underlying concepts. Neither do they possess the theoretical knowledge or the ability to function at the cognitive level required to recognise existing patterns and structures.
3. A third problem which is primarily relevant to modelling, but which also applies to discovery learning, is that the learner's experience is often restricted to visible inputs (what the learner or the expert does) and outputs (the observable results of those actions). The underlying processes which occur and thus the basis for understanding those processes are, for the learners, 'black boxes'.
4. Even if the first three problems are not accepted as problems, the sheer amount of practice that would be necessary to achieve the competency would be so great that it would not be practical to use a discovery-based approach in an educational setting in which time and resources are severely limited. Kreitler & Kreitler (1974) remark that a person must be confronted repeatedly with many different manifestations of a concept before he or she can understand it. It is possible to demonstrate a concept during a lecture, but that is only one demonstration. Even highly talented students are frequently unable to derive meaning from a single manifestation of a certain concept after only one demonstration. That is why modelling and discovery learning are not only ineffective, but are also inefficient methods for acquiring competence (Kirschner, 1992).

Having said this, we must add that discovery learning and modelling do have certain merits with respect to creating a relevant task environment for the acquisition of competencies, and we will discuss this in a later section. In that section we present an alternative to these approaches, namely experiential and situational learning which integrate the strong points of discovery learning and modelling without the shortcomings just described.

In the following section we describe a basic procedure which can serve as a starting point for designing a setting for acquiring competence. After that, a number of current theories of learning will be integrated into our basic procedure to arrive at a model for designing an environment for achieving competence.

A Basic Procedure: orientation, practice, feedback

A basic learning procedure for acquiring skills (note: not competence) consists of three elements: orientation, practice and feedback. The procedure was initially developed to acquire (psycho)motor skills. Later it was used increasingly to acquire cognitive skills such as solving closed-ended problems. For example:

A mathematics teacher shows a pupil how to determine the zero points of the function $f(x) = x^2 + x - 2$. She does this step by step and gives detailed instructions. The pupil is then given a comparable function and told to determine its zero points. The pupil does this out loud, and is told to go through the same steps demonstrated by the teacher. The teacher corrects the pupil whenever he makes a mistake. The pupil repeats the exercise a number of times, each time receiving feedback from the teacher.

This basic procedure incorporates a number of behaviourist learning principles. It involves observable behaviour which is demonstrated, imitated and corrected until it is satisfactory (Newell & Rosenbloom, 1981). There is scarcely any attention given to the ideas that the student might or should possess. Indeed, one of the shortcomings of this method, in the narrowest sense, is that it is too close to a 'trick'. The feedback is frequently low on information content, and there is little concern for the underlying knowledge needed for meaningful learning/acquisition of a skill. As a result, it often happens that students are unable to use skills that they seem to have acquired in other, new and somewhat different or ambiguous (poorly defined) contexts.

Feedback is an important element of this procedure. After each exercise, the student should be receiving feedback on what is correct or incorrect, and how (s)he can improve his/her work. The feedback can take on many different forms. In the example above, the mathematics teacher might tell the pupil what he has done wrong, in the hope that the pupil will not repeat the mistake again. The mathematics teacher could also ask the pupil whether he believes he is correct in what he is doing, forcing him to rethink his steps. At a certain point the teacher could suggest a monitoring strategy or a mnemonic aid allowing the pupil to monitor his performance himself the next time around, so that he will not make the same mistake again.

The orientation-practice-feedback triad reappears time and again in education in all sorts of forms. The approach to orienting, practising and receiving feedback can vary considerably, however. The following questions always play a role: how can the student orient himself/herself in a certain domain; what should be practised and how; and which elements are essential to the feedback? The answers to these questions vary depending on which theory of learning is applied, and on how education can best support how people learn, according to that theory. This procedure can also serve as the basis for an educational design aimed at the acquisition of competence. Unfortunately, however, it is not sufficient for that purpose in and of itself.

ACT Theory: cognitive structure

In the late 1960s, the growing interest in cognitive psychology and the declining interest in behaviourism meant that learning was increasingly viewed as a cognitive process. In other words, the ability to deal with knowledge was seen as the most important criterion for successful behaviour.

Anderson's ACT theory (Adaptive Control of Thought), which attempted to cast the cognitive process into a model, gained wide acceptance. In Anderson's view, the acquisition of new knowledge through cognitive skill proceeds in three stages: the

declarative stage, the knowledge-compilation stage and the procedural stage. In the declarative stage, humans acquire declarative (i.e. factual) knowledge about reality. They process/interpret this knowledge by making use of generally accessible procedures (production rules: if ... then ... else ...). Then, in the knowledge-compilation stage, they make connections between the newly acquired knowledge and their existing knowledge by generating new production rules, or by replacing old rules by new ones (Neves & Anderson, 1981). Finally, in the procedural stage, they tailor the production rules to the task: the production rules are extended (generalisation), specified (discrimination) and reinforced through frequent use or weakened through minimal use. Thus:

A person who is learning to conduct research must first gather a large store of factual knowledge in the declarative stage, for example on such common concepts as measurement level, hypothesis and validity. This knowledge is processed according to general procedures which consist of production rules, for example, 'if one measures at the ordinal level, then the median and the mode are both possible indicators of a central tendency'. Next, during the knowledge-compilation stage, these procedures are worked out in greater detail; for example, 'if the distribution is uneven, then the mode is likely to be more accurate than the mean'. Finally, in the procedural stage, the procedures are tailored closely to the task: 'in uneven distributions with very extreme values, such as income distribution in various countries, the modal income is a better measure of comparison than the median or the average income'.

Anderson (1980,1982,1993) tries to make clear that the acquisition of new knowledge must be viewed as an interactive process between existing knowledge and new knowledge which involves practice and feedback. New information is understood in terms of old information. At first glance, therefore, he appears to add little to the basic method described above: new knowledge is introduced (part of an orientation) and cognitive skills acquired through practice and feedback. He does, however, concentrate on the acquisition of declarative knowledge in particular. The difference is that he attempts to uncover the underlying cognitive processes which orientation, practice and feedback should take into account. He further emphasises the independent role of the learner. It is the student who makes the connections between familiar and unfamiliar information and who attempts to make knowledge productive. Finally, it follows that the learner also controls the cognitive process: the responsibility for the learning result shifts from teacher to student.

Action Psychology: learning mental operations

Another set of terms and another point of departure have been proposed by the Russian action psychologists Vygotsky (1978) and Gal'perin et al. (in van Parreren, 1987). Orientation means, in their terms, 'constructing a complete basis of orientation' (knowledge), in which students have the answers to four questions: what, why, how and why so? If the orientation is complete, the (mental) operation (skill) can be practised.

According to van Parreren (1987), Gal'perin has imposed a stepwise structure on to the practice element: the operation is first carried out materially, then verbally and finally mentally. Subsequently, after much practice, the operation is abbreviated and becomes automatic. According to this approach, reflecting on one's actions plays an important role.

Gal'perin provides examples taken from initial instruction in arithmetic, which is difficult to transfer to adult education and more abstract reasoning and problem-solving skills. A study on problem-solving behaviour involving children in special education (Hummel & Alberts, 1985) used Zak's (1980) strip test (based on action psychology principles). The experimenter presented the child with a strip of paper

of a particular length, and asked the child to match the length of this strip with shorter strips of paper. The first time the experimenter told the child what the purpose was and showed him or her the strips he or she could use (orientation basis). The child described in words which operations he or she carried out, making it clear which solution strategy would emerge in his or her problem-solving behaviour (for example: 'I'll start by taking three of those ... and then I'll look to see which ones I need to make it the same length').

Language is crucial in Russian educational psychology. Language and thought go hand in hand. The teacher's instructions are repeated out loud by the pupil (imitation), as if the latter were instructing himself, after which they evolve (through an internal monologue and verbalisation) into mental operations. Although the Russian psychologists say nothing about the way in which knowledge is organised, their ideas concur, for the most part, with Anderson's ACT theory. The interaction with existing knowledge is comparable to Vygotsky's interaction within the learning environment. Anderson's generalisation and discrimination principles are comparable to the evolution of verbal operations into abbreviated and flexible mental operations as described by Gal'perin. The most important contribution that the Russian action psychologists make to higher education is their notion of the complete orientation basis, which preferably involves reflection on one's own actions (the question: why so?) Each time, students will have to ask themselves why they do something and why they do it in the way that they do. Reflection (also known as cognitive monitoring) allows the student to explore why something does or does not work so that (s)he can perform adequately in the future (see also Flower & Hayes, 1980; van den Brink, 1992). This aspect of the complete orientation basis is an important criterion for acquiring competence.

Experiential and Situational Learning: the context of learning

The previous two variations--or better said, enrichments--of the basic procedure focus specifically on the way in which orientation takes place. Where the first variation (the ACT theory) focuses on carefully offering students new knowledge while taking into account their existing cognitive structures, the second (action psychology) tends to concentrate on constructing a complete orientation basis and carefully building up practice. Both approaches accentuate the constructive nature of learning. Most situations, however, are rather predictable because situations are specified, players have interlocking roles to follow, and they share understanding of what is supposed to happen. Experiential learning and situated learning add to this by promoting that constructivist learning takes place within unfamiliar and changing situations that do not behave in a stylised fashion.

The experiential learning method creates an environment which requires the participant to be involved in some type of personally meaningful activity. Such an environment allows the participant to apply prior knowledge of theory and principles while developing commitment to the exercise and experiencing a real sense of personal accomplishment or failure for the results obtained (Walter & Marks, 1981). In order to bring about behavioural, attitudinal, and knowledge change, a circular, four-state experiential learning model is often advanced (Kolb, 1971, 1982, 1984; Kolb & Wolfe, 1981; Kolb et al., 1986) but challenged by some (Freedman & Stumpf, 1978, 1980; Lamb & Certo, 1980). This model consists of a cyclic process with four stages (see Fig. 1), which implies that the learner can start at any point in the cycle--that is, there is no specific beginning or ending.

The stages of the learning process are plotted with reference to two dimensions: concrete experience versus abstract conceptualisation, and active experimentation versus reflective observation (Urban, 1992). The ideal learner can function on all four stages:

- concrete experience: the learner experiences the results of his or her active experimentation and stands open for these new experiences;
- reflective observation: the learner is able to see different perspectives relating to the situation and reflect on them;
- abstract conceptualisation: the learner integrates the perceptions into logical theories; and
- active experimentation: the learner tests the theories in practice by problem-solving.

Supporters of experiential learning state that experiences are the basis of learning and development. According to Kolb (1984) people learn from their experience, and the results of that learning can be reliably assessed and certified for college credit. Kolb also states that learning is the process through which knowledge is created through the transformation of experience. Learning is enhanced through having realistic experiences. Kolb states that:

Knowledge does not exist solely in books, mathematical formulas, or philosophical systems; it requires active learners to interact with, interpret, and elaborate these symbols. (Kolb, 1984, p. 121)

Bowen's (1987) review of experiential learning theory suggests that learning has a greater impact when it (1) is accompanied by an optimal amount of emotional arousal; (2) takes place within an environment of safety; and (3) is accompanied by adequate processing time and a clear summary providing a cognitive map for understanding the experience.

Situational learning emphasises the importance of realistic situations in which practice and learning can take place (Brown et al., 1989). One of the prerequisites of this more open form of education is that students must possess a sufficient store of basic knowledge, skills and motivation, and that they must monitor their own learning process (Chung & Reigeluth, 1992). In this approach, students must be more than the passive recipients of information and education; they must actively construct their own reality as they interact with their environment.

In situated learning, the nature of an environment determines the perception of the learner and the changes to his or her construction of knowledge (whether this takes place independently and/or in interaction with others). Learning occurs most effectively in a relevant context. In other words, knowledge is context-dependent and cannot be abstracted from situations in which it is learned. Jonassen (1991) accuses many educational environments of decontextualisation in spite of the advantages of situated learning. Tabbert (1993) outlines three reasons why situated learning has advantages over unsituated learning. First, unsituated learning often yields a motivation problem since students often do not see the point of what they are learning. Second, there is an inertness problem because students do not know how to apply what they have learned in real situations. Finally, in unsituated learning retention is a problem because it is hard to remember abstractions if knowledge is not used in a relevant context. She concludes that in situated learning, students:

- come to understand the purpose of the knowledge they are learning;
- learn by actively using knowledge rather than passively receiving it;
- learn the different conditions under which their knowledge can be applied; and
- acquire knowledge in dual form, both tied to the contexts of its uses and independent of any particular context, thus promoting its transfer to new problems and new domains.

Competence is acquired whenever students are given tasks and problems that are typical of the situations in which they will later be required to apply their acquired knowledge and skills. The underlying idea is that they will be able to transfer what they have learned from the classroom to the professional world more effectively if their educational experiences resemble professional practice as much as possible. The problems and educational aids that they are offered should be authentic enough to elicit problem-solving behaviour from them (Resnick, 1987; Brown, et al., 1989). Among the more effective methods within this approach to education are the case study method, simulations and games, project-based learning, problem-based learning, traineeships and term papers. Students are given a realistic assignment which forces them to deal with problems closely resembling those in the real world (see also van Vilsteren, 1995). Cognitive psychologists emphasise the need for 'situational learning' (that is: learning in an experience-rich context) during practice, in which contextual information plays an important role. They claim that the one-way communication of practical skills is seldom enough, and prefer interactive communication and learning environments which resemble authentic situations in which students can practise (Brown & Duguid, 1993). For example:

An environmental science student working on an interactive computer practical plays the role of a policy official employed by the soil protection unit at the Provincial Government of North Brabant (a province of the Netherlands). He is told to draft a document covering a soil protection intervention programme. The document is supposed to report on the methods that are available to survey and identify potential soil protection areas. The student is allowed to consult a number of sources on file: the results of various different sampling methods, processing with a Geographical Information System, interviews with soil researchers and other relevant experts, topographical information, and so on (Lansu et al., 1994). Both the assignment, the research environment and the available sources and aids are highly authentic.

Whereas Vygotsky mainly studied and described social interaction as a criterion for learning, Anderson emphasised the acquisition of production rules. The third variation on the basic procedure (situational and experiential learning), finally, places the overriding emphasis on the context in which the student practises.

Given our earlier definition of competence, it is obvious that these notions of experiential and situational learning should be given serious consideration when developing a study environment aimed at the acquisition of competence. This is the focus of the following section.

Designing a Study Environment for Acquiring Competence

In the previous section we first of all indicated that there is a basic procedure for acquiring skills which consists of three elements: orientation, practice and feedback. We then discussed a number of theoretical notions that complement our definition of competence. In the present section we use these notions to 'embellish' the basic procedure and integrate it into an educational design in which the point is not to acquire 'only' skill but rather to gain competence.

Environments

Anderson's ACT theory emphasises the organisational structure of knowledge and the way in which cognitive skills are acquired. His theory complements our definition of cognitive skills: operations on knowledge and operations with knowledge. New knowledge must be acquired and integrated into the existing cognitive structure; the first two stages (the declarative and knowledge-compilation stages) therefore involve performing operations on knowledge through a process of practice and feedback. This new knowledge must next be applied to concrete tasks; the final stage (the procedural stage) hence involves performing operations with

knowledge, once again through a process of practice and feedback.

In keeping with our ideas on competence, Russian action psychologists emphasise that students must possess a complete orientation basis to be able to perform operations. They must know what they are supposed to do, how they are supposed to do it, why they are supposed to do it, and finally, they must be able to justify why they have done it in precisely that fashion. Competent behaviour therefore requires students to use declarative, procedural and strategic knowledge.

The theory of situational learning is specifically concerned with the context-specific nature of competence and the importance of situational knowledge (knowing when). If we can assume that competent behaviour means that someone is capable of choosing the appropriate action from among all those available and carrying it out at the right moment in a specific situation, then it is obvious that learning should take place in similar or analogous situations.

As plausible as the theoretical notions sketched above may seem, it is the student who ultimately determines whether or not something is actually learnt. The guidelines for facilitating the development of competence which can be derived from these notions come dangerously close to being recipes for success. In reality, education can do no more than design a study environment which takes these notions into account. Figure 2 represents a study environment for the acquisition of competence. The ovals represent three environments encircling each other, in which the four main learning activities (rectangles) occur.

- The study environment is where students find a sufficient number of source materials and aids, and in which they are given a chance to construct an orientation basis of their own or with each other and determine their goals and the activities they will involve themselves in. These source materials and aids are located within two overlapping 'fields', the task environment and the knowledge environment.
- The task environment consists of the assignment or problem, the limiting conditions within which the student is expected to finish the assignment or solve the problem, and the aids which are available. The problem or assignment resembles, as closely as possible, those situations which will be encountered in professional practice. Limiting conditions and aids are defined by the characteristics of the professional practice. Limiting conditions and aids are defined by the characteristics of the professional situation. The situation can require cooperation with fellow students, for instance in a business simulation, or can put a student in a more isolated role of an adviser to the board of directors, for instance in a case assignment (van Vilsteren, 1995). The main difference is that in an educational setting the point is to practise. In such a setting mistakes are seen primarily as opportunities to facilitate learning.
- The knowledge environment is the sum of all domain-specific and domain-independent knowledge that is available for the task. Some of that knowledge is available to the student as prior knowledge. Some is knowledge which can be obtained from books and other sources (including the teacher and fellow students) which are accessible to the student. The knowledge environment is an aid for completing the task and in this model, therefore, is considered a part of the task environment. In spite of being 'nested' within the task environment the scale of the knowledge environment can grow to a considerable extent.

Student Activities

Strictly speaking, operations on knowledge take place in the knowledge

environment and operations with knowledge, which in turn lead to new knowledge, take place in the task environment. The knowledge environment is part of the task environment, where other aids besides knowledge are available and can be used. The knowledge environment and the task environment are set up in such a way that the student has all the aids he or she needs to achieve the intended results. Hence, the knowledge environment is not taken for granted, but will be made to fit in the design of the task environment.

We can differentiate between the three stages in the classical learning process: orientation, practice and feedback. These stages are found in both the knowledge and the task environments. Orientation takes place largely in the knowledge environment as the student seeks to answer the questions: what should I do; when should I do it; how have others done it; why should I do it; when should I do it; why should I do it in that way? The point, then, is to allow the student to find answers to these questions in the knowledge environment, so that the orientation basis is as complete as possible before the student begins to practise. The design of the knowledge environment should make this possible, and it should take into account the prior knowledge that the student possesses, the way in which this prior knowledge is activated and the way in which new knowledge can be integrated into the existing knowledge structures.

Practice is chiefly done in the task environment. The student tackles the various problems using the knowledge available. He or she uses declarative, procedural, strategic and situational knowledge to solve the problems. All these knowledge elements play a role in the acquisition of competence and return in the exercises presented to the student.

Finally, feedback is the link between the knowledge environment and the task environment. The result of the operations with knowledge (within the task environment) may or may not be the intended one. Consequently, the image of the situation may have to be adjusted, as will the procedural and strategic knowledge (within the knowledge environment). A student may receive highly personal feedback from a teacher, a tutor or fellow students (peers), or more standardised feedback from a computer program (see, for example, Essenius, 1995).

The task of monitoring the study process as a whole takes place more at a meta-cognitive level within the study environment. Monitoring can be undertaken by an external supervisor, an expert or even by fellow students. However, the goal of education should be that the student ultimately assumes the role of self-monitor, reflecting on his or her own learning process and results, and attempting to identify what has gone wrong and how he or she can do better or work faster next time.

As indicated in this section, each one of these elements is indispensable for the acquisition of competence, and should be adequately attended to and coordinated throughout the learning process. We consider Fig. 2 as the point of departure for the design of education aimed at the acquisition of competence, incorporating notions taken from the ACT theory, action psychology and situational learning. As such:

- any design of the knowledge environment will have to consider issues such as prior knowledge, the availability of relevant sources, and so on;
- consideration will have to be given to maximising cognitive processing (this means stimulating a systematic working method in which monitoring and reflection form an essential part); and
- the design of the task environment will involve generating problems and problem situations which are as authentic and realistic as possible, and in which the aids available are as genuine as possible.

Implementing Study Environments within Education

In this section we briefly describe how the study environments described above can be implemented within education. The complexity of certain types of competence means that any study environment whose purpose is to acquire such competence must be carefully constructed. The basic procedure--consisting of orientation, practice and feedback--has to be repeated in increasingly complex configurations (i.e. concentric curricula) before a student can acquire a complex competence at a higher education level.

Complex competencies, such as conducting research, writing an essay, drafting a blueprint, designing a system or developing a business plan--all set in a realistic context similar to those encountered in academic or professional life--cannot be acquired after a single orientation-practice-feedback cycle. It takes many different cycles, at increasing levels of difficulty, to lead students to the required level of competence. The structure of these cycles can take two extreme forms: holistic and atomistic.

Holistic Approach

The holistic approach to the acquisition of competence is based on the entire process. In other words, competence is not divided into individual components, but is exercised as a whole. The student begins by making the simplest blueprint or most general system design imaginable in a realistic context, which already contains most of the fundamental elements that constitute a blueprint or design, especially in terms of procedures. The student starts by conducting the most basic type of research involving each and every research stage, without using advanced techniques or having to satisfy the strictest requirements of validity and reliability. He or she goes through the entire process and receives feedback on it, and after demonstrating competence, goes on to increasingly complex levels.

A number of competences are acquired largely in a holistic fashion. For example, most forms of problem-oriented education are holistic in nature. By giving students realistic (complex) problems which they will have to deal with later on in professional practice, they are inspired to develop and practise their own solution strategies.

When students learn to set up and carry out scientific research, they run through a large number of steps and learn to answer questions in a particular order. An aspiring researcher will therefore first need to become familiar with the systems and relationships within research. It makes more sense to utilise simple but realistic examples of research to illustrate all the various steps and questions in a digestible fashion (i.e. broadly) than to discuss each step or question in-depth by presenting the student with more complex and subtle questions. For example, the Research Methods and Techniques courses at the Open University of the Netherlands attempt to teach research skills by means of (computer) practicals at various levels. At the first level, a simple research design is employed to give the students the overall picture; not until they reach the higher levels do they gain experience in conducting more complex research and using the necessary aids.

It is immediately apparent that the holistic approach does justice to a number of educational psychological principles discussed in the previous sections. According to Stephenson & Weil (1992), the separate development of education aimed at acquiring competence (a 'bolt-on-approach') only has superficial meaning, because it denies the holistic character of competence (which they refer to as capability). When we take the entire process as our point of departure, the orientation basis is immediately as complete as it can be. Students instantly have some notion of the goal and the result of their action, whereas the goal and the result of a partial action may seem abstract and remote to them. The entire action can also take

place within a meaningful context, whereas a partial action is often set in a construed classroom version of reality. The holistic approach, hence, embraces the principles of action psychology and situational learning.

Atomistic Approach

In the atomistic approach to education aimed at the acquisition of competence, such competence is broken down into specific skills or simpler competences. These are presented to the student, who then practises them and is given feedback on his or her performance at each stage. The student exercises these simpler competences correctly and in the right sequence, and will go on to combine them into more complex ones. The student goes through the entire cycle of orientation, practice and feedback for each and every competence. Once the student has acquired a number of simpler competences, they are combined in so-called integration modules (or chapters or blocks or lessons) and demonstrated and practised as an integrated whole.

Mathematics is a superb example of a field that is highly sequentially and hierarchically ordered. For example, one needs to know about functions before one can understand differential equations and about differential equations before one can handle integral equations. The sequence (and not the way) in which the subjects are dealt with is always the same.

The atomistic approach is easy to identify in many educational programmes by the subject-specific sequence of the material, which the students must then integrate and use during traineeships, while writing term papers and while taking part in supra-disciplinary projects. The atomistic approach is often used in the case of competences which can be broken down or demarcated easily, for example mathematics, programming and typing.

Holistic and Atomistic--a synthesis

The acquisition of competence will seldom be made available to students in an entirely atomistic or entirely holistic fashion in higher education. When we speak of a complex academic competence, such as designing a complex whole or conducting research in a realistic setting, the relevant study environment will make use of both the holistic and the atomistic approach. The problem inherent in the atomistic approach is that the sum of all knowledge and skills does not automatically result in a whole, i.e. the desired competence. Even if the aim is to use the holistic approach, competence will frequently still have to be broken down first into various partial competences.

For example, conducting research consists of component activities such as 'formulating working hypotheses' or 'statistical processing of the research data'. These are partial competences, each of which can be learnt separately. This subdivision of learning is usually to be preferred, if only to ensure that the information density of the knowledge environment does not reach excessive levels. In the atomistic approach, however, there is always the risk that the component activities will overshadow the operation as a whole. Time and again, the task environment will have to indicate, and emphasise the context of, these components and the place each one assumes in the entire operation, in order to provide the students with as complete an orientation basis as possible and to make meaningful learning possible. In the case of complicated mathematics problems, it is necessary to select and use specific knowledge and skills from various component fields, combined with more general mathematical skills (such as formulating and presenting arguments correctly). Students can be given such problems to solve in integrative sections of a programme. They demonstrate their mathematical

competence by being able to recognise general mathematics structures in the problems set for them and by choosing the best techniques to solve these problems. Many students never acquire such competence, unfortunately, and never go beyond reproducing isolated mathematics knowledge and skills. For them, mathematics continues to be a jumble of magic tricks.

Acquiring competence in making a business presentation in a professional setting can largely take place holistically, first by having students work on simple presentation situations which gradually become more complex as they progress through the study environment. In the meantime, it would naturally be a good idea to focus from time to time on partial skills such as talking into a microphone or using an overhead projector. If the knowledge environment continuously impresses upon the students what the function of these partial operations is in the overall operation, and the students are given the opportunity to reflect on this, the atomistic approach can effectively complement the holistic approach. Reference is sometimes made in this connection to the just-in-time approach; the student learns a partial action whenever the situation calls for him or her to do so. The context of the partial action remains clearest in this way, and the need to learn the greatest.

Conclusions and Recommendations

Employers have let it be known (Hummel et al., 1993) that graduates, although they possess a substantial store of (isolated) knowledge and skills, do not always know how to use them correctly in their company (hence, they are often not competent). In one way or another, they perceive that higher education is not as successful as it might be in turning out competent professionals.

Curricula in universities and professional schools are, according to Schon (1986), based upon technical rationality. He asserts that:

technical rationality holds that practitioners are instrumental problem solvers who select technical means best suited to particular purposes. Rigorous professional practitioners solve well-formed instrumental problems by applying theory and technique derived from systematic, preferably scientific knowledge. (p. 3-4)

Using this as a starting point, traditional curricula focus upon the teaching of this knowledge and the stimulation of its application. But, as Schon shows, the problems of the real world do not present themselves to practitioners as well-formed structures, but rather as 'messy, indeterminate situations'. As he sees it, there are gaps, on the one hand between the scientific knowledge generated by academics and its relevance to professional practice, and on the other hand between the 'school's prevailing conception of professional knowledge and the actual competencies required of practitioners' (p. 10). Schools try to alleviate these problems by 'keeping up with' knowledge and integrating 'marginal additions' of courses on ethics, strategies, and the like. As a solution he proposes 'turning the problem upside down' by creating learning situations in which people learn to design, perform and produce by engaging in design, performance and production in a safe environment where practice is contextually rich, where reflection is stimulated and where there is access to coaching.

In other words, in most curricula the educational design is not explicitly set up to allow students to acquire competence. We have attempted in this article to approach the problem from an educational perspective and to make a number of suggestions for the design of study environments in which competence can be acquired. Course design needs to focus on the processes involved, the systems of tutorial and resource support, the procedures to be followed, general objectives to be reached, and criteria which have to be met. We have defined the concept of competence as a unique combination of knowledge (knowing what, how, when and why) and skill (being able actually to perform specific operations). The arguments that we put forward here do not do justice to the complexity of the material, but in

our opinion they do offer a satisfactory interpretation of the concept of competence. The definition we use makes it possible for us to describe the exit qualifications of an educational programme in terms of competence. That description involves both the knowledge components and the skill components, as well the setting or context within which competent behaviour must be demonstrated.

The definition of competence also makes it possible for us to seek out theoretical notions of learning which complement this unique combination of knowledge and skill, and to incorporate these notions into a model for the acquisition of competence. For example, we have taken the basic method for acquiring competence (orientation-practice-feedback) and augmented it with notions drawn from the ACT theory (Anderson, 1980, 1993), action psychology (Vygotsky and Gal'perin, according to van Parreren, 1987) and the theories of experiential learning (Kolb, 1984) and situational learning (Brown et al., 1989). This collection of complementary approaches offers a suitable frame of reference for designing education in competence.

Students do not acquire competence by learning a loose collection of skills. They should know what they are supposed to do, why they are supposed to do it, how they are supposed to do it, and why they do it in a particular way and not some other. In short, students must acquire a broad orientation basis before they can act effectively. The knowledge environment for learning must be designed to make that possible. The form and content of the exercise itself should, as much as possible, resemble the task that the student will face later on in professional practice. He or she must be able to acquire and use situational knowledge ('when and in which circumstances you are expected to perform certain actions'). The task environment (limiting conditions, opportunities for interaction) must be designed in such a way that that becomes possible.

In summary, we have 'embellished' the basic procedure used by educational institutions since Thorndike for the acquisition of skills (orientation-practice-feedback) to make it more appropriate for achieving competence. It is possible for an educational institution to design a study environment in which the principles described above are given full expression. However, whether students ultimately learn something depends on them. Monitoring and reflecting on one's own behaviour are therefore important tools with which students can be made aware of their own learning processes and improve them. No study environment should fail to encourage students to do so. According to Stephenson & Weil's (1992) capability approach, assessment should give students opportunities to demonstrate a grasp of specialist studies, the ability to explain what they have learnt, the ability to work effectively with others, and the ability to evaluate their own learning. They warn that a requirement to demonstrate one's competence to others can be a more rigorous demand than that of the demonstration of isolated skills, such as the estimation of a margin of error in an experiment.

We finished this article by giving a brief sketch of a possible design for education aimed at the acquisition of competence. The atomistic approach, with its modelling assignments, appears to be suitable for learning basic (partial) actions. More complex competence is better served by the holistic approach. We discussed both approaches briefly and indicated that in most cases, education in competence usually involves a combination of holistic and atomistic approaches. We also mentioned a variation on this combined approach, known as just-in-time: the student only learns a particular action when the situation requires it. Finally, the article repeatedly emphasised that, if the goal of education is the acquisition of competence, then the usefulness and context of the action must be made clear to the student.

DIAGRAM: FIG. 1. The experiential learning cycle of Kolb.

DIAGRAM: FIG. 2. Representation of a study environment for the acquisition of competence.

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Source: Studies in Higher Education, Jun97, Vol. 22 Issue 2, p151, 21p

Item: 9707174825

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