

Learning Environments: An Introduction

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ABSTRACT

This chapter presents an overview of the chapters of the book. Some recent theoretical and design characteristics of learning environments are discussed. Different disciplinary perspectives can be discerned: pedagogical, psychological, and sociological. But also the characteristics of the learning environments can be studied as being part of the system level on which they are pertinent: the global school level, the intermediate classroom level, and the local learning activity level.

INTRODUCTION

Recently there has been a growing interest in the characteristics of the task environment of the learner. Not only the physical environment is meant by this, but also the intellectual environment that facilitates the learning process. Traditionally, this environment consisted of teacher(s) and students. In ancient times the learning environment was created by the master who taught the novice student by introducing him to an environment that was almost identical to the real context of performing a job. In medieval times in Europe the so-called guild system was very prominent as a vocational-training system. Students learned professional skills by interacting with real tools also used by experts. They gradually became experts themselves through a process in which the influence of the master faded. This form of apprenticeship learning has almost disappeared in the Western educational system of nowadays. Apprenticeship-like practice became a small part of the curriculum of vocational-training systems, at the end of the formal training within schools. Within these systems more emphasis is put on the acquisition of basic skills and also of cognitive skills that are supposed to transfer to other situations, in particular the job context. There is no dyadic interaction of teacher and student any more. Less collabora-

tive learning takes place. Instruction is to be given by a teacher before a class of 20 to 30 students or even more. Learning research therefore concentrated on the conditions that make effective learning within these environments possible, e.g. instructional strategies to be used by the teacher, communication between teacher and students, and interaction between students.

Before the technological revolution came to an important impetus within the field of learning and instruction, theories of instructional design were assumed to pertain to instruction presented to groups of students through traditional means such as lectures, demonstrations and texts. A limited form of communication, almost always one-way, was permitted due to technological inadequacies and constraints. But quite recently, great progress has been made in computation and storage capacity of technological aids and this has a positive effect on designing intelligent learning environments. Still, the main goal to accomplish is to promote the relevant cognitive processes and also to promote their immediate use in context. By the time technological resources became more available research was concentrated on text design and text processing, audio-visual design and even computer-based instruction. Individual learning became possible and there was a tendency to ban the teacher. Information technology runs our life, so why cannot it run our schools and our learning processes? But quite recently, maybe due to a nostalgic tendency to the good old days there has been a growing interest in apprenticeship learning (e.g. Resnick, 1987; Collins, Brown & Newman, 1989; Brown, Collins & Duguid, 1989). Their work on apprenticeship learning originates from cognitive anthropological studies by Scribner, Rogoff and Lave (in Rogoff & Lave, 1984). They stated that effective learning has to be situated in a context similar to the one in which the skills will be used, that student and master or coach have to be active participants in this intellectual enterprise, and that cognitive processes are to be externalised and displayed for inspection and reflection. Success depends on the instantiation of these design features of cognitive apprenticeship. Thus, realistically simulated environments play a major role in transferring inert knowledge into workable procedures to apply in the context of their use. Learning environments can become effective instructional environments if the purpose of the design is to facilitate the cognitive processes by letting the student solve authentic problems within the defined learning environment. In this way it is possible to create what Montague (1988) calls a working environment or functional context for learning. The heuristics in the study of Montague for a func-

tional context are derived from studies on vocational education of more than thirty years ago.

From different perspectives features of optimal environments for learning have been under study for quite a long time and just recently, emphasis has been put on the optimal design of learning environments to come to instructional environments.

Pirolli and Greeno (1988) present an interesting overview of the components of the instructional design problem space of which learning environments form a part. Their problem space consists of nine subspaces, from two dimensions with three levels. These two dimensions are Levels of design issues and Issue types. Under the heading of technological resources (second issue type) Learning environments are to be considered. Technological resources by Pirolli and Greeno (1988) are assumed to provide means for achieving goals and satisfying constraints. If their overview can be functionally read from top to bottom, then learning environments are to be used as an overall generic term for every technological resource used in a functional context intended to promote learning. Pirolli and Greeno (1988) stated that due to current technology, three kinds of instructional environments have been provided. According to these authors one class of instructional environment "... involves an exploratory microworld where students can manipulate objects in a computational system that is designed to embody a set of theoretical principles". Another kind of instructional environment "... involves a sort of apprenticeship in which a teacher first models behaviour that he wants students to emulate and then coaches students as they work to acquire the skill". As learning progresses the influence of the coach fades and the student tries to solve problems independently. A third kind of instructional environment "... emphasises collaboration, either among students or between the students and the teacher on intellectual goals that they share". Instructional environments hence defined in terms of exploration, apprenticeship, and collaboration, bring us back to where we started. Learning knowledge and skills can take place in a relevant environment of their intended use, although due to technological possibilities this transmission of knowledge and culture can be provided at a higher level of aggregation. Highly sophisticated computer and other technological aids simulate job contexts and other real-life situations to enhance learning and to facilitate cognitive functioning. Hence, learning environments are to be studied at the various system levels on which (simulated) contexts can be created. These functional contexts can serve as discovery worlds where the student controls the outcome or as instructional environments where the teacher or the program controls the

outcome. Learning environment instead of instructional environment is therefore the term we want to use for each of the contexts of effective learning mentioned above.

THE ORGANISATION OF THE BOOK

The organisation imposed on the chapters to address the issue of learning environments is deduced from the various aspects of learning environments, in its broadest meaning, both theoretical and structural. Under the heading of goals and constraints the chapters about *classroom environments and its characteristics* can be classified in combination with chapters about *global system evaluation*. A main technological resource is provided by the computer. Chapters about applications and their effects are presented in this book under the title of *computer-based environments*. In the third place theoretical resources have to be mentioned. Chapters about *environments for meta-learning* and *fundamental theoretical issues of learning environments* are provided here.

Classroom environments

The first section of the book is about the characteristics of classrooms as learning environments and the constraints they impose on the learning that is taking place.

Reischman studied a learning environment in which the subject-matter specialist and an adult educator together conducted a course. Continuing vocational training and education and in-service training in companies is almost always performed by subject-matter specialists with no or little andragogical competences. This limits the instructional effectiveness as well as the readiness for lifelong learning. To increase the short-term and long-term effectiveness of such vocational training measures *Reischman* constructed the "tandem"-situation. In his chapter the educational concept and the training scheme are discussed, and the data of a preliminary study are presented.

The central theme of the chapter of *Oosthoek* is how the conceptions of teachers about education in their domain shape the learning environment and will influence learning outcomes. To investigate this question attitudes toward the teaching of law were gathered from teachers in eight law faculties in the Netherlands. Law students in these faculties provided data on

the perception of their learning environment and on their attitude toward law at the end of their first year.

Secondly, the hypothesis was tested that the influence of conceptions about the teaching of law do influence the legal attitudes of students via the arrangement of the learning environment (especially selection of tasks and content) and not via the perception of the learning environment.

Treep and Pieters discuss the current development of automation and information technology and the resulting growing gap between vocational education and the requirements of the labour market. They report about studies that reveal that not only vocational skills must be acquired but also that social skills and attitudes must be a part of a vocational training.

One of the possibilities to realise these educational goals is to build work simulations in which the job reality is simulated. Integrated learning of skills and attitudes mentioned above can take place in an authentic situation. In a work simulation a safe work environment has been created where people can learn how to perform in an job. *Treep and Pieters* report about a preliminary study initiated to investigate what forms of work simulation are used in secondary vocational training and adult education and also what their advantages and disadvantages are. The effectiveness of work simulation was assessed. As a result several models were designed to encompass the existing forms of work simulations.

Schwarzer and Schreiber-Neumann observed instructional behaviour of teachers, who are rated as being enthusiastic. Students first rated the level of enthusiasm of teaching situations in video-film sequences. Verbal and non-verbal instructional behaviour was analysed by different observation indices. Their aim was to identify those observable teacher behaviours that correlate with the rating of teacher enthusiasm and are therefore responsible for the judgement of "enthusiasm". Non-verbal gestures, direct verbal statements to the students, and behaviour variability turn out to be the important dimensions.

In an empirical study in two types of Dutch schools for secondary education *Van der Sijde, Dijkstra and Bennink* systematically observed lessons for teacher praise behaviour. It appears that in the lowest grades more teacher praise behaviour is shown by the teachers than in the higher grades. This holds for task-oriented as well as for student-oriented feedback. Furthermore, there are some major differences between the two types of learning environments. The teacher praise data are related to the outcomes of a

student questionnaire on classroom climate. There are some strong correlations between task-oriented teacher praise behaviour and the scales of the questionnaire 'order & organisation', and 'teacher control'; a similar correlation was found with positive feedback. The implications of these results are discussed in the development of a model incorporating the interrelatedness of the two concepts.

Evaluation of learning environments

Effectiveness of learning environments can be studied at the various system levels on which they are designed. In this part of the book chapters are presented that deal with evaluation aspects of learning environments.

The study reported by *Roßbach* deals with the German adaptation of the ECERS (Early Childhood Environment Rating Scale). Main objectives were to explore the appropriateness of the scale for a culturally different learning environment, to assess the reliability of the total scale and of subscales, to explore its factor structure and to compare item and scale statistics with those of the U.S. original. The results of *Roßbach's* study indicate the appropriateness of the ECERS for German kindergartens in general. However, some cultural adaptations have to be made.

At the school system level of learning environments two output measures, truancy and drop-out rate, are very prominent in determining the effectiveness of these environments. In their study *Van Kesteren and Bos* gathered data from various sources to estimate the effect of truancy and drop-out rate. Truancy and drop-out rate are also related to other school system characteristics. Although they have different causes based on characteristics of the societal system, parental background, student characteristics, and characteristics of the school system, it is the responsibility of schools to take measures to overcome these problems.

Effective school research has not led to unequivocal insight into the relations between school characteristics and output measures like the extent of truancy, dropping out and class repeating. *Bos, Ruijters and Visscher* discuss the problem of data collection. School output as a variable is mainly based on unsystematic perception and subjective interpretation, which often leads to unreliable data.

In their study *Bos, Ruijters and Visscher* systematically collected truancy rates in secondary schools as well the relevant school system characteristics.

The results point out that schools differ in amount of truancy, drop-out and class repeating. Correlations turned out to be significant regarding the relation between characteristics of the learning environment and output measures.

Computer-based environments

Using computers to facilitate the learning process has evolved into conceptions about an environment that tries to solve problems in collaboration with the student. It involves the difference between working with the computer as a technological aid to control the learning environment and enhancing the creative and problem-solving possibilities of students. Salomon, Perkins & Globerson (1989) defined the effects of instructional technology as the effect of working with a partner in cognition. The effects pertain to the acquisition of knowledge and skills while working with current technological systems. It is no longer the system that controls the information processing but the student himself solves problems in an facilitating environment, collaborating with the computer. The chapters in this part of the book concern the enhancement of learning and the acquisition of knowledge and skills within artificial environments like microworlds, intelligent tutoring systems, adaptive systems and other computerised environments.

We mentioned above Pirolli and Greeno's distinction of forms of intelligent learning environments. The chapters can be divided along this distinction.

An important technological resource is the computer. For the main part its influence is on the local level of instruction, although more and more other aspects of computer-based instruction can be found on the intermediate and global level of instructional design. On the local level computer-based instruction can be called computer-assisted instruction, on the intermediate level computer-enriched instruction, and on the global level computer-managed instruction.

In their contribution *Van 't Hul, Lijnse and Moes* report evidence for the simulation of microworlds to provide a useful mean of designing instruction that is effective in developing the necessary conceptual change. This change will be brought about by letting students solve conceptual problems (caused by misconceptions) they encounter in understanding physics. Strong examples of such misconceptions are found in the field of classical mechanics. *Van 't Hul, Lijnse and Moes* developed a microworld based upon a theory of conceptual change by trying to arouse a conceptual conflict. In

their chapter this microworld deals with the principle of inertia in both a real and frictionless world.

Intelligent tutoring systems may help students to acquire skills that they can apply in different areas, for instance in the domain of second language teaching. The contribution of *Kanselaar, Wichmann, Giezeman, Zuidema, Van der Veen and Koster* approach the second-language learning problem by stressing the issue of the learning of communicative skills. Their computer program PRESTIGE subscribes to the views currently held in communicative language teaching. Among those are learning the meaning of a word through deduction of the word's meaning from contexts, and emphasising the use of productive language. To realise these ideas in computer-assisted instruction, the computer program consists of several parts: a parser which checks whether the input sentences are syntactically correct, and a database which consists of grammatical features of words, descriptions of the meanings of words, and sentences in which the words are used in ordinary everyday English. In their chapter research issues on the use of different help options in the program are addressed.

Another domain is studied by *Beishuizen, Felix and Beishuizen*. Based on empirical data and theoretical models, that distinguish rule-based levels and transitions in the acquisition of cognitive skills, a genetic model, with developmental stages for learning mental addition and subtraction with bigger numbers (20 - 100) is proposed. An adaptive computer program will be described that has been developed with an intelligent tutor component, that coaches children according to different learning routes, deduced from this genetic model. First, the preferred strategy, with which a child enters the program is stabilised to mastery level. Secondly, the child's strategy is restructured according to a nearest-higher developmental stage. The hypothesis will be tested that such student-based tutoring will result in more effective and more flexible mental strategies than giving only expert-based feedback (as in mathematic books).

A more theoretical contribution concerning the use of production system technology within the domain of arithmetic skills is put forward by *Van Putten and De Ronde*. Learning-disabled students in Dutch Junior Vocational Education have severely deficient written arithmetic skills. Procedural and metacognitive aspects of their long division performance are taken into consideration for explaining errors and for providing a basis for diagnosis and reinstruction in CAI. Expert long division performance is

represented in a production system for a standard, efficient algorithm. Some of the student errors can be reproduced by changing production rules. The most frequent error 'forgetting to write a zero in the quotient', has to be explained by an overgeneralised starting rule, and not, as usual, by 'forgetting' to execute parts of expert production rules.

Arithmetic skill learning was also studied by *Ippel and Meulemans*. They designed a microworld environment for addition and subtraction. Their study is aimed at specifying constraints on states of the worlds determined by this environment and on operators applied on those states. One of the basic assumptions with the use of this environment is a limited state of prior knowledge. The students are supposed to acquire knowledge by using general problem-solving methods. A computer simulation was run and the results of this simulation are presented.

Vernooij presents a learning environment based on the SPABEC-method that facilitates learning to solve problems within the domain of business economics. A theory of instructional design containing a systematic problem approach in Business Economics Courseware is used. To create a meaningful interaction structure between the CAI-program and the student, study problems must be analysed in six stages. Stage four contains a systematic problem approach.

By using the method of goal analysis, the study problem is transformed by backward reasoning. Every concept in the transformation is an epitome to discover a procedure connecting other concepts. Step by step concepts are revealed and an inventory of (sub)procedures is made. These steps can be presented in a diagram. This diagram offers the possibility for both a heuristic and an algorithmic way of interaction.

Wierda, Van den Burg and Tromp tested courseware for traffic education. It became apparent that optional 'help' can and should be built in the program. The procedure should at least provide help on the content of the subject matter (concepts, relations and definitions) and functions of the program, for example the user interface. Hence, the teacher can pay attention to specific students while others work individually. The teacher can, furthermore, offer a wide range of subjects since he does not need to know the entire learning environment as long as it is adequately incorporated in the software.

Environments for meta-learning

Recent advances in cognitive science have yielded new insights in human mental functioning. The student can not be seen any longer as a passive system in which information can be poured. Instead, the student is an active participant in a learning encounter in which other students, teacher(s) and technological resources participate, too. He processes information in a very particular and often a very personal way, which is displayed by recent technology to externalise problem-solving processes. By letting the student recapitulate, reflect or articulate his ideas and strategies he gains insight in his own learning. Supportive environments have been designed in which students are indeed encouraged to perform in a mindful way. In this part of the book effects of those supportive environments will be discussed.

Wolters explored the relation between metacognition and learning to learn on the one hand and learning-to-think skills on the other hand. Students from regular and special primary schools were tested to assess the developmental level of metacognitive skills. A quantitative analysis of the results of this study shows that there are differences in metacognitive functioning between the two groups of students. A qualitative analysis of the results of a sample shows that the differences must be primarily interpreted as a difference in planning behaviour. A three-stage process in the development of planning behaviour is observed: Stage 1 - haphazard non-planning behaviour. The student is unaware of the end result until after it has been accomplished. Stage 2 - inductive stepwise planning behaviour. The student's approach is a step-by-step changing of the situation. Stage 3 - deductive planning behaviour. The student does all the planning prior to the execution.

Büchel noticed that an increasing interest for the teaching of learning and thinking can be observed in educational practice and applied psychology during the past ten years. Programs based on theories of general information processing, metacognition, and social constructivism are offered to adolescents and adults in professional school setting, but also to normal and retarded children in regular and special schools.

In a series of studies with vocational students, learning skills are described differentially. Exercises of experimentally separated components were executed with students of different age and ability level. In his contribution he presents an evaluation of the different training approaches.

From a Vygotskian point of view *Terlouw and Pilot* studied students' behaviour in problem-solving courses developed in the physical and social science domain. The courses were aimed at teaching a system of domain-specific problem-solving methods for an improvement of strategic acting. Field regulation - external help of teachers and teaching aids for formulating an orientation basis - was supposed to change into the direction of self-regulation of strategic acting - independent formulation of an orientation basis.

The developed courses turned out to achieve this goal. Implications for instruction are discussed by *Terlouw and Pilot* in relation to the student's use of the strategic problem-solving methods.

De Jong's study is focused on the effects on self-control of students who followed an executive control training embedded in their extra homework for a regular mathematic course. His experiment is addressed to trace the effects of the training on the executive control processes. Thinking-aloud protocols were analysed of the 26 participating first-year secondary school students. They were qualified for participating, if their mark for mathematics on their second term report was lower than a seven (7; fairly good). The supportive tutoring was effective to the metacognitive knowledge of the trained students and on certain executive control processes, especially on checking processes.

In his chapter *Boonman* describes the results of a study on problems by 10-12 years old students with text coherence. The students are monitored while reading a text containing inconsistencies and unknown words. The main results show that students used local strategies with shallow criteria for dealing with text coherence. This is consistent with the knowledge-telling model proposed by Bereiter and Scardamalia. *Boonman* discusses implications for instruction, especially for teaching reading comprehension and studying texts.

The Leittext method is a German individualised system of industrial education to stimulate self-regulation in learning and working. This method is related to ideas of self-regulated learning and can be considered as a domain-specific training program to enhance self-regulation. *Teurlings* implemented the method in a training for mechanics in the pay of Philips Lighting Roosendaal. It turned to be a practical and useful instrument for systematic vocational education. *Teurlings* discusses future applications of the Leittext method to really support self-regulated learning and working.

Van Hout Wolters discusses the preceding studies of Büchel, De Jong, Terlouw and Pilot, Boonman and Teurlings on self-regulated learning. She concludes that training self-regulated skills have positive effects on problem solving and learning to learn in other domains.

Theoretical issues of learning environments

Fundamental questions about speed-accuracy trade-off problems in measuring cognitive outcomes, about motivational problems in instruction and about effects of prior knowledge in instruction are discussed in this section.

Errors and latencies are complementary aspects of performance. *Lohman* explores the consequences of attempting to ignore one aspect of performance while analysing the other. In particular, he argues that the twin problems of what to do with error-response latencies and how to equate subjects on speed-accuracy trade-off have seriously clouded our efforts to understand individual differences in cognitive processing. He then shows how both of these problems can be solved by collecting data in a way that allows one to determine how accuracy and latency covary within each cell of the design.

Results from four studies using diverse cognitive tasks also suggest that this method yields scores which better capture the information-processing characteristics of individuals than conventional analyses based on errors or latencies do.

Schiefele presents results of two studies pertaining to the influence of topic interest on the comprehension of expository text. The primary goals were: a new conceptualisation of the construct "topic interest", consideration of quantitative as well as qualitative measures of comprehension, and determination of the degree of independence of the interest effect from the factors of previous knowledge, intelligence, short-term and long-term memory, and assorted motivation variables. In addition, an attempt was made to tentatively identify factors that could be used to explain the interest effect (e.g., attention, arousal, flow experiments).

Dochy discusses the role 'old' knowledge plays in the acquisition of 'new' knowledge. Prior knowledge has proven to be a very effective variable. About 30 to 60 per cent of the variance is explained by prior knowledge. In his chapter *Dochy* presents eight hypotheses from previous research and their implication for designing learning environments will be discussed.

A model is designed that shows the different points of view of the stated theories and their relationships and argues for some implications for research and instruction.

CONCLUDING COMMENTS

Human and non-human aspects of the learning situation play a major role in the acquisition of knowledge and skills by the learner. The learning environment serves at least three functions: as a tutor, as a tool or as a tutee. At first, as a tutor the environment controls learning process and decides what to teach to the student. He, she or it presents problems to solve and may or may not have a decision mechanism that determines what the next presentation or problem should look like. Traditional CAI but also more sophisticated systems like TICCIT (Merrill, Schneider & Fletcher, 1980) or MAIS (Tennyson & Christensen, 1988) are good examples of this category.

Secondly, as a tool the learning environment is a buddy for the student. He, she or it advises the student what to do, it can help the student to solve problems by letting him know what the preceding solutions or steps were, and it can serve as a database. Expert systems serve this function.

Thirdly, the learning environment may play the role of a tutee. By manipulating the environment the student may get insight in his own decision or problem solving strategies. Social simulations with or without computer are nice examples.

This way of facing learning environments pertains to the micro-level of the educational system. Learning environments may also be manifest at other levels of this system. In this book we will encounter applications of learning environments at various levels of the educational system.

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