

Running Head: INTRODUCTION TO THE SPECIAL ISSUE

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**The Pedagogical Use of Information and Communication Technology in Education:
A Dutch Perspective**

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Abstract

This special issue discusses Dutch research on Information and Communication Technology (ICT) in education. In this introduction, four broad research lines are distinguished: Policy-oriented research, research on learning technologies, research on computer-based instructional design tools, and research on the pedagogical use of ICT. The focus of this special issue is on the last type of research. The main research questions, findings and conclusions of the six contributions are discussed. It is concluded that the most important directions for future research deal with the added value of ICT for *information* problem solving in resource-based learning, for *collaboration* using external representations and tools that provoke critical discussion and reflection, and for *simulation* in learning environments for competence based learning and discovery learning.

The Pedagogical Use of Information and Communication Technology in Education:

A Dutch Perspective

Each year, the American Educational Research Association (AERA) invites the Netherlands Educational Research Association (NERA) to organize an invited symposium at its Annual Conference. This symposium is typically prepared by one of the ten NERA divisions. In the year 2003, the relatively new division *Information and Communication Technology in Education* (for short, the NERA ICT division) had the honor to organize the invited symposium at the AERA Annual Conference in Chicago. The papers presented in Chicago gave an excellent impression of the kind of research on ICT and education that is currently conducted in The Netherlands. Therefore, it seemed a good idea to make this overview available for a broader public, and the intention to publish the set of papers as a Special Issue was a logical next step. We are grateful that *Computers in Human Behavior* was willing to consider this set of papers for publication.

This Introduction to the Special Issue will first discuss the state of affairs with regard to ICT and education in the Netherlands. Four broad research lines are distinguished, and this issue will focus on only one of them: research that is explicitly concerned with the pedagogical use of ICT in and outside schools. The second section positions the contributions to this Special Issue in the Dutch educational field. The main research questions, findings, and conclusions of each contribution are discussed. Third, some general conclusions are formulated. Future research directions should deal with information problem solving in resource based learning, collaborative learning using tools that promote critical discussion and reflection, and simulation in learning environments for experience based learning.

ICT and Education in The Netherlands

Four broad strands can be distinguished with regard to Dutch research on ICT and education: (1) policy-oriented research on ICT in education, (2) Research and Technology Development (RTD) in the field of learning technologies, (3) research on computer-based Instructional Design (ID) tools, and (4) research on the pedagogical use of ICT. *Policy-oriented research on ICT in education* is typically conducted under the authority of the Dutch Ministry of Education, Culture & Science, and organized in research programs such as ‘ICT in Education’, ‘Education On Line’ and the ‘ICT monitor’ (for an overview, see www.ictonderwijs.nl). In the Netherlands, the schools are responsible for the innovation of their own teaching, including the use of ICT, while the government stimulates and facilitates such innovation. Compared to other Western countries, the technical infrastructure available in Dutch schools is good. There are about 10 students per computer and all schools are connected to the Internet as well as ‘Kennisnet’ – a network especially for schools. A point of special attention has been and still is the schooling of teachers with regard to their ICT skills, but over the last years reasonable progress has been made in this respect. For the near future, policies will be mainly directed at solving two persistent problems, namely, the continuous lack of high-quality and affordable digital learning materials in schools and difficulties with applying ICT in such a way that it actually improves teaching and learning processes.

RTD in the field of learning technologies is mainly dealing with the fact that the development of sufficient high-quality learning contents proves to be extremely difficult. It requires considerable time, large budgets, and design and development expertise that are only scarcely available (Rosenberg, 2000). The dominant line of research focuses on enabling the reuse of learning materials. The basic idea is that once made, learning content could be used

many times in many different instructional settings. If the learning content is divided into small, modular chunks called “learning objects”, developers will be able to combine and recombine these objects to create new learning content. Learning technology standards are intended to ensure that learning objects will be developed, organized, and distributed in a uniform manner. Such standards hardly deal with pedagogical issues because the claim is made that standardization should be “pedagogically neutral”. Nevertheless, even a neutral approach should offer the opportunity to implement the widest possible variety of instructional methods in such a way that reusability is still warranted. At the Open University of the Netherlands, a generic instructional structure for learning objects was described by means of an Educational Modeling Language (EML; Koper & Manderveld, in press), which is currently in the process of being standardized by the Learning Design group of the IMS Global Learning Consortium (IMS-LD; Koper, Olivier, & Anderson, 2002).

Third, *research on computer-based ID tools* studies how ICT may help designers or teachers to perform the ID process, that is, to apply the ADDIE cycle (analysis, design, development, implementation and evaluation) in an effective and efficient fashion. Van Merriënboer and Martens (2002) describe a number of tools for analyzing tasks or contents and to design blueprints for lessons or training programs (i.e., pre-authoring tools), to develop instructional materials (i.e., authoring tools such as Authorware or Toolbook), and to implement and evaluate instruction (i.e., post-authoring tools). As is the case for RTD in the field of learning technologies, the main goal of this line of research is to make the process of developing high-quality learning contents quicker and cheaper.

Finally, *research on the pedagogical use of ICT* mainly studies how ICT may improve teaching and learning processes (Jochems, van Merriënboer, & Koper, 2003). The focus of this

Special Issue is on this third line of research. While most Dutch researchers will probably agree that ICT *per se* cannot improve instructional processes (cf., Clark, 1994), it should be clear that ICT may, at least in principle, enable the use of innovative instructional methods that may help to make learning more effective, efficient and appealing. This pertains both to delivery strategies, which are instructional methods for conveying the instruction to the learner and/or for receiving and responding to input from the learner, and to organizational strategies, which are instructional methods for organizing the learning tasks and the contents that have been selected for instruction (Reigeluth, 1983). For instance, ICT may enable the collaboration between learners that are distributed in space or time (i.e., permit a delivery strategy that would, under the given circumstances, not be possible without ICT) or enable learners to work, in the classroom, in a simulation environment that allows them to study the effects of different policies on the economical growth of a country (i.e., an organizational strategy that could never be applied in the classroom without the use of ICT). The six contributions that form part of this Special Issue are all in search of such an added value of ICT. They will be briefly discussed in the next section.

The Pedagogical Use of ICT in Education

The contributions to this special issue are representative for the whole broad field of education. The first contribution by Hans van der Meij, Kerst Boersma, Jules Pieters and Rupert Wegerif is concerned with the use of ICT in *elementary schools*. The second contribution by Simone Löhner, Wouter van Joolingen, Elwin Savelsbergh and Bernadette van Hout-Wolters is positioned in *secondary schools*, and the third contribution by Gijsbert Erkens, Jos Jaspers, Maaïke Prangma and Gellof Kanselaar is also dealing with secondary schools but focuses on the last phase in secondary education, which is in the Netherlands called the '*Study House*'. The fourth contribution by Saskia Brand-Gruwel, Iwan Wopereis and Yvonne Vermetten deals with

tertiary and post-tertiary education, studying Psychology freshmen and PhD students. The fifth contribution by Judith Gulikers, Theo Bastiaens and Rob Martens is also positioned at the tertiary level, but now studying *lifelong learning* at a distance teaching university. To close the circle, the sixth and final contribution by Joke Voogt, Marinus Almekinders, Jan van den Akker and Bert Moonen discusses an *in-service program for teachers*, dealing with the integration of ICT in the classroom.

The contribution *An examination of interactional coherence in email use in elementary school* (van der Meij et al.) reports a study of email use in elementary school. An analytic model consisting of a contextual, rhetorical and semantic dimension is proposed as a means to measure interactional coherence. The contextual dimension is critical for the embedded use of email. It characterizes the situation in which email is used and it determines its functionality. One of the important features of this dimension is the task children must accomplish. The use of email must actually support the realization of this task. In this study the children could engage in dialogues to help them in dealing with a complex assignment in the domain of design and technology. The children worked in design groups on an ill-structured problem (i.e., the construction of a plane). Email was used to extend the dialogues as each group communicated with another group from another school that had the same task. The rhetorical dimension describes the general dynamics of communicating through email. These dynamics include aspects such as turn-taking and communication threads. The semantic dimension focuses on what and how is communicated. The main concern here is to qualify the content of an interaction, but also to focus on motivation and emotion. Students' emails are analyzed using a coding system based on the analytic model. Results reveal a direction towards mutual understanding as exhibited by, among others, a majority of statements dealing with the children's learning experiences, a fair share of attention

to the process of communication, and questions that mainly serve to promote a sharing of information and experiences. The conclusion is that email can be a proper medium for engaging children in dialogues as conversations.

The second contribution, *Students' reasoning during modeling in an inquiry-learning environment* (Löhner et al.), studied secondary school students working in dyads on a computer-modeling task with a textual or a graphical representation. A task about the temperature regulation inside a house was implemented in a discovery-learning environment. During their work on the modeling task, all learners' actions were logged and conversations were recorded and analyzed in order to find out if different external representations lead to different reasoning activities and, more specifically, to differences in the way the collaborating students communicate about the models they are constructing. A normative description of the modeling process forms the basis for analyzing the data. Four categories of reasoning actions were distinguished: orientation, hypothesis generation, experimentation and evaluation. Results reveal that in both groups (with graphical and textual representation) students spend most of their time during inquiry modeling on scientific reasoning activities. Furthermore, it was found that students in the graphical condition designed more experiments with their own model, formulated more qualitative hypotheses, and spent more time evaluating their own model than students working with a textual representation. Overall, the results indicate that students have great difficulties with performing the modeling task in a systematic manner.

The third contribution, *Coordination processes in computer supported collaborative writing* (Erkens et al.), concerns a groupware environment for secondary education students that enables students to collaborate in writing an argumentative essay. The TC3-groupware (Text, Composer, Computer supported & Collaborative) offers access to relevant information sources, a

private notepad, a chat facility and a shared word processor. Two planning tools could be integrated in the groupware: a shared argumentation diagram for content generation (Diagram tool) and a shared outline facility for content linearization (Outline tool). Both tools could be combined with an advisor that facilitated the use of the Diagram or the Outline tool. Different conditions were created (with or without a planning tool or a combination of tools) in order to investigate the relation between task-related planning activities and collaborative coordination on the one hand, and the quality of the argumentative text on the other hand. In all the conditions pairs of students wrote an argument on cloning or organ donation. The argumentations (measured by the textual structure, segment argumentation, overall argumentation and audience focus) and student chats (measured by task activities and communication processes) were analyzed. Results reveal that coordination and planning of the writing activities are crucial for the quality of the argumentations. Furthermore the Outline tool in the TC3-groupware was more successful than the Diagram tool. The use of the Outline tool had a positive effect on the dialogue structure, the coordination process and the quality of the writing product.

The fourth contribution, *Information problem solving by experts and novices: Analysis of a complex cognitive skill* (Brand-Gruwel et al.), describes the analysis of the complex cognitive skill of information problem solving. University freshman ('novices') and PhD students in their final year ('experts') had to write an argument for a consumer's magazine on the keeping qualities of food and its durabilities date. The Internet had to be used to gather the necessary information. The main aim of the study was to make a decomposition of the information problem solving skill and to compare experts and novices in order to gain insight in the most critical subskills. With a coding system based on a preliminary model the thinking-aloud protocols of the participants, who had to ventilate all their thoughts during accomplishing the task, were

analyzed. Five main skills were identified: define problem, search information, scan information, process information, and organize and present information. Furthermore, subskills and regulation processes were described. The comparison between the experts and the novices revealed that experts spend more time to define the problem and more often activate their prior knowledge, elaborate on the content, and regulate their process. Experts and novices did not differ in the way they searched the Internet. These findings formed the basis for formulating instructional guidelines for teaching information problem solving.

The fifth contribution, *The surplus value of an authentic learning environment* (Gulikers et al.), aims to gain insight in the value of using authentic tasks and, especially, authentic learning environments in teaching. The study is situated in the field of higher (distance) education and lifelong learning. It focuses on the central type of learning in electronic competence-based environments, namely, learning by performing realistic tasks. The main research question is if the measure of authenticity of the e-learning environment in which the learning tasks are performed has an impact on learning outcomes and student experiences. Two electronic learning environments for counselors or junior consultants were compared: an authentic environment with many multimedia features to create a virtual organization (i.e., a consultancy firm) and a non-authentic, text-only version. A remarkable result from this study is that students in the authentic learning environment did not perform better on a performance test and factual knowledge test than students in the non-authentic environment. Furthermore, the students experienced the authentic environment not as more “realistic” or more motivating than the non-authentic environment. So, it seems that all the—expensive—extra’s that make the ‘virtual organization’ more authentic do not lead to better learning outcomes.

The sixth and final contribution, *A blended 'in-service' arrangement for classroom technology integration: Impacts on teachers and students* (Voogt et al.), discusses the implementation of technology in education as a complex innovation. This study determines the effects of 'blended' in-service arrangements for implementing technology in secondary education on teachers and students. In the 'blended' approach workshops are alternated with periods in school during which the participating teachers could communicate, by using the Internet, with each other and exchange classroom materials. In the first study foreign language teachers (German and French) participated in workshops and in-service networks. The teachers got the assignment to use the Internet in their classrooms and discuss their experiences using the network. Interviews, classroom observations, questionnaires and analyses of the electronic communication reveal that teachers' attitudes changed positively during the implementation, that for almost all observed lessons the implementation of the technology was a success, and that the students were highly motivated. The second study, which was a Dutch-Russian collaborative project, aimed at (a) supporting physics teachers with the implementation of technology in a learner-centered approach for physics teaching and (b) exploring the potential of the WWW in an in-service arrangement. The same kind of in-service arrangements and measurements were used as in the first study. Results reveal that teachers were positive and said that they had learned a lot about the technology and the learner-centered approach. Also student satisfaction increased. The general conclusion is that 'blended' in-service arrangements seems promising for supporting teachers in implementing complex innovations, such as starting to use technology in their teaching.

Two discussion chapters conclude this Special Issue. Brent Wilson from the University of Colorado at Denver and Bob Tennyson from the University of Minnesota critically discuss the

different contributions. They also reflect on the state of affairs regarding the pedagogical use of ICT in Dutch education and discuss some salient differences between The Netherlands and the United States of America.

Conclusion and Future Directions

Traditionally, the added value of ICT in education is mainly related to the increased flexibility of delivery strategies, making it possible to learn independent of time and place and in one's own preferred tempo. This can for instance be found in the study by van der Meij et al., in which elementary school children discuss their designs for flying objects with children from other elementary schools; and the study by Voogt et al., in which Russian teachers in rural areas discuss their lesson plans with teachers who might be located thousands of miles away.

However, most contributions to this special issue do not deal with flexibility issues. Instead, they claim that the added pedagogical value of ICT lies in new ways of organizing learning tasks and learning contents.

With regard to instructional methods that concern organizational strategies, three conclusions pertain to educational changes dealing with (1) information, (2) communication and collaboration, and (3) simulation. With regard to information, ICT makes it possible to confront students with more information than has ever been possible before (e.g., by using the Internet) and to present large amounts of relevant as well as irrelevant information. Yet little is known about the effects of these changes. For instance, Gulikers et al. claim that the availability of irrelevant information is characteristic of an authentic environment, but their results seem to imply that learning in such an authentic environment is not always effective. Brand-Gruwel et al. also show that novice learners have great difficulties to find what they are looking for in a system of Resource Based Learning (RBL), where students have to perform an authentic task

and search for necessary information on the Internet. Future research should investigate the effects of information load, information (ir)relevance, and information redundancy on learning but also develop new instructional methods that help students to develop the complex skills for coping with the information overload in our society.

Second, ICT enables new forms of communication and collaboration between learners. The added value is typically not related to the communication facilities *per se*, but to the use of—dynamic—external representations and tools that allow students to collaborate in a fashion that would hardly be possible without ICT. For instance, in the study by Löhner et al. students work together in building runnable computer models in a discovery learning environment, and in the study by Erkens et al. students work on a common text using tools that stimulate them to discuss the topics that will be dealt with and the outline of the text. Also in other studies, communication facilities are mainly used to enrich a process of learning by design: Children are provoked to reflect on their design for flying objects in the study by van der Meij et al., and teachers are provoked to think about their lesson designs in the study by Voogt et al. The point is that ICT should enable the use of instructional methods that enhance reasoning, provoke critical thinking, and deepens understanding. Future research should precisely aim at the further development of such reflective, knowledge generating activities or “epistemic games” (Sherry & Trigg, 1996).

Last but not least, ICT enables the use of (complex) simulation in education. In our view, this is probably the most important added pedagogical value. It fits very well with modern instructional theories that focus on the performance of real-life tasks as the driving force for learning (see Merrill, 2002). The general assumption is that realistic or authentic learning tasks help learners to integrate the knowledge, skills and attitudes necessary for effective task

performance, and eventually enables them to transfer what is learned to their daily life or work settings. As described in the contributions by Löhner et al. and Gulikers et al., ICT enables the use of such simulated task environments in regular classroom or distance teaching settings and allows for experimentation, discovery and experience-based learning. Future research should carefully examine the necessary nature of authenticity and, especially, the required similarity between the environment in which the learning tasks are performed and reality. It seems plausible that authentic learning tasks must be carefully sequenced from simple to complex, that these tasks need to be performed in environments that gradually increase fidelity (i.e., similarity with reality) if learners acquire more expertise, and that learners' task performance is scaffolded by well-chosen means of problem solving support (see van Merriënboer, Kirschner, & Kester, 2003).

Summarizing, the main conclusion that can be drawn from the contributions to this Special Issue is that in the field of education the abbreviation ICT can best be replaced by ICST, meaning *Information, Collaboration, and Simulation Technology*. Three main questions for future research on the pedagogical use of technology in education are then: How can we best help learners to profit from the wealth of information that is nowadays available and easily accessible through the Internet? How can we promote effective collaboration between learners in order to improve their learning? And how can simulated task environments best be used to bring experience-based learning to the classroom?

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