Independent learning with ICT: two studies on electronic support

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1. Abstract

In this article an overview of research and some developments regarding the use of information and communications technology (ICT) at the Open University of the Netherlands are presented, mainly in the content domain of descriptive statistics. Stressed are the educational reasons for using ICT, amongst which are the need for flexible, interactive student centred education. With the increasing use of ICT more and more self study techniques are being used. In the introduction, information will be provided about the important role of embedded support devices (ESDs) to cope with disadvantages of self study. Earlier research showed that these ESDs are often used by students, can lead to better study results, and are highly appreciated. However, it was also found that electronic learning environments are needed to individualise these ESDs and other course components. Two tools for this are described: the *electronic workbook* and *Mercator/ELO*. Both tools were developed to design, develop and deliver flexible education in an electronic mode. In two investigations student and author experiences were studied. In general the results were positive. Student attitudes seem to play an important role in the willingness to study with ICT. In the final part of this article some recommendations for research and development are presented.

2. Introduction

Valcke and Thorpe (1995, p. 112-113) define distance education as 'the provision of learning opportunities which may be pursued by learners at sites (such as their homes or workplace) geographically removed from their tutors and the providing institution'. Distance education and self study are therefore often called 'independent learning'.

Increasingly more researchers and developers see advantages in distance education (see e.g., Szücs and Wagner, 1998; Wassenberg and Philipsen, 1997). These advantages include: the freedom for students to study where and when they want, educational-economic arguments (distance education may be a cheaper and more effective alternative to conventional, classical education) and a new perspective on education in which the focus has shifted to the learner (Martens, 1998). In considering how best to optimise education, some authors have hit upon the idea that the teacher plays a too central role in 'conventional' education (Moore, 1977).

Several authors stress that students focus on what the teacher wants and reproduce his/her views as much as possible. Many authors believe that it would be much better to focus

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more on the student, with the student working on his own, at his own initiative and more out of his own interest and curiosity than the teacher's. The instructional material and the teaching should be tailored more to the needs and wishes of the students, in terms of form and content next to time and place (e.g., Kirschner, Valcke and Van Vilsteren, 1997; Adams, 1997; Putter and Marnewick, 1997; van Oers and Forman, 1998).

Another crucial aspect of this development is the rise of information and communications technology (ICT) (Fletcher-Flinn and Gravatt, 1995). Distance-teaching universities have traditionally embraced this type of ICT because it helps solve some of the specific problems inherent to distance education. In this type of education the learner studies more independently mostly with learning materials that are designed for this purpose. The role of the teacher has become that of a supporter at a distance. When ICT is used in education, it is often accompanied by a greater emphasis on independent study, on the freedom to determine time and place, because physical barriers are removed (Hawkridge, 1995; Studulski, 1995). In the past ten years, the availability of relatively inexpensive, powerful personal computers has introduced a new, almost unexplored source of innovation in educational technology (Montague and Knirk, 1993; De Wolf, 1996; Neal, 1997; Zonika, 1997; Hawkridge, 1995; Bates, 1995).

Meta-analyses which compare 'conventional' educational methods to computer-assisted education emphasising independent study, frequently show that the latter methods lead to better performance, for example, in terms of the pace of study (Fletcher-Flinn and Gravatt, 1995; Montague and Knirk, 1993; Martin and Rainey, 1997; Granger and Gulliver, 1995).

Some authors believe that distance education techniques could partly replace face-to-face lectures at conventional universities (e.g., Holmberg, 1995; Sewart, 1995; Moerkerke, 1996; Jenkins, 1995; Jennings and Ottewil, 1996).

In line with these developments, in the field of statistics education many initiatives can be found in Dutch speaking higher education. For example, the Cyberstat project tries to stimulate and facilitate the co-operation between more ore less independent projects between four universities/academies[2]. In these institutes, educationalists and content domain experts are trying to improve their education in statistics by using ICT in combination with self study techniques and/or problem based or case based education. One of the Cyberstat partners is the University of Gent (Belgium) where researchers are currently constructing interactive flexible electronic learning. These materials should enable fast adaptation to student characteristics, provide more 'dynamic' presentations of course materials, stimulate use of hyperlinks, active multiple choice question, etceteras. (Dekeyser, 1998).

Distance education obviously has disadvantages as well (for an overview see Martens, 1998). Disadvantages are the relative lack of support, guidance and interactivity, the fact that course material is often static and not tailored to meet the needs of the users, and the lack of interim adjustments to take account of what students actually do. These are critical problems which are at least partly to blame for the difficulties students encounter in the process of self-study. Such problems may express themselves in the form of students' falling behind in their studies or dropping out. Distance education attempts to solve these problems by making use of embedded support devices (ESDs) in (written and electronic) course material. These didactical aids consist of a whole spectrum of additions such as examples, questions with feedback, study guidelines (e.g., 'Write down the most important points raised in the

[2] More information in Dutch can be found on www.ouh.nl/open/rma/cyberstat/.

summary about analysis of variance'), advance organisers (e.g., 'Your next task will be to explore the theory mentioned above'), exercises and margin texts. For typical examples of the ESDs we refer to the courses in the domain of statistics that have been developed by open universities in several countries. All these devices are in fact an attempt to replace the teacher in front of the classroom.

In a series of investigations (Martens and Valcke, 1995) it was concluded that ESDs have a positive impact when added to course material. Students make frequent use of them, usually at a deep level (focusing on understanding). Students are appreciative of ESDs and using ESDs improves study outcomes, particularly concerning insight questions. Because the average use of such devices is high, however, it is difficult to explore the correlation with individual student characteristics. The high level of use also suggests that ESDs do not really take account of differences between students, despite the great diversity of students (Martens, Poelmans, Daal and Valcke, 1994; Martens, Valcke, Poelmans, and Daal, 1996). Martens and Dochy (1997) investigated one type of ESD, assessment with feedback, and found about the same results.

Electronic learning environments are an educational medium which, in addition to many other advantages, are capable of responding to individual differences between students (Martens, Valcke, and Portier, 1997). In such environments it is easier, both in technical and in practical terms, to take differences between students into account. For example, it is possible to draft problems which are tailored to the needs or the context of specific students. A study was carried out at a mainstream university, with students (n=502) studying for a examination on descriptive statistics. The setting made it impossible to vary the actual contents of the course material (e.g., quantity or type of ESD), as this could be to the disadvantage of some of the students. Instead, there was variation in the form in which the material was presented within the self-study conditions. The two forms used were written material and electronic material. There was also material in which the layout of the basic text was distinguishable from that of the ESDs, and conditions in which the subject matter was simply presented as an uninterrupted text. A post-test revealed that there were no differences in terms of performance between the various conditions and between the experimental and the control conditions. The control condition was the 'mainstream', traditional lecture, which is supposed to be replaced by self-study for educational-economic reasons. The students' own assessment of the consumability of the material was significantly more positive in the self-study conditions. There were also significant interaction effects. In one condition the ESDs were easy to distinguish from the basic content by means of a different lay out (Figure 1), in the other they were completely integrated in the content. It was found that students who made frequent use of ESDs (measured in log files) in the electronic conditions earned significantly higher post-test scores when the ESDs were indistinguishable and vice versa. These interaction effects are an important indication of how electronic learning environments can serve to tailor ESDs to student characteristics measured online.

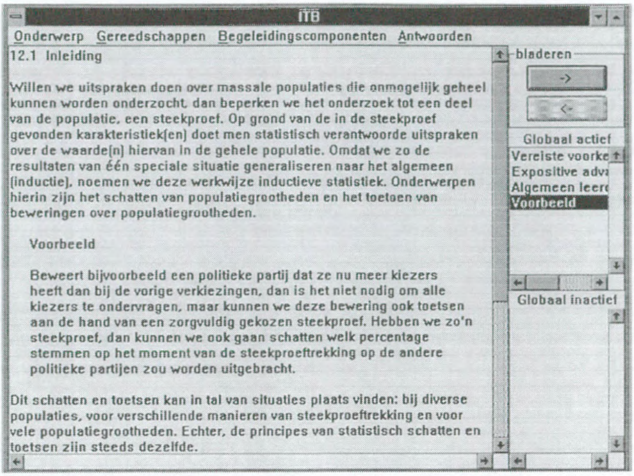

Figure 1 **ESDs in the basic content**

The conclusion was that ESDs make an important contribution to self-study, and are an important form of support to this type of education, as they generally have a demonstrably positive effect on study outcomes and, moreover, are given a positive score by students. Students frequently use ESDs, at a deep level. It was also concluded, however, that the combination of ESDs as it is used now in many self study materials, does not offer 'individualised' support. Some ESDs are designed, for example, for students with high prior knowledge, but in practice almost all students use almost all ESDs. It was concluded that a tool was needed to systematically develop flexible course materials, enabling the production of 'individualised' courses. This means that these courses can vary in the types or content of ESDs or the basic content.

In the following sections we will describe two of these tools, the '*Electronic workbook*' and '*ILCE*' which was renamed '*Mercator*' (Valcke and Martens, 1997). The '*Electronic workbook*' can be seen as one of the precursors of '*Mercator*'.

The main question that we will focus on is how students experience working in electronic learning environments. We seek to provide information about how it is for students to study in a distance educational context and how ICT can help to provide students with 'personalised' ESDs. Also some author experiences will be highlighted. Statistics are an interesting field to study this question because it is seen as a difficult subject by students, often accompanied with fear of failure. Moreover ICT is often used (for instance for statistical analysis) and offers a lot of opportunities to develop flexible (adapting to the user) or interactive ESDs (e.g., simulations). In this article we will discuss two investigations that were set up in the subject domain of descriptive statistics.

3. Study 1: Electronic Workbook

The *Electronic Workbook* is an example of an interactive learning environment in which the ideas mentioned earlier and the expertise of the Open Universiteit Nederland (OUNL) have been worked out to meet the specific problems in the first-year statistics course of the Faculty of Political Sciences at a 'traditional' Dutch university, the University of Nijmegen. This learning environment was part of a total redesign of the statistics course. The central issue within this re-design was a shift from teacher-delivered to student-centred education. One of the problems that were tackled was that students tend to postpone their study too long. Also, the electronic workbook is a tool to individualise ESDs, such as exercises and examples. In this first study we will focus on student evaluation of this electronic environment.

The *Electronic Workbook* can be summarised as follows:

- the development and implementation of a computer environment to design and elaborate supportive learning materials (ESDs) to facilitate independent learning processes of the textbook. This provides the basic content (teacher perspective), with the future possibility to individualise these ESDs;
- the implementation of a communication facility to support communication between students and teacher and among students;
- the development and implementation of a computer learning environment to access and study support learning materials (student perspective);
- providing easy access to all applications (e.g., SPSS©) that may be required during the course of the study process.

In Figure 2 the student perspective is depicted. The text in the left field contains the basic content with hyperlinks. In the right part of the screen there is the table of contents and a list of available ESDs. General tools are depicted on the bottom of the screen: a link to SPSS©, an electronic scribbling-pad, a calculator, a glossary, a mail facility and an exit button.

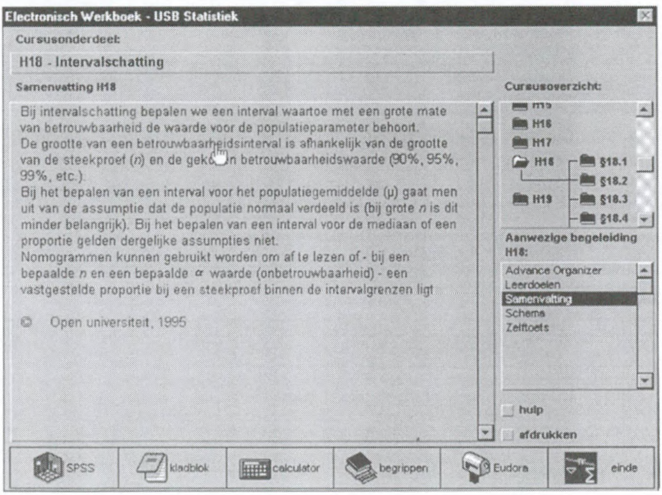

Figure 2 The *electronic workbook* - student perspective

In two successive years, experiments with the *electronic workbook* were carried out with small groups of students. We will describe the results from the last experiment. At the end of this experiment students were given questionnaires to measure the outcome of their study processes in terms of efficiency, effectiveness and satisfaction.

3.1 Research Set Up

We will report on the evaluation of the *electronic workbook* in the academic year 1994-1995. The *electronic workbook* was tested for six weeks. For a detailed description we refer to Portier, Hermans, Valcke and Van den Bosch (1997). During these six weeks seven chapters of the statistics textbook were studied. At the end of the six-week period, questionnaires were distributed. Students made an explicit choice for a specific condition. To support this choice, an information session was organised during which all conditions were explained in detail and the *electronic workbook* was demonstrated. Three choices were available: (1) face-to-face workgroups, (2) independent learning with the *electronic workbook* and (3) a third condition for students who wanted to study the statistics course completely independent. In all conditions, students had to hand in SPSS©-tasks.

3.1.1 Subjects

232 students attended face-to-face workgroups, 27 students opted for the *electronic workbook*-condition, and 31 students chose the completely independent learning condition (all choices were completely free). At the end of the course, a week before the final test, 158 workgroup students (68 %) achieved the course objectives and had regularly been working on the weekly tasks.

3.1.2 Results

In the electronic workbook condition 19 students (70 %) finished the course. In the independent learning condition 8 students (26 %) finished the course. Overall, 185 students (64 %) met the requirements to finish the course.

For the questionnaire results we will focus on the students who worked in the *electronic workbook*-condition.

Eleven out of nineteen students returned their questionnaire. Due to this small group size, only descriptive statistics will be presented. The main results can be summarised as follows:

- Students 'worked more regularly for the statistics course' (self reported by students). The mean score on a four-point scale was 3.18 (s= 0.75). Students were more active and engaged when they were obliged to work through pre-structured course sections, completed by a SPSS©-task.
- In accordance with the first study, the students highly appreciated the support devices in the *electronic workbook*. The overall appreciation level (on a 4-point scale) was 3.05 (s= 0.54). Support devices that were specifically appreciated (mean score > 3) are summarised in Table 1.

Table 1 mean scores and standard deviations for specific support devices in the *electronic workbook*

Support device	mean score (1-4)	s
learning objectives	3.17	0.75
summary	3.71	0.76
study advice	3.17	0.75
self-test	3.17	0.98
exercises	3.43	0.54

- Almost all responding students appreciated the possibility of integrated access to other, relevant applications (mean 3.37, s= 0.67).
- Other aspects of the evaluation results indicate that students thought that the weekly tasks enhanced their SPSS©-skills and that these tasks are a useful method to pace their learning process. However, some students questioned the relevance of the weekly tasks to enhance their statistics skills.
- Ten of eleven students explicitly appreciated the way they could organise and plan their own study activities. Moreover, a majority of the students who asked questions to their teacher (8 of 9) thought that it is easier (less threatening) to ask them by e-mail.
- Some negative points were mentioned about the limited amount of information (e.g., when and how to hand in the weekly solution), and the feedback by the teacher (limited amount, sometimes long reply periods).
- Some students stated that computer performance in the local area network was still limited.
- No differences in examination scores were detected.

The majority of the students indicate that they could not always reserve a personal computer at a preferred time. Nine of eleven students explicitly mentioned that they would prefer to install the *electronic workbook* on their own personal computer at home.

The evaluation results show that students appreciate the possibility of active exploration that is provided by several types of support devices, especially the support devices summaries and examples (Portier, Hermans, Valcke and Van den Bosch, 1997). Students were fairly positive on being responsible for their own study activities and being able to control their own time management. It may be noted that many students choose to follow the normal face-to-face lectures (see discussion).

4. Study 2: Mercator/ILCE/ELO

A computer based system to support course design, -production and -exploitation was developed at the OUNL with technical development done by the company *SPC group* in the Netherlands. The precursor of *Mercator* was called *ILCE* and the technically different successor will be called *ELO* (Electronic learning environment). The basic concepts and ideas behind these versions are about the same. To avoid confusion about these different environments, with many different releases, we will aim on the common basis of it and explain more about the educational background by means of a short description of *Mercator*. Note that the technical tool to develop the delivery that is presented here was developed with *ILCE*.

Mercator supports development of learning materials that are: adaptable, in content as well as in didactics to the educational needs of specific user groups; just-in-time available; dynamic (meaning not static, like a paper book); and continually adaptable (SPC group, 1997). An overview of the current set of modules in the *Mercator* system is depicted in Figure 3. The module without a name indicates that the system is continuously updated.

The complete environment is linked to a database environment (SQL driven). From a technical point of view this database can be put on a central computer (a server), of the educational institution (client-server set-up) to which other PC's can log on. This gives developers the opportunity to share models, templates and even learning materials while designing or developing new materials.

Figure 3 Components of *Mercator*

For the authors of the learning material there are two central modules: *Mercator Course Services* and *Mercator Course Development Environment*. With these two linked programs, authors, often working together in teams, can design the (didactical) modelling of courses or complete domains, and they can produce actual learning materials. These materials can be delivered to students in a printed mode or in an electronic mode.

The modules *Publishing module*, *Subscription centre* and *System administration* are designed to control authorisations for students and authors. The *Navigator* (see Figure 4) is the part which presents to students in an electronic way the selected part of the database of learning materials. This selection is based upon a student profile which is determinated by means of an intake (a test or some question about e.g., students' prior knowledge). Which student characteristics will be used is up to the author, and the possibilities and combinations of characteristic are almost infinite. There are many ways in which materials can be presented to students.[3] Internet delivery of courses or support for students, is more and more used at the OUNL. The *Navigator* can also contain links to other Windows applications, for example SPSS©. By ticking on a button, SPSS© will start up with a specific, by the author defined

3 Some of the results presented are based on a *navigator* that looked somewhat different, although the main ideas were the same.

SPSS© sav file. When no interactive basic contents or ESDs are required, course materials can also be printed (Printing On Demand).

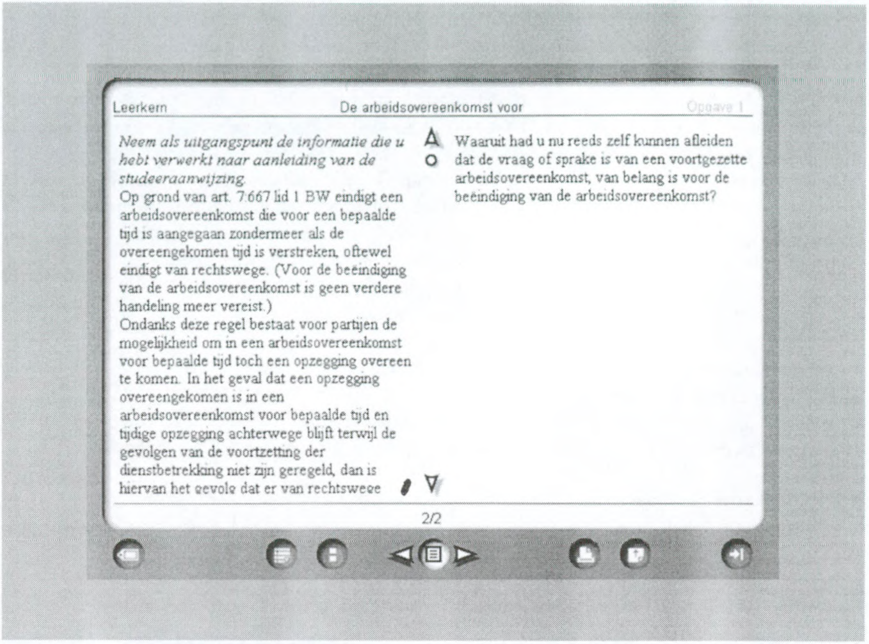

Figure 4 ***Mercator Navigator***

4.1 Student Perspective

Martens, Valcke, Portier, Weges, and Poelmans (1997) reported the results of three experiments, in which students studied at their home PC courses of at least 20 hours in the content domains: descriptive statistics, continuous mathematics and substantive criminal law. Comparisons were made with students studying regular printed courses from the OUNL and with students studying at 'conventional universities'. In the elaboration of the learning materials the developers adapted materials to student characteristics that were considered relevant for their course. For descriptive statistics these adaptations were prior knowledge of mathematics, prior knowledge of statistics and faculty (economical or social sciences). In the electronic intake, students could indicate, for example, their prior knowledge on mathematics (via a prior knowledge test) before their actual study. *ILCE* would then construct a tailored course in which examples, additions, etceteras, were added suited for a certain student profile.

In this study, we mainly aim at students' opinions about the learning-access-level, rather than looking at product outcomes. Learning-access-level (LAL) is defined as a quality measure of the learning materials. It reflects the level of structure, the extent to which students can distinguish main themes from subthemes, can orient themselves, etceteras. The choice to put emphasis on learning process variables is based on the assumption that students often will compensate for less suited learning environments with a higher time investment or learning with more effort (Corno and Snow, 1986). In a distance education research set-up, the latter factors are difficult to control.

The following hypotheses were tested:

- students are positive about the LAL of the learning materials
- students judge the learning in the context of *ILCE* as positive

In earlier studies at the University of Gent, Belgium (a 'conventional' university) and at the OUNL, questionnaires were used that are partly identical to the research instruments that were used in this experiment. This way it is possible to make comparison hypotheses between research samples studying in different contexts:

- students' judgements about the LAL are the same for the present research sample compared to judgements of 'Gent'-students, who studied printed and electronic learning materials.
- students' judgements about the LAL are the same for the present research sample compared to judgements of OUNL-students who study 'regular' (mostly printed) courses

Hypotheses about elements of the *ILCE* are:

- students have no problems with learning from screen
- students experience no problems in the intake phase
- students appreciate the distinction between ESD and basic content
- students do not print most learning materials
- students appreciate the fact that the learning materials can be printed on demand
- students appreciate the specific features and functionalities of the *ILCE*.

4.1.1 Research Instruments

In Table 2, the research instruments and the variables that were derived from these instruments are displayed. Between brackets the number of items clustered to compute a mean value for a variable is printed.

Table 2 Instruments and variables

instrument	variables
1. questionnaire about attitude towards- and use of computers	• attitude towards computers (10) • attitude towards learning with computers (5) • experience with computers (4)
2. *ILCE*-questionnaire	• experience with OUNL-courses • primary training • sex • learning access level (9) • attitude towards learning with *ILCE* (7) • average general judgement • appreciation of technical features • learning from screen • possibility of flexibility towards student characteristics • appreciation of distinction between ESD and basic content • printing
3. log-book	• time used • comments
4. pre- and post-test	scores not used as research variable

1. The first questionnaire was designed to measure attitudes towards computers en learning with computers. There are also questions included about subjects' experience with computers. Most scales were five-point Likert-scales.
2. The *ILCE*-questionnaire was designed to gain insight in subjects' opinions about *ILCE* and the presented learning materials. Parts of it are exactly the same as questions used by the department OID ('research, information and target groups') of the OUNL. These questions were used in large-scale annual inquiries at the OUNL. Most questions are presented as five-point Likert-scales. One question asked students to give a general rating of the LAL with a mark ranging from 1 (low) to 10 (high).
3. Students kept a log-book, which was used as an extra information source.
4. Since there was no control group, studying exactly the same material in another condition, the value of the pretests and posttests was restricted. It was used to stimulate students to work seriously and to gain insight in the starting level of students at the intake. The tests were not based on an objective and validated standards.

Besides these instruments, also group discussions were organised as a source of extra information that is not provided by the questionnaires. The results of these discussions were not used to test hypotheses but will be summarised, especially with regard to future perspectives.

4.1.2 Subjects

About 50 percent of the voluntary subjects was student at the OUNL. The other subjects studied at regular universities at an academic or higher vocational level: the University of Maastricht and the Hogeschool Utrecht (which is an institute for higher vocational education). Students needed to have access to a PC. Forty-seven students started with the experiment (for descriptive statistics 19 students, for continuous mathematics 11 students, and for substantive criminal law 17 students). Thirty-five students finished the experimental course, which is 75% of the initial group. Regular drop out at the OUNL is 50% per course (Boon, Janssen, Joosten, Liefhebber and Poelmans, 1995). The average study time that students reported was 5.23 hours per week and 20.34 hours in total.

4.1.3 Research Procedure

For each experimental course we set up separate research procedures. All courses started with a joint meeting, including a pretest (for descriptive statistics and continuous mathematics) and an instruction about the installation and evaluation procedure. After this meeting, students installed *ILCE* at their home computer by means of a self-installing program and studied independently during a period of about six weeks. The courses were concluded by joint meetings in which students discussed there experiences, and completed posttests and questionnaires.

In the statistical analysis we used T-tests and ANOVA. Many variables were tested against a neutral norm of 3 on a 5 point scale (completely disagree (1)...completely agree (5)). This was done by means of Hotellings T^2, which tests the hypothesis that scores differ significantly from a certain previously defined norm.

The reliabilities of the separate scales were satisfactory (Martens, Valcke, Portier, Weges, and Poelmans, 1997).

4.1.4 Results

Learning access level and studying with ILCE

The results show that the learning access level (LAL) is rated positive. It differs significantly from the neutral norm '3'. ($F(1,23)=20.47$, $p<.001$).

Also studying with *ILCE* is rated positively ($F(1,23)=27.56$, $p<.001$). Looking at the items constituting this variable then it shows that especially 'adaptation to individual student characteristics' and 'possibility of interactive delivery' were judged highly positive. This was confirmed by the general opinion about *ILCE* and the learning material rated on a scale from 1 to 10 with a score of 6.71 (s = 1.04).

The relation between student characteristics and opinion

There are no significant relations between student characteristics and opinion of learning access level and studying with *ILCE*. Student characteristics are defined in Table 2 (gender, experience with OUNL-courses, primary training and sex). This means that the results found are stable across student characteristics. There were no significant differences between the three different content domains and ratings of learning access level opinion about studying with *ILCE*.

The results in relation to other research groups

The results can be related to other research groups. First the results will be compared to a research population of thousands of regular students of the OUNL. These comparisons are based on the results of five years of the Annual Review (JOO), which is a questionnaire about various aspects of students' study at the OUNL, that is sent to 2000 students every year.

Table 3 Comparison of ILCE students with 'regular' OUNL-students

variable (range)	N (JOO)	m (JOO)	s (JOO)	m (ILCE)	s (ILCE)
study hours per week (0-n)	2746	10.26	6.85	5.23	3.68
is the course easy to study without the help of others? (1-3, 1=yes)	3941	1.20	0.45	1.44	0.56
difficulty of the course (1-3; 1=difficult)	3939	1.82	0.58	1.89	0.72
quantity of learning material (1-3, 1 is less then expected)	3932	2.30	0.60	1.88	0.73
did you experience lack of prior knowledge? (1-2, 1=yes)	3934	1.90	0.30	1.70	0.47
positive-negative about the contents (1-3)	3935	1.30	0.59	1.40	0.60
contents are interesting (1-3, 1 is less interesting)	1606	2.11	0.64	2.06	0.60
satisfied with the ordering of subjects in the course (1-5, 1 is positive)	1600	3.57	0.65	2.44	1.19
practical relevance (1-5, 5 is high)	1604	2.74	1.20	2.85	0.93

We will compare the different research groups at a descriptive level. There are no important differences in the student opinions about the courses (regular OUNL-course or *ILCE* course). *ILCE* students are more satisfied with the ordering of the subjects in the learning material and the quantity of learning materials is somewhat smaller than expected, compared to students studying regular OUNL-courses.

With respect to attitude towards working and learning with PC's the results on the scales 'attitude towards computers', 'attitude towards learning with computers' and 'experience with computers' can be compared to the results of a sample of 502 students of a 'traditional university' (University of Gent, Belgium). In the Gent population the scores were 2.63, 3.15 and 2.12. T-tests showed that these means differ significantly from our research population [$t(80.71) = 13.90$, $p<.001$; $t(51.76)= -4.90$, $p<.001$; $t(58.00)= -8.62$, $p<.001$]. Our voluntary research group had a more positive attitude towards computers and is more experienced.

The same questionnaires were also used in a research setup with volunteering OUNL-students (n=35) of whom 15 knew that they did not have to work with computers. The means were 1.8, 4.0 and 3.8, respectively. These means did not differ significantly from our research population.

The main conclusion was that students found the interactive learning environment suitable for their study. In Table 4 some other results are presented.

Table 4 Student opinions about an interactive learning environment

item (1 to 5, 5= agreement)	m	s
Learning from a computer screen is <u>more</u> tiring (e.g., for the eyes) than learning from a printed book	3.83	1.22
I did <u>not</u> find it difficult to define my student profile (intake phase)	4.54*	1.04
The distinction between basic content and ESD's is useful	3.71*	1.17
I often printed parts of the course	2.28	1.68

*= $P < 0.05$, item score differs significantly from neutral category (n=35)

The results in Table 4 show that students did not significantly agree or disagree with the statements 'Learning and reading from a computer screen is more wearing (for the eyes) in comparison to a book' and 'I often printed parts of the course'. This may indicate that it is not such a problem to learn from a computer screen as is often believed.

Students did not find it difficult to state their student characteristics, such as their prior knowledge level or educational background in the intake phase. They judge the distinction between basic content and ESD as useful.

Table 4 does not include the judgements about specific features and functionalities of the delivery environment (*Navigator*). These judgements were either neutral or positive.

4.2 Author Perspective

Authors have to learn to write courses in a somewhat different way. Because of the required flexibility of the learning materials, components of text (e.g., the ESDs) have to be more 'isolated'. They cannot write one 'continuous story' anymore, but rather have to structure all these components in a sort of network to describe the content structure. About the author perspective, Brok and Martens, 1998, stated: 'Results show these authors were positive about the system in general and experienced little trouble designing significantly different course versions, distinguishing only a few learner variables. They did not exploit differentiation in learning path ordering, however. Findings show the importance of clear agreement on the semantics of graphical networks to describe content structure. Considerable effort is required by modular writing of actual texts, paying attention to contextual references and transitional phrases.' (p.1)

5. Conclusions and Recommendations

In general, students have less problems with learning from interactive learning environments then sometimes is believed. Students' attitudes towards new forms of education and computer seem to be important. In the first study, only a minority of the students chose to study by means of the *electronic workbook*. Most students chose traditional lectures. In the second study, we found that the students in the voluntary sample had a more positive attitude towards computers. Thus, student opinions seem to matter a lot. Unfortunately, these opinions about the use of ICT in education are not stable. The results presented are likely to change. There is the rise of the 'Internet generation': students that are used to Internet browsers and that find perfectly normal to use ICT for a long time in order to get information.

The students that chose distance education and ICT were quite satisfied with it. The use of ICT in interactive learning environments is often accompanied with more emphasis on self study. Even studying large text parts from a computer screen appears not to be problematic. With the ever continuing improvement of the screen quality and the habituation to this medium, learning from computers will probably become more and more common. One cannot simply present the contents of a book on a screen, however. In that case printing on demand was to be preferred. The increased dynamic and interactivity of an electronic learning environment should be exploited.

Some recommendations can be done: embedding didactical aids (ESDs) is fruitful, as several of our studies show. Although at a theoretical level the distinction between ESDs and basic content is sometimes difficult, in practice it was found that authors and students did not have problems with this distinction.

For effectiveness and efficiency reasons it is strongly recommended that tools should be generic. This means that there is one tool (e.g., *Mercator*) to develop multiple courses or even domain structures in various content domains. Actual content and the tools to develop and deliver this content should be relatively separate entities. If not, development costs will increase rapidly and the wheel has to reinvented time after time.

From a technical point of view, the development of these generic tools is a complicated project. We are not aware of any such applications available on the commercial market. To date the OUNL tries to further develop *Mercator* in the *Electronic Learning Environment* (ELO).

Educational innovation can have many different reasons. De Wolf (1996) states that there are three major goals for educational innovation: improving the effectiveness, efficiency and/or satisfaction of the educational process. These three aspects should be viewed from the perspective of the educational institution and the perspective of the student.

This means that the students' test scores are not the only measure for determining the success of an innovation. Interactive learning environments and ESDs fit into concepts of flexible, individual education. Improving the 'consumability' plays a dominant role. Evaluation of interventions should assess all these intended effects. It is evident that more research is needed to come to more or less generally applicable conclusions and recommendations concerning the use of ICT in the content domain of statistics. Projects, such as 'Cyberstat' and 'ILO' (Dekeyser, 1998) that were introduced above, might add to our insight in the effects of ICT use in this content domain.

6. References

Adams, M. (1997). *Distance learning takes a learner-centred approach*. Paper presented on 'the new learning Environment'. The 18[th] ICDE conference, The Pennsylvania State University, June, 1997.

Bates, A.W. (1995). *Technology, open learning and distance education*. London: Routledge.

Boon, J., Janssen, J., Joosten, G., Liefhebber, J., & Poelmans, P. (1995). Looking back to face the future. In: M. Valcke & K. Schlusmans (Eds.), *Inside out. An introduction to the Open University of the Netherlands* (pp. 13-28). Heerlen: Open University.

Brok, E., & Martens, R. (1998). *Authoring modular courses: exploratory experiences. Paper presented at the BITE conference*. Maastricht: Universiteit Maastricht.

Dekeyser, H. (1998) *Basisconcept elektronische leeromgeving voor gebruik in Statistiek en Wiskunde-onderwijs* [Basic concept electronic learning environment for education in statistics and mathematics]. Gent: Rijksuniversiteit Gent.

De Wolf, H. (1996). *Het overmijdelijk samengaan van onderwijs en multimedia* [The inevitable mixing of education and multimedia]. Diepenbeek: Limburgs Universitair Centrum, Belgium.

Fletcher-Flinn, C., & Gravatt, B. (1995). The efficacy of computer assisted instruction (CAI): a meta-analysis. *Journal of Educational Computing Research, 12*, 219-242.

Granger, D., & Gulliver, K. (1995). Toward a new approach to quality in open learning. In: D. Sewart (Ed.), *One world many voices*, ICDE June 1995 (pp. 81-84). London: Eyre & Spottiswoode Ltd.

Hawkridge, D. (1995). The big bang theory in distance education. In: F. Lockwood (Ed.), *Open and Distance Learning Today*. London: Routledge, 3-12.

Holmberg, B. (1995). The evolution of the character and practice of distance education. *Open Learning, 10*, 44-47.

Jenkins, J. Past distance. In: D. Sewart (Ed.), *One world many voices*, ICDE June 1995 (pp. 427-430). London: Eyre & Spottiswoode Ltd.

Jennings, P.L., & Ottewil, R. (1996). Integrating open learning with face-to-face training: a strategy for competitive advantage. *Open Learning, 11,* 13-19.

Kirschner, P, Valcke, M., & van Vilsteren, P. (1997). *Placing the student at the center: higher distance education addressing the challenges of the twenty-first century*. Paper presented on 'the new learning Environment'. The 18[th] ICDE conference, The Pennsylvania State University, June, 1997.

Martens, R., & Dochy, F. (1997). Assessment and feedback as student support devices. *Studies in Educational Evaluation, 23,* 257-273.

Martens, R., Poelmans, P., Daal, M., & Valcke, M. (1994). Studeren in afstandsonderwijs: hoe gaan studenten om met de didactische uitwerking van zelfinstructiemateriaal [Studying in distance education: how do students deal with the didactical composition of self-instructional materials?] *Tijdschrift voor Hoger Onderwijs, 12, (2),* 80-94.

Martens, R., Valcke, M., Poelmans, P., & Daal, M. (1996). Functions, use and effects of embedded support devices in printed distance learning materials: a review of recent OU-research. *Learning and Instruction 6,* 77-93.

Martens, R., Valcke, M., Portier, S., Weges, H., & Poelmans, P. (1997). Research with interactive learning environments in three content domains: Descriptive statistics, continuous mathematics & substantive criminal law. *Distance education, 18,* 44-58.

Martens, R.L. (1998). *The use and effects of embedded support devices in independent learning*. Thesis. Utrecht: Lemma.

Martens, R.L., & Valcke, M.M.A. (1995). Validation of a theory about functions and effects of embedded support devices in distance education learning materials. *European Journal of the Psychology of Education, 10 (2),* 181-196.

Martens, R.L., Valcke, M.M.A., & Portier, S.J. (1997). Interactive learning environments to support independent learning: the impact of discernability of embedded support devices. *Computers & Education, 28,* 185-197.

Martin, E.D., & Rainey, L. (1997). *The effect of distance learning on student achievement and student attitude: a longitudinal, controlled study*. Paper presented on 'the new learning Environment'. The 18th ICDE conference, The Pennsylvania State University, June, 1997.

Moerkerke, G. (1996). *Assessment for flexible learning*. Thesis. Heerlen: Open University of the Netherlands.

Montague, W.E., & Knirk, F.G. (1993). What works in adult instruction: the management, design and delivery of instruction. *International Journal of Educational Research, 19,* 329-331.

Moore, M. (1977). *On a theory of independent study*. ZIFF papiere 16. Hagen: Zentrales institut für Fernstudienforschung.

Neal, L. (1997). *Using multiple technologies for distance learning*. Paper presented on 'the new learning Environment'. The 18th ICDE conference, The Pennsylvania State University, June, 1997.

Portier, S.J., Hermans, H.J.H. & Valcke, M.M.A., & van den Bosch, H. (1997). An *electronic workbook* to study statistics: design and evaluation. *Distance education, 18 (1)*, 59-75.

Putter, H., & Marnewick, C. (1997). *Quality integrated learner-centred courseware*. Paper presented on 'the new learning Environment'. The 18th ICDE conference, The Pennsylvania State University, June, 1997.

Sewart, D. (Ed.) (1995). *One world many voices*, ICDE June 1995, London: Eyre & Spottiswoode Ltd.

SPC group (1997). *Mercator. Product information Mercator v3.0*. Den Bosch, The Netherlands: SPC group.

Studulski, F. (1995). Over levenslang leren en informatietechnologie [About lifelong learning and IT]. *Tijdschrift voor Hoger Onderwijs, 13*, 238-246.

Szücs, A., & Wagner, A. (Eds.) (1998). *Proceedings of the EDEN conference. Universities in a digital Era. Transformation, innovation and tradition. Roles and perspectives of open and distance learning*. Bologna: University of Bologna.

Valcke, M., & Thorpe, M. (1995). Distance education: A particular context for teaching and learning. *European Journal of Psychology of Education, 10,* 111-120.

Valcke, M.M.A., Martens, R.L. (1997). An interactive learning and course development environment: context, theoretical and empirical considerations. *Distance Education*, 18, 7-23.

Van Oers, B., & Forman, E. (1998). Introduction to special issue on Mathematics learning in sociocultural contexts. *Learning and Instruction, 8,* 469-473.

Wassenberg, M., & Philipsen, H. (Eds.) (1997). *Placing the student at the centre. Current implementations of student-centered education,* Maastricht: Maastricht University.

Zonika, R. (1997). *Technology assisted training at Netech*. Paper presented on 'the new learning Environment'. The 18th ICDE conference, The Pennsylvania State University, June, 1997.

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