COMPETENCY-BASED STATISTICS COURSES WITH FLEXIBLE LEARNING MATERIALS

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This paper focuses on research and development work that concentrates on the design, development and research of electronic learning environments as implemented in the field of the teaching of statistics (especially descriptive statistics). Flexibility is seen as (1) adapting the didactical elaboration of the materials to student characteristics/needs and/or (2) adapting the content to these characteristics/needs. Results of several researches support this new direction. This 'flexibility' discussion also introduces questions about what students have to study in relation to statistics and opens the debate about the basic competencies to be acquired. This discussion is illustrated with a basic reorientation that is currently under way at the Open Universiteit of the Netherlands.

THE OPEN UNIVERSITEIT OF THE NETHERLANDS: BASIC CONTEXT INFORMATION

The Open Universiteit Nederland develops and provides higher distance education with a high degree of freedom as to where and when to study. Everyone 18 years old or older can follow courses. There are no specific admission criteria or requirements with respect to prior education. Most students are in the work force. Their professional environments/orientations are very different. As a consequence, this openness results in a very heterogeneous student population when we consider study intentions, prior knowledge levels, personal interests, prior experiences, educational background, etc. It is this heterogeneous nature of the student population that incited the research and development work in the field of flexible learning materials and competency-based education.

A MICRO-, MESO- AND MACRO-PERSPECTIVE ON THE NEED FOR 'FLEXIBLE' LEARNING ENVIRONMENTS?

A strengths-weakness analysis (based on interviews) of the traditional distance education model of the Open Universiteit revealed a set of shortcomings (Valcke, 1994). It is to clarified that the traditional distance education model was mainly based on 'printed' text books and could therefore be described as typical manifestations of 'second generation distance education approaches'. Although of high quality, the heavy focus on printed courses results in a number of micro-, meso- and macro-problems:

The efficiency of the current process of designing, developing, producing and exploiting the learning materials is low, in terms of speed of the process, costs, consistency of the materials being developed, their flexibility, etc. The life cycle of the

materials is too long. Books get outdated after 2 to 3 years. Their revision implies reiteration of the design, development and production process. Next to text processing tools, no advanced computer tools were available and being used to support the entire or specific parts of the process.

- The effectivity of the learning materials, delivered as 'books' and the efficiency of the production process are low when we see that they are not suited to supporting just-in-time learning and tailor-made courses. The OU fails to meet the heterogeneous and quickly changing demands of part of the learning 'market'.
- Traditional printed courses are based on a priori decisions and selections of basic content (scientific domain knowledge, theories, principles, formulas) and a priori decisions about the (embedded) support needed by students. In the distance education context of the Dutch OU, there is hardly no face to face contact between students and teachers/tutors, so the learning materials have to be sufficiently supportive. Therefore an essential part (about 40%) of the learning materials consists of embedded support devices (ESD's), such as pre- and post questions, schemes, illustrations, content pages, indexes, tasks, summaries, advance organisers, objectives, examples, prior knowledge references and study guidelines. ESD's aim at scaffolding and focusing the study process. We refer to the study of Martens, Valcke, Poelmans and Daal (1996) to get more information about the specific functions and effects that are related to these ESD's.
  In the existing approach of the Open Universiteit, all students get the same book, with the same examples, exercises, etc. This is in sharp conflict with the demand for more demand-driven education. Tailoring courses to the specific needs of student is a world-wide issue (Kirschner and Valcke, 1994).
- Printed materials restrict the number of representation modes to support students to cope with new concepts. Especially in the field of statistics, more dynamic, constructivist or at least a large set of different representation modes might be needed. Adapting content elaboration to this kind of student needs/characteristics stresses again the needs to change current design and development approaches of learning materials.
- This set of critiques is but one way to depict the problem description/analysis when we consider the overall strategic discussion about the position of the Open Universiteit Nederland. At this moment this institution is transforming itself into a centre for knowledge transfer that - in collaboration with other educational partners - builds up flexible, electronic and multimedia resources to be used in a variety of settings. But does the current repository of learning materials reflect the perspectives of other institutes, the student differences, different user profiles, …?

TOOLS TO CONSTRUCT FLEXIBLE LEARNING ENVIRONMENTS

Research and development work at the Open Universiteit of the Netherlands has focused during recent years on the design, development and research of flexible electronic learning environments (Martens and Valcke,1997). This work aimed at the development

of a generic tool to be applied in a variety of very content domains. This tool can be described from two perspectives: an institutional perspective and a student perspective.

From the institutional perspective, the tools first of all help to ‘design’ basic models. These model indicate e.g., what set of ESD’s will be used to support student activities or what the basic ordering principle of the curriculum will be (thematic versus tasks, problems, cases). Of prime importance is the possibility to build a student model that indicates the basic differences in student differences the developers will reflect in the development of the materials and the link between these differences and ESD’s (student with low levels of prior knowledge receive other introductions and alternative representations for formulas) or specific contents. The tools also help developers to elaborate the concrete learning materials in line with the ‘models’, and to publish the materials (on-line, CD-ROM and/or printing-on-demand).

From a student perspective, the tools present the student with an electronic environment in which he/she can make choices in relation to the in-built options about student characteristics; e.g. What is your prior knowledge level of mathematics? What is your professional field? What is your preferred study approach (style)? The system then present the student with the most relevant set of materials - selected from a large set of materials - that are in line with this student profile. Next, depending on the kind of learning environment, students can navigate freely, explore, use static or dynamic materials, etc.

RESEARCH WITH FLEXIBLE LEARNING MATERIALS

A large number of researches has been set up to validate basic assumption underlying the tools designed. A large part of this research was set up in the field of statistics an will be recapitulated here in short. We refer to original the publications when the reader is interested in very concrete information about research design, methodologies, etc. We also want to stress the fact that in certain research set ups, the flexible electronic learning environment was - although a very important - not the only component of the overall teaching and learning context.

Study 1. 1995-1996

In a collaboration with the Catholic University of Nijmegen (The Netherlands), a project was set up in the faculty of policy sciences (Portier, Hermans, Valcke and van den Bosch, 1997). The “Electronic Workbook” was developed to solve four problems: study postponement, the limited relevance of statistics as experienced by the students, the lack of exploration possibilities by students and the lack of insight and overview of the study process by faculty staff. The Workbook was presented a regular part of the course and

evaluated during two academic years. We focus upon the results of the second study. First of all there was a redesign of the overall educational organisation: students no longer attended face-to-face sessions; the basic format became an independent study approach.

All students studied a text book independently (N=291). Each fortnight, SPSS-tasks had to be handed in. Students could opt for three different 'support' conditions: 232 opted for face-to-face workgroups during which exercises were discussed with the groups. 27 opted for studying with the Electronic Workbook. 32 opted for studying completely independently.

In the Electronic Workbook, the student found, building upon the thematic structure of the printed book, additional sets of ESD's. At chapter-level we added advance organisers, introductions, learning objectives, summaries, schemes and self-tests. At paragraph level, the following ESD's were added: exercises, examples, additional learning materials, SPSS-tasks and study advice. The student had access to the Electronic Workbook in open learning centres. The study was set up during the normal six-week period to take this course and dealt with the complete content of the section 'descriptive statistics'.

The results, based on questionnaire analysis, comparison of test results (final examination) can be summarised as follows: there are more involved in studying the statistics course (less postponing), there is a high level of appreciation of the ESD's (especially the learning objectives, summaries, study advice, self-tests and exercises), student appreciate the integrated computer facilities such as mail, SPSS,… the relative number of students succeeding for the course is higher,… But care has to be taken when interpreting the results, considering the limited number of students in certain conditions.

Study 2. 1994-1995

In collaboration with the State University of Gent (Belgium), a large scale project was set up involving 502 first year psychology and educational science students (Martens, Valcke and Portier, 1997). The study tried to cope with a large number of methodological issues to cope e.g., comparability of treatments, control of study length, checking for co-variables (e.g., prior knowledge), etc. The statistics content dealt with descriptive statistics.

The study compared students in 6 very different conditions: (1) students following normal face-to-face lectures, (2 and 3) students studying from printed independent learning packages in which ESD's were in one condition clearly discernible and in another condition not discernible (integrated into) from the basic content, (4 and 5) students studying in electronic environments in which ESD's where in one condition again discernible and in another condition not discernible, (6) students studying in an

electronic environment where hardly all possibilities for students to adapt the environment to their needs were omitted. The research was based on prior knowledge state tests, subject oriented mastery tests, questionnaires and attitude measuring.

The results indicate very high levels of usage and appreciation of ESD's by all students in all conditions; no significant differences in study outcomes were found between students in the six conditions and a significant interaction effect that indicates that student characteristics are related to the possibility to adapt the learning environment to one's wishes; e.g. students with high level of prior knowledge perform better if the ESD's are integrated and this in contrast to students with low prior knowledge levels profit more from a condition where the ESD's are discernible.

Study 3. 1995-1996

In a study, set up with 19 Open Universiteit students, the students agreed upon studying in a completely electronic learning environment, during a six week period.

Students could - prior to the study sessions and during the session - tell the computer system some student characteristics: their level of mathematics prior knowledge, their prior knowledge level of statistics and the faculty in which they study (social or economical sciences). The computer system took into account these differences by presenting e.g. other examples and exercises depending on the faculty orientation of the students, or other introductions for students with different prior knowledge levels. The study was based on the use of questionnaires, pre- and post-tests and logbooks. The results of the pre- and post-tests were not used for analysis purposes, considering the number of students.

The results reflect a significantly high level of appreciation for the interactive learning environments. The same holds true for the possibility to adapt the content or didactic elaboration to specific student characteristics or needs. No significant interaction effects were found with certain student characteristics. Since the students were forced to study only with the electronic environment, some of their remarks deal with this issue: they ask for a media-mix in future study set-ups, they feel a need for extra support to have/get a clear overview of the content, they ask for a full exploitation of the ICT-environment: use of communication facilities and more interactivity.

The outcomes of the researches with the electronic learning materials has resulted in the design of a new, more powerful system, called Mercator® , that is now also available as a commercial product (for more info, contact SPC/Group; e-mail j.bijlstra@spc.nl).

COMPETENCY-BASED EDUCATION

The concept of ‘flexibility’ has introduced at the Open Universiteit a discussion about the basic set of learning objectives that has to be pursued for specific student (sub)groups. This discussion was especially intensified when researchers - in collaboration with content specialists - explored alternative ways to build up content models for the statistics courses. Whereas traditional approaches build upon the structure of the knowledge as represented in the academic/scientific settings, thus resulting in a thematic structuring of the knowledge, new approaches have been explored. An already widespread alternative approach builds upon real life problems, cases or tasks and links the scientific statistics knowledge to the solution of the problems, tasks,… In the study reported earlier with the Electronic Workbook, students reported e.g. that working with SPSS on concrete problems enhanced their understanding of specific statistics techniques and concepts and helped them to pace their study.

The discussion that might result from this kind of reorientation is easy to predict: content specialist fear that students do no longer acquire a basic understanding of the structure of the domain, they fear that student only acquire fragmented bodies of knowledge that are stripped from their theoretical (e.g., mathematical) base or isolated instead of integrated in the full overview of the knowledge domain.

To tackle this discussion, we have introduced at the Open Universiteit the concept of “competencies” in a number of experimental domains. One of these domains is “Statistics and Research Methodologies”. Content specialists, in collaboration with educationists are asked to build up a “competency map”. Each competency is stated and made more operational by defining related “Task profiles”. For each task profile, one has to state: the expected behaviour, product outcomes, criteria to judge the list of product outcomes, contexts/settings in which the task profile is of major relevance, a clear definition of the set of knowledge and skills upon which each task profile builds. It is clear that such a competency map is related to the professional and academic job profiles for students in specific disciplines. As such, the nature of the discipline is always taken into account. A straightforward consequence of this way of reasoning is that it will be less likely that student in e.g., a social sciences faculty will only be presented a purely ‘mathematical’ discussion of certain statistics concepts.

The competency map is, in a next phase, used to build up a curriculum that is based on complex tasks. These tasks reflect the task profiles. In relation to each task student receive problems, support, objectives, sources, collaborative working tools, manipulative tools,… Since the underlying body of knowledge (skills and declarative knowledge) is clearly defined, developers are not again confronted with the earlier dilemma. It is clear that student have to master basic knowledge and skills, but it is also

clear that the ‘instrumental’ positioning of this body of knowledge in relevant problem fields is part of the learning experience.

CONCLUSIONS

At this moment, several curricula are being constructed based on these competency maps. The tasks are presented in electronic learning environments and are linked to electronic and/or printed resources where the basic knowledge and skills can be acquired. Student profiles that build upon student differences/needs/orientations have been taken into account when designing the tasks and/or the resource materials. As such the potential of flexible learning environments is linked to the potential of building up competency maps. During the conference session, up-to-date progress reports on this issue will be presented.

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