Computer assisted learning in higher education in the Netherlands : a review of findings

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COMPUTER ASSISTED LEARNING IN HIGHER EDUCATION IN THE NETHERLANDS: A REVIEW OF FINDINGS

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Abstract—This article reports some of the major results of a national survey on the use of computer assisted learning (CAL) in Dutch higher education in 1991. As a response to a call for participation, descriptions of 442 different CAL programs that were used in Dutch higher education were received. Most popular usage is in mathematics and sciences, medicine and engineering. The most popular forms of CAL are simulations followed by tutorial applications. In the sciences, emphasis is on simulation, whereas for economics and law, tutorials are most popular, and in humanities we find a large number of drills. It is also remarkable to find a high percentage of combinations of drills and simulations in economics and medicine. There is a greater trend towards providing the learner with more self-control. This reflects the general trend in instructional design to put more responsibility in the hands of the learner (as in the 'constructivist approach'). General programming languages and authoring languages are used in about the same proportion as development tools, but simulations are mostly created through general programming languages, and tutorials with the use of authoring languages. By an overwhelming majority, programs have been developed for MS-DOS environments.

1. INTRODUCTION

This paper presents data of a survey held in 1991 at institutions for Dutch higher education. The goals of the survey were to gain insight into the actual use of CAL in higher education and to create a courseware database from which prospective authors or users of CAL might find relevant information. For the latter purpose the results of the survey (a courseware guide) are for sale, both as a hard copy and as a dedicated software database that contains elaborate descriptions of all CAL programs in the survey[1]. A similar survey was held in 1988 and 1989 and, if relevant, we compare these figures with data from the present survey.

2. THE SURVEY

Survey forms consisted of a variety of questions. They were divided into a number of categories of which the main ones are:

(1) *Identification*
The name of the program, the name of the author(s), and the name and address of a contact person.
(2) *Domain aspects*
The discipline, domain, and a short description of the topic.
(3) *Educational aspects*
Here we requested the type of CAL (drill and practice, tutorial, etc.), the level of control of learner and program over interactions, program reporting characteristics (to teacher or student), presence of manuals, presence of other types of materials, the type of feedback given by the program and the type of questions that could be posed by a learner. Other requested data included: program completion time, program usage data, e.g. number of students using it, and the date on which the program was launched.

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(4) *Technical aspects*
The language or authoring system in which the CAL program was written, the availability of a demo and a listing, the possibility of adapting the program, the size and memory requirements, the hardware that was necessary (including extra components such as video discs) and necessary extras such as a mathematical coprocessor.

The survey was performed under the auspices of SUNCOO which is the Consortium for Computer Assisted Instruction in Higher Education in The Netherlands. Survey forms were sent to a large number of people in Dutch institutions for higher education. The Netherlands has a total of 14 universities, including the Open University, and about 85 higher vocational institutes. For mailings we used the database of addresses of SUNCOO, including the addresses of contact persons for CAL programs in the already existing database, in which all Dutch universities and organizations or institutions of higher vocational training are represented. We also sent the survey forms to educational coordinators of university departments and of higher vocational institutes. We asked these individuals to pass the survey to others in their institution involved with CAL. Those that did not respond were sent a reminder after a few weeks.

In total we sent out 236 questionnaires, and received 138 answers: 74 contained the descriptions of one or more CAL programs, 39 contained changes to a description already in the database, 16 descriptions had to be removed from the database because they were not used any more, and in 9 the old information was still valid. Finally, 6 were returned because the addressee was unknown. In this study, however, response rate is not an adequate measure of the coverage of the survey since the size and members of the population are to a certain extent unknown. This was the reason that, to cover the population as much as possible, we also sent survey forms to individuals and institutions where we only had an intuition that they were involved with CAL. This policy, of course, will have increased the chance of reaching everybody involved with CAL, but also will have reduced the return rate. Moreover, in some cases where we sent survey forms to a number of individuals at an institution we received a set of forms from one person of that institution who happened to be the coordinating person. On the other hand, we also received answers from people to whom we did not personally send a survey and who received the survey form through a colleague.

The survey aimed at only describing CAL programs in which a subject matter domain (taken in a broad sense) was taught. Information about authoring systems, etc. used to develop materials was collected separately. The data was processed as received (forms were usually filled in by the authors themselves), which means that no external qualitative judgment was made about the accuracy of information or the quality of the materials themselves.

After processing the survey forms, and removing CAL programs that were submitted twice, a database of 442 different CAL programs resulted.

3. DISCIPLINES AND DOMAINS

For each program the recipient was requested to specify a subject matter discipline, topic domain, and a short description of the content. The discipline (humanities, for instance) is defined at a broader level than the domain (e.g. English). The category 'general' refers to programs for which no clear discipline could be indicated. Examples are programs for learning about oral presentations, statistical processing of data, and searching literature databases. Table 1 gives the number of CAL programs per discipline in absolute numbers. Because a specific program could be reported by more than one discipline, the total number from Table 1 (516) exceeds the total number of CAL programs listed in our survey (442).

We see a high position for medicine, engineering, and mathematics and sciences. Our surveys in earlier years show the same high position for these disciplines. A possible explanation could be that enrolment for medicine, engineering and mathematics is greater than for other disciplines. This trend is in line with the one reported for elementary education[2]. A combination of factors could explain this phenomenon. First, CAL began earlier in the sciences; its contents more readily lend themselves to representation via algorithms, rules or laws; they contain many possibilities for real time simulations. A great many of the first applications were in mathematics, statistics and

Table 1. Number of CAL programs per discipline in the survey

Discipline	No. of programs
Mathematics and sciences	139
Medicine	102
Engineering	88
Social sciences	42
General	42
Humanities	30
Economics	23
Law	22
Agriculture	14
Veterinary medicine	13
Not given	1
Total	516

Table 2. Types of CAL in the survey

Type of CAL	No. of programs
Simulation	110
Other	103
Tutorial	76
Tutorial + simulation	42
Drill and practice	37
Drill + tutorial	22
Drill + simulation	20
Not given	32
Total	442

engineering for which previously programmed materials (e.g. FORTRAN) could be easily modified to be presented in a courseware format. Second, many earlier grants were given by scientific foundations, e.g. the National Science Foundation, government agencies, and by computer companies that dealt more with the sciences. In general, the sciences, for political, military, and socio-economic reasons, e.g. the Health Sciences, draw more attention than other disciplines. Third, medical, science and engineering teaching is usually far more costly than the humanities, etc. so there is an impetus to reduce costs and dangers, for example via simulations. Finally, the student failure rate is usually higher in the more theoretical technology and science courses, stimulating staff to seek solutions via innovative methods.

4. TYPE OF CAL

In the literature, see for example[3,4], we find a number of descriptions about the forms that CAL may take. A classical approach is to divide CAL into three main streams: *drill and practice* (or exercise programs), *tutorial* (or instructional programs), and *simulation*. Apart from these types of CAL, in our survey, we also distinguished; *problem solving*, *testing*, and *databases*. With problem solving there is a specific learning goal: solving problems. Testing, of course, is meant to examine the knowledge of students, and may provide information to either the student or instructor, or both. With databases, learners have to extract information themselves.

Table 2 presents an overview of the distribution of programs over the three main types of CAL. Not only 'pure' types are given, combinations are listed as well. About 36% of the programs contain a combination of two or more forms, which implies that a relatively high percentage of programs refer to only one type of CAL.

Simulations are clearly the most popular, which was also true in our earlier surveys. One of the reasons that simulation is so popular could be that this is the only type of CAL in which the program adds something to the curriculum a teacher cannot offer. Tutorials and drills could be delivered by a human teacher as well, if time would allow. Also, simulations offer a safe environment for practice; time scales of real life processes can be changed and hypothetical realities can be designed[5]. Another reason for the popularity of simulation could be that this type of environment is nicely in line with the prevailing constructivist view on instruction and learning[6].

Table 3. Types of CAL as used indifferent disciplines in percentages of the total number of programs within a discipline. Infrequent types of CAL have been omitted

	Drill	Tutorial	Simulation	Drill + tutorial	Drill + simulation	Tutorial + simulation
Mathematics and sciences	6	22	30	4	2	9
Medicine	12	13	35	9	11	4
Engineering	5	8	33	1	3	24
Social sciences	2	16	14	8	4	0
General	12	31	12	10	2	2
Humanities	27	17	0	0	0	13
Economics	9	22	9	0	13	9
Law	5	50	5	15	0	5
Agriculture	14	7	36	0	0	14
Veterinary medicine	0	8	8	0	0	8

Table 4. Incidence of learner control in the survey. Some programs exhibit more than one type of learner control

Type of Learner control	No. of programs
Learners may control choice of program parts	338
Learners may return to earlier program parts	262
Learners may exit program on demand and return to same location	163
Learners have no or few control possibilities	61
Learners may choose type of feedback (for example an exercise or an example)	42
Control is not applicable (for example with a pure simulation)	68

In this view learners are not seen any more as persons into which knowledge can be poured, but as active constructors of knowledge. Simulation offers an environment in which learners engage in active manipulation of variables and parameters in the simulation model and are also invited to construct knowledge through processes such as stating and testing hypotheses.

5. DISCIPLINES AND TYPES OF CAL

It is interesting to see how the different types of CAL relate to the different disciplines that we mentioned in our survey. Table 3 presents an overview of the combination of the most frequent types of CAL and disciplines. The table gives percentages that indicate how many programs within a certain discipline are of a specified type of CAL (for example within engineering 5% of all programs are characterized as drill and practice). Figures in the table (taken as frequencies instead of percentages) diverge significantly from chance ($\chi^2_{(45,\, N=368)} = 142.48; p < 0.001$). For mathematics, sciences, medicine and engineering, *simulations* and combinations with simulations are preferred. The combination of drills and practice with simulations for economics (13%) and medicine (11%) possibly refers to a specific type of simulation (e.g. medical patient case studies) in which no interaction with an underlying model takes place but where students learn some kind of normative procedure[5]. For economics and law emphasis is on *tutorials* and for humanities emphasis is on *drills*.

6. CONTROL OVER THE PROGRAM

An important characteristic of CAL programs is the level of control that can be exercised over the sequence through the program taken by the learner. At one extreme it is the program that fully decides the steps to be taken through the courseware. The other extreme would be that in which the learner may choose any part of the courseware at any time. Most usual is control in which the learner may choose a path at specific points in the program. These points may be different topics, but also, for example, the ability to ask questions or seek clarification at any time. Quite usual is an advisory route from which the student is allowed to diverge in a certain way. Another form of control allows the possibility of leaving the program and continuing at the same place later on.

Table 4 gives an overview of the different forms of learner control present in the survey. In 61 programs the learner has no possibility for control at all. In quite a few the learner may make choices through a menu. Because different forms of control may exist within one program, the total number in Table 4 is much higher than the total number of programs.

Table 5 summarizes another form of control: program control. The table shows that providing feedback is the most frequent form of control (247 programs, 56%). Here we mean forms of

Table 5. Program control

Type of program control	No. of programs
Program uses elaborate forms of feedback	247
Program may send learner back to earlier part of program (for example when the learner makes a mistake)	71
Program chooses flow on basis of student answers	71

Table 6. Tools for creating CAL

Tool	No. of programs
Pascal	109
TAIGA	73
TenCORE	49
CALOP and Pilot	42
TAIGA and Pascal	23
BASIC	22
FORTRAN	13

Table 7. Development tools and types of CAL in absolute numbers of programs

	Drill	Tutorial	Simulation	Drill + tutorial	Drill + simulation	Tutorial + simulation
Pascal	7	9	40	1	8	9
TAIGA	11	23	0	12	2	1
TenCORE	0	11	5	1	0	21
CALOP and Pilot	4	11	11	0	1	0
TAIGA and Pascal	4	5	4	1	0	0
BASIC	0	1	13	1	5	0
FORTRAN	1	1	5	0	0	2

Table 8. Hardware utilization. A number of programs can be used on several types of computer

Hardware	No. of programs
IBM and compatibles	400
Mini/mainframe	20
Apple/Macintosh	15
Other micro's	13
Other	77
Not given	6

feedback directed at the answer given by learners and not feedback in response to outcomes of calculations that may be present in simulations. Full program control of the learner can be found in 71 programs in which the learner is sent back to an earlier part of the program and 71 other programs determine the complete route as well.

If we compare these figures to figures of previous surveys a trend is visible in which control is shifting from the program to the learner. This underscores the above reported trend towards a more constructivist type of approach in learning and instruction.

7. TOOLS FOR DEVELOPMENT

Table 6 indicates the most popular tools for developing CAL in the 1991 survey were dedicated authoring languages or systems (TAIGA [7], CALOP, TenCore and Pilot). General programming languages were used *almost* as frequently. We have taken CALOP and Pilot together in this overview since they are mostly used together. Modern graphical authoring languages such as Authorware Professional* are not reported in the survey, which can be partly due to the predominance of the DOS-environment in Dutch higher education (see next section), but also to the high price of these multimedia environments which may make them only appropriate for professional CAL development agencies. We expect, however, that in future surveys the growing use of these systems will be reported.

Table 7 displays in detail the use of specific tools for specific types of CAL.

The distribution of programs over types of CAL and development tools diverges from chance ($\chi^2_{(30, N=231)} = 409.07$; $p < 0.001$). The table shows that for development of drills and tutorials, authoring languages and tools are most frequently used. For simulations (or combinations including simulations), on the other hand, authors call upon general programming languages. This may imply that existing authoring tools and languages do not offer facilities that authors need for developing simulations (which is the most popular form of CAL). Existing authoring tools use a sequential design philosophy. Instructional simulations, on the other hand, call for a non-linear, event-driven approach.

8. HARDWARE

The data show a predominance of courseware for IBM compatibles (MS-DOS). This is illustrated in Table 8, in which the total number of programs is greater than 442 because a number of programs can be used on different type of computer.

*At the time of the survey Authorware Professional was not available for the DOS platform.

9. CONCLUSIONS

This survey of CAL at Dutch institutions of higher education shows that courseware is predominantly used in mathematics and sciences, medicine and engineering. The most frequent form of CAL is simulation, followed by tutorials. General programming languages and authoring languages are used in equal quantities and most programs are developed for MS-DOS environments.

The survey also shows extremely limited use of the newer video technologies and CD-ROM in higher education. Very few videodisc applications were reported. Most probably, many institutions find themselves held back by outdated hardware and little funding to replace or renew configurations. The same argument may hold for the absence of modern but expensive graphical authoring tools that support multimedia CAL, such as Authorware. Another reason for this absence might be the predominance of DOS-machines as the preferred platform. Our survey cannot yet reflect the availability of multimedia tools for this platform (e.g. ORGUE) that have recently entered the market.

Our analyses showed a relative scarcity of simulation programs in the social sciences, humanities and law. Also, we saw that simulations are mostly developed by using general programming languages. These general languages are less familiar to teachers/developers of CAL in these fields than it is in the sciences. A more user friendly, graphical tool for creating educational simulations could be a possible means for reducing this backlog. STELLA is an example of the type of language that could function as such.

In our view, most institutions can still be classified as being in the starting phase of CAL, where usage is dependent on the whims of individual instructors, and where there are no clear management or institutional policies regarding its application. Some Dutch institutions are working towards a more productive usage, which is characterized by top-down management guidelines, feasibility studies, and full evaluation of curriculum and department needs. Most institutions miss infrastructures to support the medium and little reward is given to staff members who produce original materials. It appears that there is a great demand for ready-made courseware. In this respect, it might be interesting to note in future surveys the percentage of English language courseware used in Dutch higher education. It probably will reflect the large number of ready-made courseware products available from our English speaking colleagues, as English is a required second language for most Dutch students.

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