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ABSTRACT

This report considers the progress of the introduction of computer-aided learning (CAL) into the curriculum, with particular emphasis on the situation in the Netherlands. It is argued that the major obstacle to further integration of computers into the curriculum is the rigidity of existing organizational and class structures, and it is suggested that further integration should be concentrated in those subject areas that have been known to be problem areas, such as mathematics or the mother tongue. In those areas, however, greater flexibility in the curriculum will be necessary in order to give CAL the chance to prove its usefulness. The effectiveness and the cost effectiveness of CAL are considered, and it is suggested that it is both CAL as a medium and the surrounding organizational aspects that are responsible for the positive results. A four-phase model for the research, development, and implementation of educational software programs is presented, and the way this approach will be used in the Dutch situation is described. The text is supplemented by two tables, three figures, and a list of nine questions for discussion. (38 references) (EW)

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COMPUTER-AIDED LEARNING: A SELF-DESTROYING PROPHECY?

by

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Summary

It is becoming clear that the introduction of computers in education as a learning aid (CAL), has entered a critical phase. Demonstrable measurable positive effects as a result of using CAL and a general personal acceptance of computers will form the ultimate basis for the success. To create those circumstances, computers will have to be introduced on a large scale. As a result of this effort, major changes will have to occur within the work habits of teachers and in the organisational structure of each school. Those changes cannot be solved in a hurry, because aspects of a general innovational nature are largely involved. Every solution in this respect therefore needs time, much more time than was expected beforehand. Consequently, the spped of the introduction of computers in education, which has been very fast over the last five to six years, has significantly been slackened. No brute force nor great amounts of money can enforce a break through. Only time and continuous training efforts can keep the ball rolling. All we can do now is to keep him rolling in the right direction.

The major obstacle for the integration of computers into the curriculum is the rigidity of existing organisational school and class structures. Because of the enormous amounts of teachers involved, their needs for in-service training, the discrepancy between the available amounts of hardware and what is needed and can be "absorbed" by schools, a concentration upon a limited number of subject areas seems to be appropriate, for instance towards those curricula that are traditionally known as problem areas (mathematics and mother tongue). In those curricula much more flexibility will have to be created in order to give CAL the chance to prove its usefulness.

There is, in a general sense, enough evidence available to show that using CAL is effective, even cost-effective. However, one has to realise that as well as the medium, compelling surrounding organisational aspects are highly responsible for thepositive results. The intrinsic value of CAL programs must therefore be that through them, structural components of good educational practice implicitly have been taken into account or will be, when using the program in the classroom.

To create opportunities to face these problems, a four phase model for the development, research and implementation of educational software is presented, as well as the way this approach will be used in the Dutch situation.

Content

1. The three pro's: promises, problems and prospects

It is becoming clear that the introduction of computers in education as a learning aid (for abbreviation purposes called 'computer-aided learning' or 'CAL') has entered a critical phase: success or failure will depend upon what will happen during the next two or three years. This situation did not come as a surprise. However, what causes its appearance ?

A successful introduction of CAL is based upon four interrelated conditions:

a - availability of sufficient amounts of standardised hardware in schools,

b - availability of a large program of pre-service and in-service training for teachers,

c - availability of sufficient amounts of good quality educational software,

d - integration of CAL in the organisation and the curriculum of the schools.

Of these, conditions a,b and c are necessary. However, they are not sufficient. It is condition d which determines the impace of the previous ones.

Till now major efforts have been concentreted upon conditions a and b. Although the connecting problems have not been completely solved yet, one can see that in many countries measures have been taken to come to large scale introduction of standardised hardware in schools and to set up training programs for teachers to get them acquainted with the possibilities of the new technologies (Ennals, a.o., 1986; Plomp, a.o., 1987; Anderson, 1986; Winkler, a.o., 1986).

The problem of the production of educational software still remains unsolved. A solution in this respect will only be reached if an industrial-like production scheme is followed (Mooneu, 1987). On the other hand, an industrial-like solution will only occur when there is a real market for the product. Nowadays, educational publishers have no confidence, or have lost it , in such a market (Van Dalen, 1987; De Vos, a.o., 1987). The educational software production problem is therefore turning around in a vicious circle. It will only come out of this, when national governments largely support such a production scheme, especailly the research and development part of it. In some countries there is a movement towards such a solution.

But what about the last condition: the integration of computers in the teaching-learning process ? After the euphoria of the past years, it is time now for the promises to become reality. Will this be the case or have we been fooling around all the time ?

Why are we suddenly confronted with all the critical remarks ? There are two answers to this question. It is clear that if one uses computers in the classroom for only a very limited amount of time or in a very restricted situation, the positive impact on the work load and work habits of teachers and on the results and motivation of pupils is negligible. Contrarily, this kind of introduction will only cause trouble, because it will be experienced as an aberration of normal routines. Teachers who are enthusiastic about computers and education take these extra efforts for granted. But those teachers form only a small minority. The majority of them have to be convinced explicitely.

It must be absolutely made clear to them that they and their pupils will gain in one way or another by ysihg computers. As long as this evidence is not without any doubt, they will resist the introduction of computers, certainly because one also gets the impression that those computers will even threaten their jobs. Therefore, a better understanding of the possibilities and restrictions of computers by using them as much as possible, for instance at home, will help to overcome their resistance.

Demonstrable measurable positive effects as a result of using CAL and a general personal acceptance of computers will form the basis for condition 'd' ever to have a chance for succeeding.

To create those circumstances, however, computers will have to be introduced on a large scale. As a result of this effort, major changes will have to occur within the work habits of teachers and in the organisational structure of each school. Those changes can not be solved in a hurry, because aspects of a general innovational nature are largely involved. Every solution in this respect therefore needs time, much more time than was expected beforehand.

Consequently, the speed of the introduction of computers in education, which has been very fast over the last 5 to 6 years, has significantly been slackened. No brute force nor great amounts of money can enforce a breakthrough. Only time and continuous training efforts (in-service and pre-service_ can keep the ball rolling. Aol we can do now is to keep him rolling in the right direction.

In the following paragraphs some data will be presented in order to sustain these statements and to present some evidence indicating which was to go further.

2. Patterns of the use of computers in education

Surveys

There are data available about how computers are used in schools. Becker (1983, 1984, 1986) has published an enormous amount of detailed information about the situation in the US, investigated through a first survey between December 1982 and February 1983 and a second survey in the spring of 1985. The survey of 1985 included a sample of 2331 elementary and secondary schools public and private. In the Netherlands, the Ministry of Education Inspectorate (Ministerie van Onderwijs en Wetenschappen, 1986,1987) conducted a survey at the end of 1985, in which all the Dutch primary and secondary schools were included. Although the results of these surveys were published very recently, pay attention to the fact that the data themselves were gathered more than 18 months ago. This means that the actual situation can differ significantly.

Number of Computers

Becker reports that 'seven years ago, half of all high schools had no computer al all; and only four years ago, fewer than half of elementary schools had any'. In January 1983, 53 per cent of all schools in the US had at least one microcomputer obtained for use in instruction (85% of all high schools, 42% of all elementary schools). In the spring of 1985 these percentages had risen to almost 100% and 80%. A typical high school had more than 20 computers, a typical elementary school had 6.

In the Netherlands the percentages at the end of 1985 were 91% for secondary schools and 28% for elementary schools. The expected numbers for 1986/87 are 95% and 59%. A typical secondary school had 9.7 micro-computers, a tupical elementary school had 1.6.

Because the educational system in the US is fundamentally not different from the systems in other industrialised countries and because Western Europe started approximately two years later with the introduction of computers in education, one can expect that the numbers of the US will be met by West European countries within one or two years. Especially in elementary education a spectacular growth can be expected.

Use of computers

Becker states that 'a typical high school student could use computers to write compositions, memorise facts and vocabulary, understand relationships and concepts in mathematics and science and write computer programs'. He estimates that for each of these activities the student could use 30 minutes to three hours. This means as much as an hour or two per day, which translates to a student-computer ratio of 6 to 1 or 3 to 1. The numbers of the 1985 survey showed a ratio for high school students of 31 to 1, and for elementary school students a ratio of 60 to 1. These numbers illustrate clearly the discrepancy between an 'ideal' and the real situation.

Qualified teachers

Not only the amount of the hardware available determines the use of it. Teachers are also needed, to guide and stimulate the practical use of computers regularly with students versus only 15% of the secondary school teachers. Because secondary schools tend to be larger than elementary schools, the same number of teachers (5 per shcool) use computers regularly during the year. Of these teachers only 10% respectively 25% could be considered as computer-knowledgeable, meaning that per two elementary and per secondary school one 'expert'-teacher is available.

Major instructional uses

The way computers are used by students is quite different per school sector. Becker (1986) reports the following distribution of computer activities:

Grade Span of School	Drill & Practice Tutorial	Discovery Learning Problem Solving	Programming	Word Processing	Other	Total
K-6 Elem	56%	17%	12%	9%	6%	100%
Middle/Jr.High	30%	15%	32%	15%	9%	100%
High School	16%	10%	49%	20%	5%	100%

Table 1: Mean Percent of Instructional Computer Time

The numbers are percentages of the total instructional computer time in a school sector related to schools having computers. In Dutch elementary schools, 17% of them use computers for CAL (drill and parctice, tutorials, discovery learning, problem solving). Related to the schools who already have computers, this percentage rises to 61%. Thiry percent of the lower secondary schools and 47% of the upper secondary schools use computers for CAL. Because most of these schools have computers, these percentages do not have to be adjusted. In 65% of Dutch lower secondary schools computer literacy courses are given. In 60% of the upper secondary schools a course in informatics/programming can be taken.

In comparing these figures with htose of the US, it is remarkable to see that especially in the elementary education of both countries, the use of CAL is widespread. In the Netherlands a higher percentage for CAL appears in the upper secondary level, but this is due to the fact that a new mathematics curriculum has been introduced recently, in which computers and computing is one of the topics. although the percentages for CA1 suggest a widespread use of computers as a learning aid in Dutch education, a qualitative analysis reveals that these percentages do not mean that the impact of CAL is already of some significance.

About informatics/programming in the upper secondary sector, the same tendency appears in the US and the Netherlands. The same is true concerning computer literacy in lower secondary schools.

Regular or supplementary

Another approach can be made in distinguishing computer activities for remediation (help for students behind in their understanding or achievement), for enrichment (activities apart from regular curriculum) and within regular instruction. The distribution of activities in the US following this distinction is shown in figure 1.

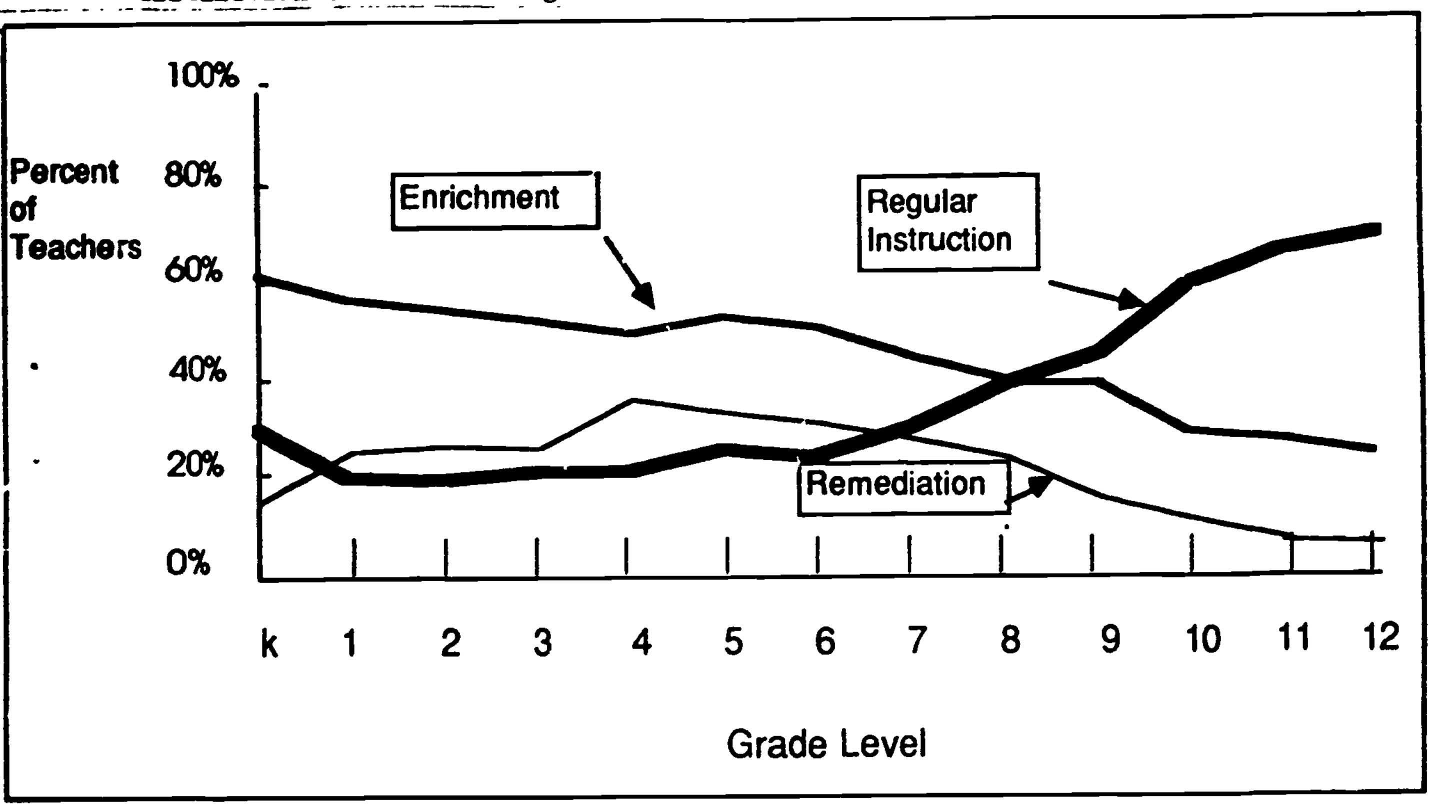


Fig 1: Function of Computer Activity for Teachers
Enrichement, Remediation, or Regular Instruction

As can be seen, in most cases, the use of computers can be described as supplementary to regular insturction. Only in the highest classes of secondary school, use of the computer is integrated in regular instruction.

Major subject areas

'Mathematics and language arts (English and reading) are the major subjects for which computers are used in elementary schools. These two are joined by computer literacy as a third major use in middle schools. In high school, computer literacy and programming are the dominant subjects, with business education and mathematics following', says Becker (1986) in his report.

Forthe Netherlands, mathematics, mother tongue and geography are the major subject areas in elementary school. In lower secondary major interest is towards computer literacy, mathematics and the physical sciences. The same is true in the upper secondary education with interest towards informatics/ programming, mathematics, physical sciences and business education.

As can be seen, a remarkable similarity appears between the US and the Netherlands with respect to this topic.

Some patterns

First observation

Large amount os computers have found their way into education and with great speed, certainly in secondary education.

The introduction of huge amounts of computers in school has, in many cases, been stimulated by individual, private and non-coordinated efforts. As a result, the impact on the educational and organisational level has not or insufficiently been anticipated, especially in relation to the consequences on the innovational level.

Second observation

In speit of this spectacular growth, the amount of time a pupil can use a computer, in relation to the total school time available, is marginal.

This means that one can not expect to see measurable effects of the use of computers on a significant scale yet.

Third observation

Only a minority of teachers are really involved in using computers in education, out of which only a very small proportion can be considered to be an 'expert'.

Considering the numbers of teachers involved, the training of all of them in order to get them acquainted with computers and educational computing will take a whole generation. There is no way to speed up this process. One has to realize that the efforts done now, will have to continue for years to come.

Fourth observation

CAL is mostly used in elementary education, especially in the area of mathematics and language teaching, mostly for drill and practice and tutorial purposes and as a supplement to regular teaching.

The reason is most probably because of the appearance of a great number of problems in these subject-areas. In addition, the ease of use of drill and practice and tutorial programs and the great flexibility within the curriculum and the organisational structure of elementary education create opportunities for CAL.

Fifth observation

Use of computers integrated in regular instruction is mostly connected to classes in computer literacy or computer studies (informatics, programming).

As soon as the organisational s-ructure creates possibilities for the use of computers, their usage becomes widespread.

Comments

The major obstacle for the integration of computers into the curriculum is the rigidity of existing organisational school and class structures. Because of the enormous amounts of teachers involved, their needs for in-service training, the discrepancy between the available amounts of hardware and what is needed and can be 'absorbed' by schools, a concentration upon a limited number of subject-areas seems to be appropriate, for instance towards those curricula that are traditionally known as problem-areas (mathematics and mother tongue). In those curricula much more flexibility will have to be created in order to give CAL the chance to prove its usefulness.

3. Existing evidence about the impact CAL

It is no longer sufficient to defend the use of CAL only on theoretical grounds. All of us know the marvellous stories about the potentialities computers have in education. As long as you are a 'believer' those arguments will be of value for ever. If you have not joined this religion, you will ask for evidence. And there is evidence available now to show that the use of computers has a positive impact on the quality and the productivity of education. It is even possible to show, in certain circumstances, that using computers is cost-effective when compared to other teaching-learning situations.

Effectiveness

Since the meta-analysis statistical method has been published by Glass, a.o. (1981), a great number of reviews about the effects of CAL have been published, Kulik and his colleagues started these publications in 1980, with reviews about effects of CAl in higher, secondary and primary education (Kulik a.o., 1980,1983,1985). Later, their studies were repeated by others and augmented with new results. There was also some criticism about their publications: waht was the influence on the results by unknown or uncontrolled variables, what about the quality of the teachers, the instructional material and the organisational structure involved, what about the amount of time effectively used within the instructional process? Another point of critic has to do with comparing results connected with different kinds of CAL-applications.

Kulik and his colleagues agreed to most of the criticism and published new reviews in 1985 and 1986, using more stringent selection criteria for the studies involved (Bangert-Drowns, a.o., 1985; Kulik, a.o., 1987). Recently, Niemiec and Walberg (1987) have examined a great deal of those literature reviews (a total of 16 reviews covering 250 different primary studies) in order to come to a comprehensive overview of the effects in different educational sectors. They conclude that 'the mean and median effect sizes are both 0.42, and the standard deviation is 0.08'. This means that the 'average and typical effect of CAL is to place the average student using it at the 66th percentile of traditional groups'.

More detailed analysis reveals the following conclusions. Concerning applications such as drill and practice programs ant tutorial programs: these kind of programs have a definite positive impact on the performance. The effect is greater with pupils below average and pupils in special education. The same is true in situations with a lower instructional level, meaning that the lower the educational level, the greater the effect. Finally, there is a clear reduction in needed instructional time. The gain is minimal 20 to 30%.

although conclusions for other kinds of applications are less clear, it seems appropriate to conclude that a positive effect of discovery learning (simulations, problem solving) is more likely to appear in higher education than in primary and secondary education. Much more detail is available in other publications (Roblyer, 1985).

Cost-effectiveness

It is not surprising to be able to measure imporvement of results in education, when in a given situation a much greater amount of time, money, manpower or other thing have been invested than is normally available. A real appreciation of the results as emntioned above is therefore only possible if one includes in a comparison of the use of CAL with traditional teaching methods, the value of the extra investment needed in that particular situation.

Recently, Levin (1986) has compared the cost-effectiveness of four different interventions. He concludes that CAL is more cost-effective than other interventions such as increasing the instructional time or reducing the class size. On the other hand, peer tutoring is more cost-effective than CAL.

Niemiec, a.o. (1986) have reacted to these results and explain that, based on their research, CAL is twice as cost-effective as peer tutoring, see table 2.

	Mathematics		Reading	
	Levin	Niemiec	Levin	Niemiec
CAL	1.0	4.5	1.9	3.5
Peer tutoring	4.6	2.9	2.2	1.0
Adult tutoring	0.8		0.5	
Increasing instructional time	0.5		1.2	
Reducing class size				
from to				
35 30	1.4		0.7	
35 25	1.2		0.6	
25 20	1.0		0.5	
35 20	1.1		0.6	

Table 2: Estimated effectiveness of four educational interventions in months of additional achievement gain per year of instruction for each $100 per student.

As well as a continuing discussion about the exact meaning and interpretation of this data and the use of the meta-analysis techniques (Slavin, 1986; Walberg, 1984) these data indicate that using CAL is at least as cost-effective as other kinds of interventions, mau be excluding peer tutoring. On the other hand, CAL and peer tutoring can form a perfect match. Becker (1986) found that the largest reported impact of computers on instructional practices was by mutual assistance among students, meaning that a combined effort in this respect can optimise the effects. See also Johnson, a.o. (1986). Supplementary to these results, Levin (1986) has investigated the use of a certain CAL package in different US school districts.

The results per district were quite different. The explanation Levin gave relates to the quality and quantity of the available personnel and implementation efforts per district. As well as the intrinsic quality of the educational softward, the way it was used and supported highly influenced the ultimate result on the performance of the pupils.

These results are mostly based on experimental data related to drill and practice applications of CAL, for mathematics and reading in elementary education and published in the Anglo-Saxon literature. It would be most interesting to have data available for other applications, other subject-areas, other school sectors and from other cultures, for instance Eastern and Western Europe. One of the key problems in relation to research about effectiveness and cost-effectiveness is the absence of relevant data, based on longitudinal and sound methodological methods.

Comments

The core of the critics about effectiveness studies is that the positive effect is not caused by the use of the computer, but that the use of different instructional methods, a different content, a different effort by teachers and pupils and the Hawthorne-effect lead to the effects (Clark, 1985). Summarising, one could say that positive effects of using computers in education are not related to the medium, but to the circumstances the use of this medium forces us to create. Now then, what is wrong with that ? The main question is, if these better results ask for a more expensive instructional process compared to other approaches which lead to at least the same results. This is exactly what is expressed in cost-effectiveness ratios.

In addition, the study of Levin (1986) reveals that as well as the medium, compelling surrounding organisational aspects (curriculum analysis and didactical analysis in the developemnt phase, training and personnel efforts to support the implementation phase) are highly responsible for the positive results. The intrinsic value of CAL programs therefore must be that through them structural components of good educational practice implicitely have been taken into account or will be, when using the programs in the classroom. If these aspects create supplementary expenses, these costs have to be taken into account in the cost-effectiveness ratios.

4. Research, development and implementation

Research and development in education

Mehtodological issues concerning research and development in the social sciences are critical topics (Cooley, 1986). One could get the impression that research activities in the social sciences are sometimes hindered by a pursuance to reach a level of methodology that is comparable to that of the physical sciences. From a scientific point of view, this is certainly worth while. On the other hand, it is interesting to note that also in the physical sciences, research has often as a goal just to reach an optimal solution for an existing problem. The recent developments in the field of superconduction illustrate this very clearly. It is a fact that a comprehensive theory about human learning does not exist. This is also true with respect to the theoretical foundations for effective teaching methods. Considering the specific nature of humans, may be these theories will never occur (Shulman, 1986). Becuase of this lack of didactical models, it is therefore impossible to base the development of learning material, including computerised materials, straightforward upon theoretical grounds. As a consequence, a strategy based on craft and craftmanship has to be followed.

Research, development and implementation in computer education

Research about the use of computers in education is very complex, because of the very close connection with the development of the educational software and the use of this software in a real classroom situation. Specifically in this case, the value of the research is highly dependent upon how relevant variables and teaching strategies have been technically incorporated into a computer program. The use of novelties in a real classroom situation, is a common problem in the educational research area. It has, however, an extra dimension in this case, because a lot of technical aspects, causing a long tail of connected organisational problems, complicate the matter to a high degree. Therefore, there must be a very close relation between the development of educational software packages, the use of them for research purposes, the commercialisation of the product and the implementation.

On the other hand, the expertise for making, investigating, distributing, implementing and maintaining such packages must be sufficient, in order to be able to deliver software which makes optimal use of existing expertise in the different domains. Here a conflict arises about the expertise of those who are involved. To discuss this matter the foolowing distinction of activities is suggested.

A four phases model

Development, research and implementation of computer activities in education need a cycle of four distinguishable phases.

See figure 2.

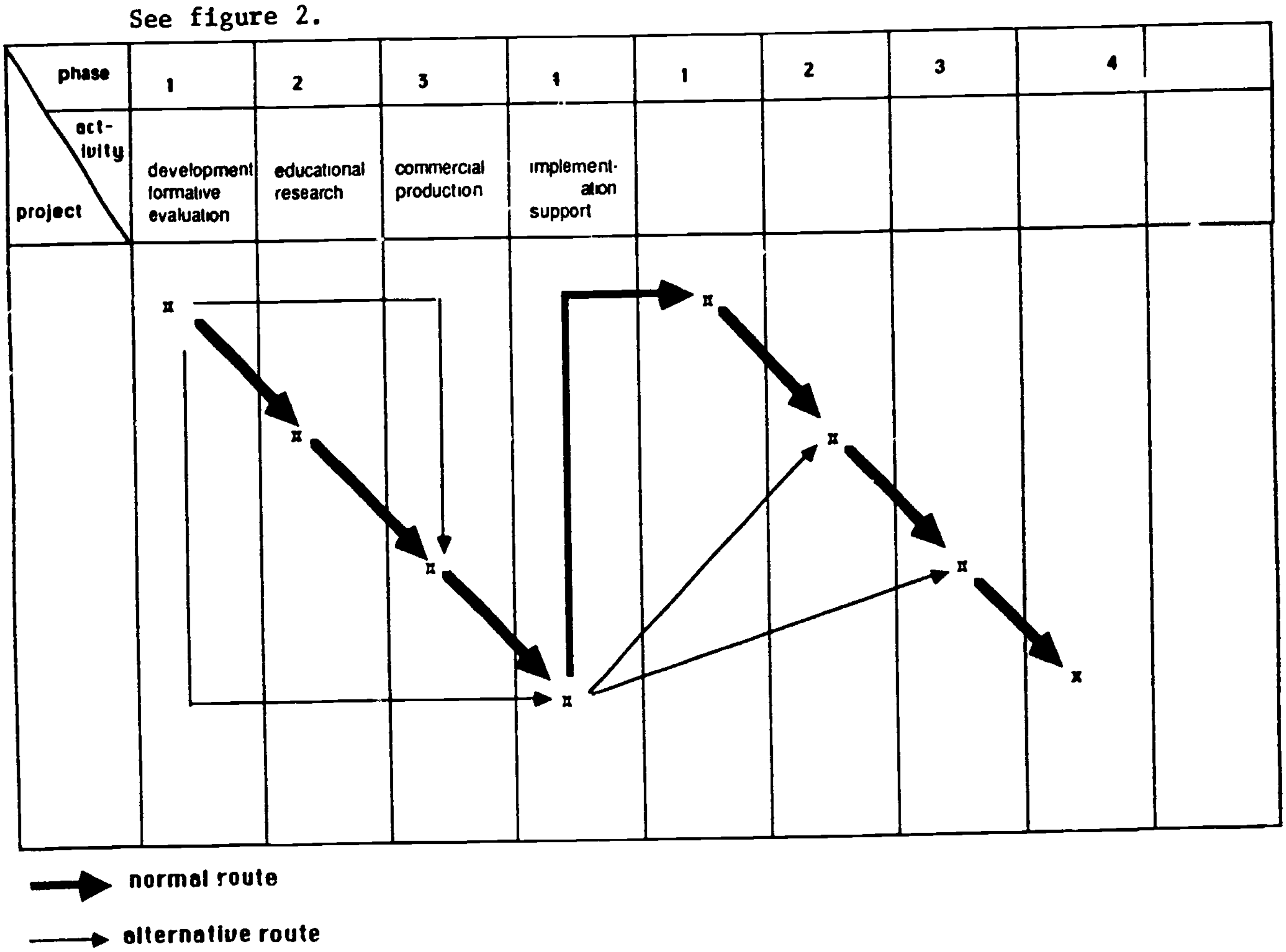


fig. 2: Development, research and implementation routes for educational software

First phase

The first phase starts from a real classroom situation and tries to solve an existing teaching or content-orientated problem as good as possible, using the most appropriate technical possibilities. This phase includes formative evaluation (Moonen and Schoenmaker, 1986; Schoenmaker, a.o. 1987). In a general sense, a systems approach has to be followed here (Verhagen and Plomp, 1987). People working in this area can be characterised as 'educational technologists'. The result of their activity is a product which has the status of a 'prototype' and a 'protocol' which describes in a detailed fashion the consecutive activities, including the formative evaluation, in this phase.

Second phase

Further study of the protocols of the first phase will form the basis for 'pragmatic' theories which will only be valuable within a specific context, called 'shallow' theories by Suppes (1986), or 'miniature' theories by De Klerk (1982). In order to enlarge the value of those theories, they will have to be examined very carefully in experimental situations, in which sound methodc-ogical procedures can be followed. In the case of computers and education, studies about effectiveness and cost-effectiveness are essential. The results of those have to indicate the influence of the use of computers on the qulity and productivity of education. there is a great need for this kind of research. One needs a clear picture in order to be able to defend the very radical changes needed as a result of a large scale introduction of computers in education.

This kind of work conincides with traditional educational research activities and is traditionally performed by universities or connected institutes.

Third phase

In the third phase a final product is produced, based upon the knowledge gathered in the previous phases. This product has to take into account all the constraints that exist in real school situations: financial, technical, organisational. One will also have to decide about the choice of the most appropriate instrumentation of the didactical process in relation to the state of the art of the technology of that moment.

As far as industry is involved in the production process of learning materials, this third phase will have to be done by industrial compa-ies: educational publishers or softward houses.

Fourth phase

As soon as the commercial product is available, the pedagogical implementation has to be performed. Now all the known porblems related to great scale educational innovations appear: the need for information, for background material, for in-service and pre-service training, for extra facilities, and so on. This kind of support has to be given by teacher training institutes, educational support centres and so on.

Comments

As well as the clear distinctions in different phases put forward in this model, the main message, however, is that different qualities are needed in order to be able to optimise the results in each of the phases. In addition and becuase of the great range of qualities concerned, also on the technical level, those qualities will not be found within one kind of person. Consequently, different people have to carry out the different phases. Further, those different phases will be characterised by a different 'working culture'. This approach causes new problems, especially on the managerial level and the smoothing of the interrelationships and connections of those phases. In a general sense, educational research in the eara of information technology, will have to shift away from a comprehensive individual approach towards a more industrial or technology-based approach. The lack of experience and tradition onthe level of research management in this area has to be the major concern for the future.

In addition, the approach as described so far, could vring about a solution for another severe problem. Recently, it became absolutely clear that educational publishers are very reluctant towards entering the educational software market, or, if they have already done so, are pulling back. This attitude came about because of the discrepancy between the costs needed for research and development, and the profits that came out of selling the products. An approach in which the government takes the lead, and finances the prototyping and research aspects of educational software development could solve this problem.

5. Situation in the Netherlands

The Advisory Committee on Education and Information Technology

In 1982 the Advisory Committee on Education and Information Technology (AOI) proposed a startegy for the introduction of computers in education. In her first report 'Information Technology: a necessity for everybody' (Plomp, 1985) the following recommendations were given:

1. To introduce, within the next five years, computer literacy activities for all the pupils in the age range of 12-15.
2. At the same time, to stimulate the use of computers in schools to support administrative and organisational aspects directly related to educational aspects.
3. For the medium range, to stimulate preparations for the introduction of computers as a learning aid, especially as a tool.
4. For the long range, to start thinking about using computers as a replacement for teachers.

This report has had a definite influence on the Dutch policy which started at that time (Moonen, 1986).

The Informatics Stimulation Plan

The main activities in the Netherlands at present in the field of computers and education are concentrated inthe educational part of the Informatics Stimulation Plan (INSP) the INSP is a five-year program, 1984-1988, to stimulate the use of computers in all the educational sectors, excluding university teaching, with a budget of over 280 million guilders for the educational part (Van Deursen, 1987).

Within the INSP special attention has been given towards the creation of an infrastructure (including a methodology) for educational software development; the development and implementation of computer literact courses and software packages in the different school sectors, with a clear (financial) priority towards vocational education and a clear reserve towards elementary education; the organisation of large programs for pre-service and in-service training; the stimulation of research.

Now, five years after the AOI-advice, we can see that the introduction of computer literacy is going well in Dutch education. And although the stimulation of the use of computers to support administrative and organisational activities has not received major attention within the current policy framework, these developments are also going well.

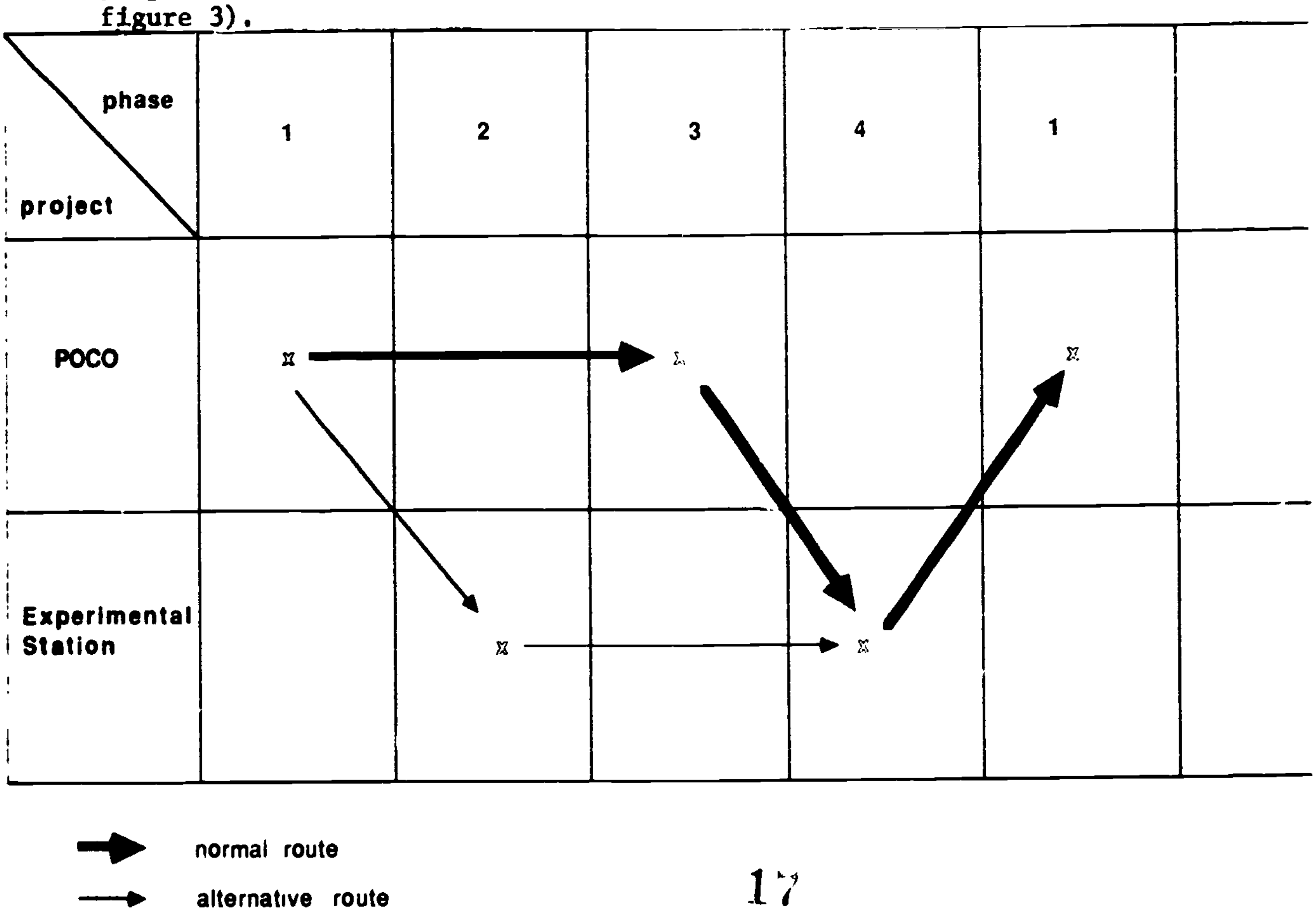
pproximately 50% of the secondary schools and 15% of the elementary schools who have computers, use them in this respect. The use of computers in vocational education has got a major impulse, especially by enlarging the budget for the inventory of the schools. Available in-service courses are constantly booked up. (PSOI, 1987). Becuase of a limited budget and because of non-agreement about the main trends to be investigated, the research efforts till now have not been too successful.

The Netherlands now faces the challenge to shift towards execution of the third recommendation of the AOI: the introduction of computers as a tool in education. In paragraph 2 we have already indicated that this new road is full of obstinate difficulties. A major concern in this respect is how to get enough educational software available in order to be able to build up educational packages which enable a 'continuing and freouent use of it in education through which a measurable and positive impact on present educational processes can be realised' (Kooreman and Moonen, 1987).

In the previous paragraph an industrial-based approach was formulated to create a context in which this problem could be tackled.

6. Future strategies

Recently, the Ministry of Education and Sciences of the Netherlands has sta: ed two new projects in order to give a concrete interpretation to activities in this direction: a courseware development project called 'POCO' (courseware development for computers in education), and a pilot-project for educational research about, and implementation of, computers in schools called the 'Experimental Stations" project. POCO is related to the first and third phase of the model of paragraph 4, the Experimental Stations-project is connected to the second and fourth phase of this model, (see figure 3).



: Connections between POCO and the Experimental Station-projects and the routes of educational software development

POCO-project

The POCO-project willreorganise a number of existing activities in the field of educational software development and concentrate the efforts more specifically towards the development of sufficient amounts of software for a restricted number of subject-areas within the elementary and secondary school sector, including lower and middle vocational education. The project will start at the end of 1987 and will have a life-span of four years. The Center for Education and Information Technology (COI) will manage this project. The main purpose of the project is to produce, within fixed time limits, a reasonable amount of good quality educational software, in order to create the basis for frequent use of it within certain subject-areas which can significantly influence results, motivation and working habits of teachers and students.

The project will be a cyclical nature. Each of the cycles will consist of four phases:

- Choosing the subject-areas, and within those areas, specific topics, for which use of computer cna be of any help. Setting up priorities in relation to the finacial constraints and political arguments.

- Productin of so-called product descriptions in which at least a functional description of the program wanted has to become available. In addition and in a more general fashion, standardised procedure concerning project and development methodology and documentation will have to be taken into account.

In both phases, the say of practitioners and the educational support system of the Netherlands, will have to be organised.

- Via a tender procedure, the technical production of the programs will be boarded out.

- The distribution of the produced packages will be orgainsed through the normal channels of the educational publishers. These publishers will be asked to engage in specific areas of the whole process. For the POCO-project a total budget of 26 million guilders is available.

Experimental Stations-project

In 1986 the decision was taken to start a project with two so-called 'Experimental Stations'. An 'Experimental Station' is a unit of two pilot schools in the general secondary sector combined with a group of educational researchers, connected to a Dutch University. It is the intention to make available within each of these pilot schools, a level and amount of hardward and (educational) software that can only be expected in the majority of Dutch schools, after a period of 5 to 10 years from now. It is the task of the educational research group to investigate in a concentrated and interrelated way questions connected with the implementation of computers in the real classroom situation (Van der Klauw, 1986).

Two experimental stations exist now: one in the western part of the Netherlands, connected to the Free University of Amsterdam and the State University of Utrecht, and one in the eastern part of the country, connected to the University of Twente.

The project will be worked out in two phases:

- The first and starting phase from May 1987 till July 1988.
- The second phase from July 1988 till July 1992.

For the Experimental Station-project a total budget of million guilders is proposed.

7. Conclusion

As is shown in figure 3, these two projects must make it possible in the Netherlands to face the problems as described in paragraph 2. The political decisions are taken and the financial means are available. The major problem still to be solved is the organisation of a smooth running project-management. What a challenge !

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Questions

1. Is the integration of CAL in the organisation and the curriculum of the school the major goal for the future?

2. The paper states that 'demonstrable measurable positive effects as a result of using CAL and a personal acceptance of computers' will form the basis for the ultimate success. Does one agree with this statement?

3. Does one agree that the rigidity of existing organisational school and class structures is the major obstacle for the introduction of CAL at this moment?

4. Does one agree that a concentration upon a limited number of subject areas is an acceptable strategy to overcome the existing difficulties?

5. Is the choice of mathematics and mother tongue in this respect a good choice?

6. Is there not a need for research on effectiveness and cost-effectiveness of CAL, especially in European countries?

7. Does one agree that a distinction in different phases, as described in the proposed four phases model, could bring about a solution towards the optimisation of the results in each of the phases?

8. Does one agree that the lack of experience and tradition on the management level in educational research, and especailly in relation to CAL, is a major concern for the future?

9. Will the combination of the POCO and Experimental Stations-project in the Netherlands form a solid basis to go on with the introduction of CAL in Dutch education?