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ABSTRACT

This discussion of the integration of computers into the curriculum begins by reviewing the results of several surveys conducted in the Netherlands and the United States which provide insight into the problems encountered by schools and teachers when introducing computers in education. Case studies of three secondary and two elementary schools in the Netherlands are then presented. The discussion of these studies leads to the conclusion that there are two important types of problems in addition to those usually cited: lack of teacher involvement; and difficulty in integrating available software into usual classroom practice. Implementation strategies drawn from the literature on educational change are discussed, and a recently developed conceptual plan for the implementation of new information technology in the Ontario (Canada) schools is described, with the focus on implications for designers of courseware. Twenty-three references are listed. (MES)

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Computer integration in the curriculum: promises and problems

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1. INTRODUCTION

In many discussions and writings about computers in education three types of problems are dominant, viz. provision of hardware, software development and teacher training. In this paper we will discuss another problem which solution is conditional for a successful implementation and incorporation of computers in schools: the integration of the computer in the curriculum.

There are nowadays many computers in the schools and many claims are formulated about the potential of computers in education. Examples of such claims are that the use of computers improves students' attitudes, has postive effects on learning achievement of certain types of students, provides didactical instruments for enhancing inquiry type of teaching and learning and for more flexible modes of teaching, while certain uses will result in higher-level cognitive skills (see e.g. Bergers, 1987; Hasselbring, 1986). For the first two claims research evidence exists, e.g. Kulik, Bangert & Williams (1983) and Hasselbring (1986), but the arguments for the other claims are primarily based on the potential properties of computers.

Besides, there is hardly any research based knowledge about the way, the frequency and intensity teachers are using computers and about changes in educational practice and in the school curricula as a consequence of the introduction of the new technology in education. We have the supposition that the actual use of computers in schools is limited and of a low level, and that one hardly can speak of effective integration of computers in the curriculum.

In this study we investigate this problem from a two-fold perspective, using Goodlad's (1979) typology of curriculum levels:

(1) the **designer** who has to strive after the (ideal) integration of the computer in the **formal curriculum** (i.e. the curriculum in documents like syllabuses, teacher manuals and student materials);

(2) the **teacher** who has to integrate new materials and a different instructional approach in the daily classroom activities (**operational curriculum**) and also in his beliefs (**perceived curriculum**).

After a first problem analysis of computer integration in the curriculum (section 2), we will discuss implementation strategies which are being proposed for introducing computers in the schools (section 3). It might be that these strategies are insufficiently taking into account some of the characteristics of the integration problem. We will discuss (problems in) these strategies from the perspective of implementation theory, with special attention for the characteristics of computers in education considered as an innovation for the schools (section 4 and 5).

2. ANALYSIS OF PROBLEMS IN SCHOOLS AND CLASSROOM PRACTICE

Integration of computers in education

We agree with Mudd and Wilson (1987) that integration of computers in a curriculum has a quantitative as well as a qualitative dimension. The quantitative aspect refers to a number of variables indicating the frequency and intensity of computer use (Plomp, Steerneman & Pelgrum, 1988). At school level we may think of the number of subjects, grades, classes per grade, teachers per subject and numbers of students (all or a special group). Within subjects integration refers to variables like the frequency of use per student e.g. per year, the time spent on the computer each time it is used, and the number of software packages being used. Qualitative aspects are those referring e.g. to the lesson phases in which the computer can be used (e.g. presentation of new subject matter, practising, testing, feedback) and to the 'level' or complexity of computer applications, which may vary from a relatively low level drill & practice or w. d processing to more sophisticated applications such as simulations or computer coach. . In this paper we will not try to construct a measure of computer integration, but will interpret results of survey research and case studies in general terms.

Survey results

Several surveys provide us some insight in problems schools and teachers have when using computers in their educational activities. E.g. a representative survey during 1985/86 of the Dutch Inspectorate (1987) reveals that in secondary education the schools have problems with the use of computers on the following aspects: scheduling (of computer literacy and computer science lessons), group size, budget, number of computers per class and lack of software. All these problems (chosen from a precoded list of alternatives) are referring to **conditions** for computer use; they are illustrating that the problems of defrayment of the lessons (extra salaries) and the software and hardware are experienced by the schools as complex. An earlier survey in 1984 (Plomp & Carleer, 1987) had similar outcomes; besides in that study the same type of arguments were given by 'non-using' schools for not using computers.

Another result from the survey of the Dutch Inspectorate (1987) is that in 1985/86 about 30% of lower secondary schools were applying some form of CAI (esp. in math and science). The intensity of computer use in these schools is not indicated with this percentage, as schools marked 'learning with the computer' as soon as there was any activity (how little as yet) in this area. Further analysis of these results leads to the conclusion that, in the predominant number of cases, CAI can be characterized as 'once in a while using a computer program during some lessons'. In 60% of the cases these programs are de\ loped by a teacher of the school, while in about 45% it was a published program. Similar results were found in elementary education and upper secondary education.

The number of teachers involved in computer use in schools is still low. The survey of the Dutch Inspectorate indicates that in elementary education about 10% of the teachers got some schooling in the use of computers in the classrooms, of which 3.6% did self study, 2.2% during initial training, while 7.2% attended some form of in-service training (some teachers were involved in more than one form). In elementary education 23.0% of the schools uses a computer in some way with students, while 50.2% of the schools has a teacher with some training.

In secondary education these figures are different. In 95% of the schools at least one teacher has been trained in using the computer, while in more than half of the schools (57%) at least one member of the school management got some training. Yet, the intensivity of participation within schools is still limited; e.g. of general secondary schools 61.2% were not applying any CAI (in the meaning of use the computer for any instructional activity), 19.5% in just one course and 9.6% in two courses. Also the number of teachers within schools involved in computer activities is generally spoken yet limited, e.g. mostly math. teachers, followed by science teachers. The ratio male : female is 2.7 in general secondary schools.

Similar data were found by Becker (1986) in his 1985 survey in the USA. E.g. 85% of the K-6 elementary schools, 97% of the high schools and 95% of the middle/junior high schools used in Spring 1985 any computers for instruction. The average percentage of computer using teachers was 31% and the K-6 elementary schools, 12% in the middle/junior schools and 11% in the high schools, indicating that on the average a small number of teachers per school are using computers for instruction. The major use in K-6 elementary schools is for drill & practice and in high schools for programming, while in the middle schools these two uses are about equal. In the elementary schools computers were mainly used for math and english, in the middle schools for math, computer subjects and english, and in the high schools for computer subjects (programming), business and math.

All these figures indicate that in many school great efforts have been carried out to introduce computers in education. However the intensity of these efforts and the variety of the applications are still so limited that we hardly can speak of real integration of the compute. in the curriculum across the schools. To get a better understanding of the possibilities and problems of computer integration in the curriculum, we decided to study in more detail the developments in schools, which are being considered as forerunners in the Netherlands. Case studies were done in the Netherlands in three general secondary schools and in two elementary schools.

Case studies in secondary schools

The three schools are general secondary schools indicated by the Dutch Inspectorate as forerunners. The schools vary in size and background. Some background data are:

School A: private, part of an organization with 49 schools in several cities, contains pre-university and higher general secondary education; grade range 7-12, age range 12-18; 67 teachers, 1180 students.

School B: public; contains pre-university education, higher and middle general secondary education; grade range 7-12, age range 12-18; 100 teachers; 1700 students.

School C: private, part of an organization with three schools in one city; contains middle general secondary education only; grade range 7-10, age range 12-16; 21 teachers; 274 students.

The case studies concentrated at the sector of lower secondary education (grade levels 7, 8, 9) in these schools; the results are reported by Plomp et al. (1988) and Steerneman (1988). A national scheme in the Netherlands is intended to result in letting all schools in the sector of lower secondary education have by the end of 1988 three trained teachers and 11 MS/DOS microcomputers (partly in a LAN) and to provide for a national infrastructure for software development At the time of the case study (Spring 1987), two of the schools already received equipment under the national scheme; all schools also acquired machines from other resources. In one school computers are being used in six subjects, in the other two only in 2 resp. 3 subjects (no trend in choice of subjects). All schools do have a computer coordinator. Teachers use computers not frequently (mostly 3-6 times a year; exception is e.g. the use of word processor) and almost always in a drill & practice way (for more than 90% developed within the school). Usually the computer application is meant for use with all students, and not for just a special group. Only in one school the computer is used for lower ability students, viz. for three subjects in a remedial mode (but outside the normal classes). Given this limited use of computers the conclusion is that even in forerunner schools the integration of computers in the curriculum has not yet made a real start; they are still in the stage of grassroot developments. From interviews with administrators, computer coordinators and teachers it appears that none of the schools has a clear educational vision of what they would like to achieve with the new technologies; the statements are vague and there is no written or even informal policy statement in these three schools. With a reference to conditions for successful implementation of change (Fullan, 1985) some other outcomes of the interviews are (Plomp et al., 1988): teachers have a need for materials and also for time, there is administrative support on the school building level, but school managers are just stimulating and not indicating 'what, why and how', the national scheme is providing some conditions, but is not inducing directions for the developments on school level; there is no ongoing staff developments in the schools; there is only very limited use of external sources (almost all software is selfmade and training is mainly internal).

Why did these schools start with computer use? On school level the arguments are either 'political' (e g. school can become a forerunner) or qualitative (e.g. possibilities to implement new teaching strategies). The arguments of computer using teachers are personal motivation (e g. curiosity, enjoy the use) and the expectation that the use of computers may improve their teaching and student achievement. In all three schools also some non-using teachers were interviewed. Their arguments for non-use can be summarized in two statements. (i) they don't see the surplus value for their own teaching and (ii) they believe that the computer does not fit within their teaching approach (Steerneman, 1988).

Case studies in elementary schools

Keursten (1988) performed case studies in two elementary schools. There is no national scheme in the Netherlands for providing all elementary schools with facilities. Some schools are participating in an experiment; one of these schools was in the case study. Developments in the other school were stimulated by the principal. Both schools are being considered as forerunners. Where there are only very few elementary schools with more than one microcomputer, these schools do have 6 resp. 3 computers for educational use. Nevertheless, lack of hardware is mentioned by the schools as their most important problem. The schools are using the computers for LOGO, some word processing and further for drill & practice in arithmetic and spelling. Computer applications are not replacing any instructional activity, both are used next to the normal lessons. The computer is being used in some grades, and for some subjects. In summary, in these forerunner schools computer use has not brought about real change. None of these schools has a clear picture of computer use in the future, present activities are depending mainly on coincidences, like the enthousiasm of the principal, a teacher or parents, and the availability of hardware and software. The schools are exploring the possibilities of the computer for their instruction. From interviews with teachers the impression arose that each school has a few pioneers, who are stimulating the developments in their school. These pioneers do have a picture about the possibilities of computers for their schools; drill & practice software is no longer of much interest to them, they are more interested in LOGO, word processing and data base applications. The 'followers' don't have a pronounced opinion and like to use the computer as something extra. These followers don't have a clear need for new programs and applications, nor for extension of computer use.

Some comments

Evaluating the outcomes from the surveys and the case studies of the five schools some conclusions can be drawn. In 1986 a large majority of the schools havs one or more computers and in each of these schools there are at least a few teachers who are enthousiastically applying computers in their teaching. However, the large majority of teachers is still non-user and is also not trained in any computer use. This implies that a majority of teachers has not yet started to use this innovation and is not seeing the possible surplus value that a good educational use of computers may have for their teaching.

A real integration of computers in the school's curricula demands the stake and commitment of a vast majority of the teachers. Therefore, in striving of enlarging the use of computers in the curricula of the schools, one of the biggest problems - next to the often mentioned problems of lack of hardware, lack of software and teacher training - is how to involve the large group of non-using teachers. On school level adoption and implementation are difficult to separate. In getting a real integration of computers in education, many non-users have to be brought to the adoption decision, i.e. they have to become convinced that computers can be used for improving teaching by exposing them to applications useful for their practice. Positive first user experiences may facilitate adoption decisions and stimulate further implementation.

We have to realize that for the integration of computers in education not only the above discussed 'quantitative' problems has to be solved, there is also a 'qualitative' problem asking for solutions. This can be illustrated by using the results of the studies of Hawkins and Sheingold (1986). In three projects they studied the process of incorporating microcomputers in the classroom, viz. Logo programming into both elementary and middle-school classrooms, the use of prototypes: mathematics and science software in upper elementary classrooms, and the implementation of database management software in sixth- and eighth-grade classrooms. Their main interest was to study how careful selected computer use could facilitate the teaching of higher-order problem-solving skills. Some of their research outcomes, which are of relevance for our curricular problem, are:

- because the database software was not designed for educational use, teachers had problems with integrating the database software tools in their curriculum ('software in search of an application'), students had problems in using the software (the system did not protect students from accidental loss of data), the teacher had difficulty thinking of ways consistent with her curriculum to make use of the data processing capacity of the program, the most obvious uses ultimately were not for curriculum but for record keeping;
- the science software was designed for processing results of experiments and to query these data once they had been recorded; however, the teacher found it difficult to use the data-

recording capacities of the computer, and that it was the new classroom science activity rather than the 'traditional' one that could truly make use of the database management capacities of the computer. Only a new approach to science in the classroom would make this software a useful sensible tool.

Hawkins & Sheingold (1986, p. 47) conclude that the innovative 'software did not have an obvious fit with the traditional curriculum. The curriculum in these classrooms had to be stretched or modified in some way to accomodate the technological functions. In these cases, adoption of the technology by the classrooms was not a process of simply incorporating new into old, but or reshaping what was there'.

These conclusions are being confirmed by the results of other research on this topic. Johnston (1985) reported about five case studies of middle school use of computers in the USA in 1984. The teachers express hesitance in using computers as an instructional tool. Besides lack of hardware, important reasons appear to be personal ignorance of how a computer might be used and the challenge that computers pose to existing instructional routine. Phillips et al. (1984) observed 174 lessons of 17 math teachers, which promised to use the computer at least once a week during one trimester. Interviews with teachers who stopped using the computer revealed two reasons for this, viz. too many practical problems (e g. with making reservations and preparation of the computers) and the belief that the computer did not fit within their teaching approach. Jorde (1985) reports that teachers and schools are experiencing unexpected consequences of computer use, such as poorly documented software with too heavy claims, unforeseen costs for hardware, software and maintenance; much more time needed for implementation and unanticipated roles for teachers. Stevens (1983) finds in a survey that teachers believe that computers will have a permanent influence on education. But asked about their own future use, many teachers gave no answer or expressed that they expect that little will be changed in the way they are handling their class, in their teaching style and in the content of their lessons. Finally, Ridgway et al. (1984) observed 150 math lessons in which CAL was applied. They found a great number of problems, which they categorized in five groups. problems with acquisition of hardware, with the positioning of the computer in the classroom, with the selection of good software, with the use and operation of the computer in the class and problems with the integration of computer use in the lessons and in the curriculum. They conclude that these problems should be avoided, because disappointing experiences of teachers may result in stopping of the use of computers.

To summarize the results of this problem analysis section, in studying the integration of computers in education we are facing (besides the problems about personnel, budgetary and material conditions) two types of problems: a quantitative (dissemination) problem because many teachers in the schools are not yet in the adoption phase, and a qualitative (implementation) problem because teachers have problems to integrate - even less advanced - software in their usual classroom practice.

In the next section we will explore which strategies are being proposed for a successful introduction of computers in schools and classrooms, and investigate how far these strategies are taking into account the above mentioned implementation problems.

3. SOME IMPLEMENTATION STRATEGIES

Implementation strategies are recommended from different perspectives, e.g. the educational manager like the superintendent responsible for a school system, the researcher/(software) developer, the change agent. In this section we will describe some of these strategies which are proposed in the literature on computers in education. In the following section these strategies will be discussed in the context of the general literature on educational change.

Steber (1983) suggests a **strategic planning approach**, which can be summarized as follows: determine the curriculum (for computer education) and related administrative applications; select appropriate software to support the programs, purchase hardware which supports the software and, in turn, the curriculum. His strategy is hypothetical (no empirical evidence), although he is referring to the Tyler rationale for curriculum development. Although he is mentioning the importance of encouraging staff, his approach is typical 'top down' (author is assistant superintendent!), not dealing with the 'subjective' meaning of the innovation, i.e. the teachers' perspective.

Cory (1983) rejects such a strategic planning approach, because she does not believe in the idea of having a full plan in advance. 'It is impossible for a school system to know what to do with computers until its own faculty and staff know what computers can do, and it is not possible for them to know what the potential really is until they have purchased enough hardware, used enough software, and spent enough time learning to really understand what the possibilities are' (p. 11). She believes in a kind of **experiential learning** by suggesting that a school system has to go through for different stages before they can fully utilize computers. At each stage six factors are identified: hardware, software, staff development, computer-assisted learning, computer literacy and attitudes. These stages of development school systems have to go through for full implementation of computers for instruction are according to Cory (1983) the following.

Stage 1 of **getting on the bandwagon**. In this stage the acquisition of hardware is the primary focus; the emphasis is on quantity. Little software is acquired, because the money is spent on hardware and it is expected that teachers will write their own software. Staff development is not considered to be important; if there is any training, it comes from the computer store. At this stage there is no distinction between computer-assisted learning and computer literacy; any time spent on the computer must be good since it is making the children computer literate. The general attitude is ambivalent, combined feelings of fear, mistrust, uncertainty and curiosity.

Stage 2 is the **stage of confusion**. Things seem to be going in many different directions at the same time. School administrators have not yet recognized the amount of money and human resources needed to achieve system-wide success. A few teachers are making great gains in their own knowledge, but no overall plan exists to train teachers in the school system.

Stage 3 of **pulling it all togethter** is characterized by a flurry of committee work and efforts to get things coordinated. There is a general sense that computers are wonderful machines that could do tremendous things for education if only we could get it all pulled together.

Stage 4 is the stage of **full implementation**. This stage has a beginning, perhaps a middle, but no end, as growth, improvement and change continue forever. It is the final stage, however, because there is a real understanding of what computer technology can do. At this stage, computers are used to provide the greatest service possible to teachers and students in the school system.

There is an interesting difference in the two management perspectives. Steber in his strategic planning is not paying any attention on the process aspect of introducing an innovation in the school system. His approach has the optimism of the planner who is not bothering himself about the problems the organization and the persons within this organization will have with integrating the innovation in their daily functioning. At other side, Cory is taking into account the process problems to such an extent that she is only referring to any planning processes in the later stages of her model. One may ask whether she is right by suggesting that there are no possibilities for steering and regulation from the beginning of the process. Furthermore, in her approach a real danger is that teachers will not 'survive' the first two stages because of disappointing, or better: lack of stimulating and rewarding experiences.

There are several other implementation strategies to be mentioned, proposed by authors who are involved in research and development of educational software.

Under the device 'think first, act later', Beishuizen et al. (1987) suggest a six-stage strategy for schools, also reflecting a typical planning approach. orientation, training, organization of hardware and software, organizational preparation, initial use and advance use and evaluation. The strategy, a result of their experiences with twelve elementary schools, has been discussed with teachers and school counselors. This group appreciated the approach of careful planning and consideration based on the choice of educational objectives (in the orientation phase), but stated that it is impossible for a school to make decisions on educational objectives and on utilization of the computer without having the opportunity to learn from hands-on experience. So people working in the educational pratice clearly indicated that a purely strategic planning approach will not function in schools. As a result Beishuizen et al. (1987) adapted their strategy, dividing the six stages into two parts. Part 1 consists of the stages of orientation and training and is devoted to free exploration of educational applications of computers. No direct results on student level should be expected during these stages, but the school should become acquainted with the possibilities of computers and build up the expertise necessary for a good use of it. There should be no external evaluation of computer use in the school during the first part, which may, according to Beishuizen et al. (1987), last for three till five years. Part 2 of their strategy has four stages, viz. organization of hardware and software, organizational preparation, initial use and advanced use and evaluation (by the school in cooperation with specialists). The idea is that at the end of the first part of the implementation strategy, the school management has learned so much from the practical experiences that a plan can be made for a real and substantial integration of computers in education. This plan will probably involve the acquisition of more professional hardware and software than the school has been using during the exploration stage. Tangible results may be expected from the execution of the plan. Therefore, careful evaluation is necessary and profitable to future users of computers in the school (Beishuizen et al., 1987, 640-641).

It should be noted that in this case a very interesting process took place. The group of researchers drew up a typical planning strategy based on their conviction of 'think first, act later'. Then under the influence of practical people the first stages were changed such that typical elements of the adoption process were taken into account. However, the second part of the strategy remained a planning approach, in which no clear attention is paid to the process aspects of implementation in the schools.

The strategy Cox (1987) proposes is clearly taking into account factors which may inhibit on school level the use of computers. Besides limited resources, she points to the possible irrelevance of CAL when the topics to be dealt with in CAL are not closely related to the existing curriculum. Another factor is the inability of teachers to respond appropriately to the change. In her implementation strategy these points are reflected. Her strategy is not a planning approach, but is presented as an overview of issues, together with policy statements, which should be common in the planning of 'local' strategies. The issues she is mentioning are: software development, training the trainers, and incorporating CAL into the school curriculum. Some of her policy recommendations are:

- **software development**: design for the type of hardware used in schools and for ease of transfer into future hardware, design the software to be usable with classes, groups and individuals; design the CAL packages to be part of curriculum innovation; provide guidelines for teachers use in the subject, in the classroom and with other materials;
- **training the trainers**: trainers need experience and knowledge of curriculum content for which the software is designed; they need to understand the impact of CAL on all aspects of the curriculum; trainers need to train teachers on the incorporation of the computer into the school;
- **Incorporating CAL into the school curriculum**. (i) role of CAL inside the school. training the principal, developing a school implementation policy, selecting CAL for the curriculum, choosing priorities of resources, organizing the classroom, inservice training for the school teachers; (ii) advice and support from outside the school in the form of repairing hardware, recommendations on CAL software, information on new technologies, also of curriculum changes, updating training linked to staff changes. This support function is needed permanently (Cox, 1987, 46). Cox rightly remarks that in very few cases all these aspects have been covered.

Reviewing Cox's strategy it is important to notice that she is not proposing a general strategic planning approach (like Steber and Beishuizen et al.), nor a naturalistic approach (like Cory) in which hardly any planning is foreseen in the beginning stages. The merits of her approach is the taking into account of important factors which on school and teacher level may inhibit integration of computers in the curriculum. How these issues should be translated into a strategy, i.e. a plan of action, on district or school level is not discussed by her.

4. TOWARDS MORE SOPHISTICATED COMPUTER INTEGRATION STRATEGIES

In the previous section we described several implementation strategies which had a rather weak base in empirical research and also in the literature on educational change. It is difficult to find literature wherein the problem of the integration of computers in education is analysed in a balanced way and wherein the current body of knowledge about educational innovations is applied systematically. A recent, successful effort has been made by Fullan, Miles and Anderson (1987) in their report "A conceptual plan for implementing the new information technology in Ontario schools". We shall discuss here some of their reflections and recommendations. In view of our primary research interest in curricular matters, we shall focus on implications for designers of courseware (including accompanying curriculum materials).

Fullan et al., building on earlier publications, present a conceptual framework with ten research-based factors affecting educational innovations in schools and classrooms. Each of these factors is analysed from both a "from above" and "up close" perspective. The first three factors are clustered as "characteristics of the innovation" itself: clarity and complexity; consensus/conflict; and quality/practicality. The remaining seven factors belong to the "local conditions": central office direction, commitment and support, proces for implementation and institutionalization; professional development and assistance, implementation monitoring and problem solving; principal's leadership; community support and environmental stability.

A general conclusion in their study is that "using microcomputers and curriculum software in the classroom (....) represents a major and difficult change in practice for most teachers, and that effective utilization will depend on follow-through or ongoing assistance, clarification and innovation adaptation during the implementation, in addition to the availability of easy-to-use technologies, curriculum relevant software, and introductory training". The authors add that "high uncertainty about the impact of the new technologies on learning outcomes and about the most effective methods of classroom use poses a major obstacle and challenge for implementation of the part of teachers and administrators".

In contrast with some of the previously mentioned strategies, Fullan et al. propose a "backward mapping" approach, that is taking the perspective and problems of innovation users in the schools as the primary basis for implementation planning, rather than the perspective of policy-makers external to the implementation settings.

The current focus of implementation in Ontario, according to Fullan et al. (p. 1), is to assist teachers in learning to use microcomputers and educational software with students in the classrooms. The authors emphasize the integration of this use into the teaching/learning process of all subject areas and levels of the curriculum (the computer as a tool).

It is important to realize that such an integrated use of computers comprises more than a simple innovation; it appears as a "bundle of innovations" with many components and persons involved. Above all the process of implementation is one in which teachers learn or do not learn new practices and about new understandings about effective uses (cf. Van den Akker, 1988). Like most innovations, the integration of computer use in the classroom covers three dimensions of change:;

- the use of new hardware and software materials;
- the use of new activities, behaviors or practices in teaching and learning;
- changes in beliefs and understandings.

Fullan et al. emphasize that the production of high quality software is an important, but relatively easy first step when it comes to the realization of these several aspects of innovation. Especially the central aim - effective pedagogical use of software in the classroom - will require intense and sustained efforts.

In the remaining part of this paper we will focus our attention to the desirable characteristics of the innovation itself, thus leaving the 'local conditions' aside.

Fullan et al. report that many studies indicate that beginning implementation of NIT (like many other curriculum innovations) is characterized by frustration and difficulty. To gain a clear understanding of what to do and change in order to put the innovation into practice and to reduce the complexity of the new approach, for the beginning users a high degree of a priori procedural specification seems useful. But that is only justified when the innovation is thoroughly debugged and when replication of an exemplary practice is the main goal. Such a strategy requires a careful evaluation of effective practices and the incorporation of the evaluation experiences in the materials. Too complex innovations can easily lead to partial or superficial use of even giving up. In order to avoid that risk, much attention should be given to the reduction of complexity.

Fullan et al. sound a warning note about the degree of specificity in software documentation. But their remarks seem to refer to the specification of the operational procedures of the software program. They underline that more attention should be paid to identifying and developing effective teaching practices in relation to each program. This may be a false contrast. When effective teaching practices have been developed and tested in various settings, there seems every reason to incorporate these findings in the program documentation ('lessonware') in a highly specific way. Especially in the initial implementation stage the teachers can only profit from these directions.

Another point made by Fullan et al. concerns the problems that many individual students have with understanding and using the programs. Close supervision and guidance from teachers is important, especially when more creative computer use is expected. Clear suggestions for this teacher's role should in our opinion also be incorporated in supportive teacher guides with the program.

Consensus among potential users about the need, appropriateness and the priority of the change effort will benefit the implementation process. But Fullan et al. make a right observation, when they put that consensus can only be superficially meaningful in the absense of experience with concrete, high quality usage. This conclusion seems even more valid for the implementation of NIT as it is for the implementation of most curricula, because the discrepancy with the traditional practice is so big. This is an argument once more for providing teachers with concrete, prototypical experiences with easy-to-use computer applications in an early stage of the change process (cf. Van den Akker, 1988).

Fullan et al. mention several characteristics that can raise the quality and practicality of NIT-innovations: technical certainty of the program; early and apparent student outcomes; much concrete how-to-do-it information for the teacher, starting with manageable chunks, materials as easy to use as possible. Teachers must be helped with support materials (and inservice training).

We presume that best results can be expected when the development of support materials does not happen after the production of the computer software, but when a simultaneous and integrated development approach is followed. Only then a reasonable chance exists on a good alignment between the several courseware components.

A real integration of the computer as a tool in many curriculum areas can only be realized when teachers recognize the surplus value of computer use. Early (modest) successes in the implementation phase seem crucial for motivating teachers to become committed to the change efforts. An infusion approach (small-scale and controlled explorations with high quality materials) may help. Necessary conditions for such an approach are: the design of curriculum-embedded courseware and very careful field testing of the products (with both teachers and students). The availability of supportive print materials may be of special help for the learning process of the teacher in figuring out what the program means and how it can be used in the classroom.

We are (at the Univesity of Twente) involved in several research projects to explore such design and evaluation strategies of courseware. Our perspective is curriculum- and implementation-oriented. In the next years we hope to contribute to the knowledge about possibilities for effective integration of computer use in the curriculum.

REFERENCES

Akker, J.J.H. van den (1988). The teacher as learner in curriculum implementation. **Journal of Curriculum Studies, 20**, 47-55.

Becker, H J. (1986). **Instructional uses of school computers, reports from the 1985 national survey** (issue no. 1). Baltimore: Center for Social Organization of Schools, The John Hopkins University.

Beishuizen, J., Mannaerts, G. & Brazier, F. (1987). Otopia: an implementation strategy for computers in education. In J. Moonen & Tj. Plomp (Eds.), **Eurit '86: Developments in educational software and courseware** (pp. 635-642). Oxford: Pergamon Press.

Bergers, L (1987). **Courseware voor procesgericht natuuronderwijs** (Courseware for process-oriented science education). Enschede: University of Twente, Department of Education.

Cory, S. (1983). A 4-stage model of development for full implementation of computers for instruction in a school system. **The Computing Teacher**, November, 11-16.

Cox, M.J. (1987). Computer-assisted learning/CAL and the future. In Tj. Plomp, K. van Deursen & J. Moonen (Eds.), **CAL for Europe**, pp 33-49. Amsterdam: North-Holland.

Dutch Inspectcrate (1986). **Onderwijs en informaietechnologie: stand van zaken** 1985/1986 (Inspectierapport 7) (Education and information technology: state of the art 1985/1986).'s-Hertogenbosch: Ministerie van Onderwijs en Wetenschappen, Inspectie voor Speciale Diensten.

Fullan, M. (1985). Curriculum implementation. In T. Husen & T.N. Postlethwaite (Eds.), The **International encyclopedia of education** (pp. 1208-1215). Oxford: Pergamon Press.

Fullan, M., Miles, M.M. & Anderson, S.A. (1987). **A conceptual plan for implementing the new information technology in Ontario schools.** Toronto: Ontario Ministry of Education.

Goodlad, J I. and Associates (1979). **Curriculum inquiry: the study of curriculum practice.** New York: McGraw-Hill.

Hasselbring, T.S. (1986). Research on the effectiveness of computer-based instruction: a review. **International Review of Education**, 32, 313-324.

Hawkins, J. & Sheingold, K. (1986). The beginning of a story. computers and the organization of learning in classrooms. In J.A. Culbertson & L.L. Cunningham (Eds.), **Microcomputers in education** (85th NSSE Yearbook) (pp. 40-58). Chicago: The University of Chicago Press.

Johnston, J. (1985). Microtrends in the middle school: Byond computer literacy training. **Educational Technology, XXV.**

Jorde, P. (1985). Microcomputers: tempering the pro-innovation bias. **Education**, 106, 388-393.

Keursten, P. (1988). **Integration and implementation of computer use in the (science) curriculum** (In Dutch). Enschede: University of Twente, Department of Education.

Kulik, J , Bangert, R. & Williams, G. (1983). Effects of computer based teaching on secondary students. **Journal of Educational Psychology, 75**, 19-26.

Mudd, S. & Wilson, W. (1987). Achieving curriculum-integrating computing. **Computing Education**, 11, 63-69.

Phillips, R.J., Burkhardt, H., Coupland, J., Fraser, R. & Ridgway, J. (1984). **Computers in Education**, 8, 173-177.

Plomp, Tj. & Carleer, G. (1987). Towards a strategy for the introduction of information and computer literacy courses. **Computers in Education**, 11, 53-62.

Plomp, Tj., Steerneman, A.H.M. & Pelgrum, W.J. (1988). Curricular changes as a consequence of computer use. In F. Lovis (Ed.), **Proceedings of the IFIP TC 3 European Conference on Computers in Education** (Lausanne, Switzerland, 24-25 July 1988). Amsterdam: North-Holland.

Ridgway, J., Benzie, D., Burkhardt, H., Coupland, J., Field, G., Fraser, R. & Phillips, R. (1984). Conclusions from CALtastrophes. **Computers in Education**, 8, 93-100.

Steerneman, A.H.M. (1988). **Experience with computer use in three schools** (In Dutch). Enschede: University of Twente, Department of Education.

Stevens, D.J. (1983). Why computers in education may fail. **Education**, 104 (4), 370-376.