Digital learning materials: classification and implications for the curriculum[1]

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Curriculum materials are no longer exclusively associated with textbooks but also with information and communication technologies (ICT). However, the clear image of a textbook is non-existent for these digital curriculum materials yet. One may relate digital materials to a simple drill and practice program, but also to a complete simulation of a plant in the process industry. The expectations of digital materials for educational innovations are pitched high. A sober look at the impact of digital materials shows that these high expectations are not met. But, there is still a growing conviction that digital materials will gain significance for learning in school and non-school settings. In order to give a valid examination of the value of digital materials for learning purposes, it is necessary to be more precise about the specific characteristics and educational potential of these materials.

A classical book concerning computers in education is *The computer in the school: Tutor, Tool or Tutee* (Taylor, 1980). In this book computer use for educational purposes is divided in three classes. First, the computer may function as a tutor, which organizes content and delivers instruction. Second, the computer may be seen as a tool, which is used to support student learning activities. And third, the computer may be perceived as tutee, referring to the computer as programmable machine that can take actions according to the instructions of the students or teacher. More then twenties years later this classification, although basically still viable, needs to be extended and refined. An important reason for this extension is that in 1980 delivery and communication facilities specific for the Internet were by no means so far-reaching as today. But also the tutorial role of the computer has become more diverse and more easily accessible through powerful personal computers. Moreover, in education the importance of learning computer programming in languages such as Basic and Pascal has nearly vanished. All kinds of authoring tools and object-oriented computer languages make the former programming skills superficial for non-professionals. The learning curve for the authoring tools (the 'new tutees') is less steep then that for the traditional languages, whereas the result are usually more sophisticated.

In the next section a classification of types of digital learning materials is presented and their function in the teaching learning processes is briefly outlined. Subsequently the way these materials may impact curriculum innovations is discussed. Special emphasis is put on the role of the teacher.

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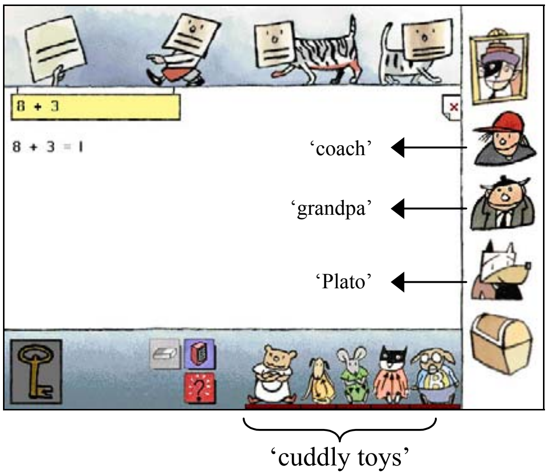
Types of digital learning materials

Drill and Practice

Maybe drill and practice programs are the most well known digital learning materials. Essentially, these programs built on existing knowledge and give learners the opportunity to consolidate and repeat knowledge and train and automate skills (cf. Weber, 1999). Drill and practice programs do not have a good reputation nowadays, they are associated with an out of date learning theory in which dull repetition and lower-order thinking are dominant factors. Moreover, drill and practice programs are condemned for not optimally using the technological power of new generations of computers. In spite of the many ill-designed drill and practice programs, this criticism seems to be too harsh. The educational value of these programs (like all programs) depends one the quality of its instructional and technical design. And although rather scarce, there are sound drill and practice programs which also stretches the capabilities of modern computer technology to its limits. An example of such program is the Dutch program ‘Plato en de rekenspiegel’ [Plato and the arithmetic mirror] that provides learners with ample opportunities to practice their numeric skills. This program consists of excellent facilities to diagnose performance and give adequate feedback and guidance. The program calculates a model of the learner, and based on his/her past performance, subsequent tasks are given. Feedback is also provided by means of suggesting and supporting different calculating strategies. In Figure 1 the user-interface of Plato is presented.



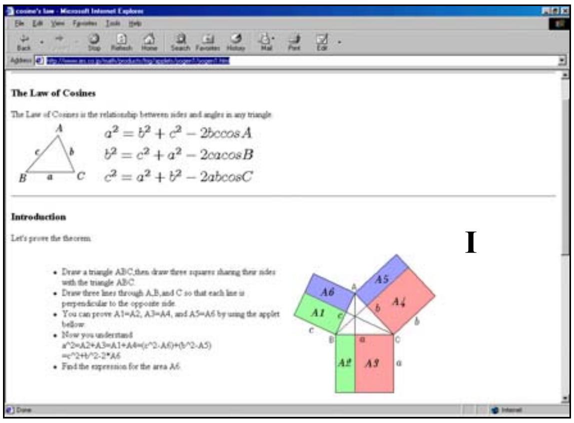
(Uitgeverij Zwijsen: http://www.zwijsen.nl/)

'Plato en de rekenspiegel' [Plato and the arithmetic mirror] is an advanced drill and practice program, published by the Dutch educational publisher ‘Zwijsen’. The program provides learners with ample opportunities to practice their numeric skills. During task performance, the pupil can consult different ‘virtual coaches’, like ‘The coach’, ‘Plato’, ‘grandpa’ and four ‘cuddly toys’. Each coach supports the learning activities of the learner in its own way. Like the ‘coach’, he explains the meaning of a certain activity, makes motivational remarks en gives stamps when a sum is carried out fast and correctly. ‘Plato’ the dog is the pupil’s ‘friend’. He helps a pupil everywhere, when possible. ‘Grandpa’ on the other hand, explains a sum and helps a pupil to start a calculation activity. Finally, the ‘cuddly toys’; each ‘cuddly toy’ represents and supports a specific calculation activity, like dividing or combining numbers.

Figure 1: Drill and Practice - 'Plato en de rekenspiegel'

Tutorial

Contrary to drill and practice programs, tutorials support the *acquisition* of knowledge and/or skills. Tutorials mostly offer pre-defined sequences to build up the desired knowledge and skills. They often apply immediate feedback to guide learning in an effective way. Tutorials are very common in learning software applications (for example: http://training.ase.tufts.edu/) But tutorials may also serve instructional purposes in school subjects. The reputation of tutorials is better then that of drill and practice programs, although also tutorials fit more easily in a tradition of knowledge transmission then in more constructivist visions on teaching and learning.



The ‘law of cosines’ is an example of a tutorial for the subject area Mathematics. The tutorial is developed by the International Education Software [IES].

In this tutorial the learner gets information about the law of cosines. First, the most important formulas are presented. In the second part of this tutorial the theorem is proved by means of five arguments supported by means of a figure (see I).

At the bottom of this webbased tutorial (scrolling down the site), the learner can carry out some tasks about the ‘law of cosines’ in a Java Applet.

URL: http://www.ies.co.jp/math/products/trig/applets/yogen1/yogen1.html

Figure 2: Tutorial – ‘The law of cosines’

Multimedia

Multimedia (or hypermedia) refer to programs that contain text, images and sound which are interacted in a non-linear structure. The structure of the information may best be typified as randomly sequenced. Like tutorials, also multimedia are primarily designed for the acquisition of knowledge. The essential difference between the two lies in the organization of information: linear or branched sequences in tutorials and randomly sequences in multimedia programs. This latter sequence allows user to pursuit according to a self-chosen path. Moreover, multimedia programs usually have a large amount of the information codified in a non-text way, such as pictures, animations and video. Presenting information in a multimedia program is especially appropriate in a ill-structured and complex knowledge domains in which opinions differ. Teacher knowledge is an example of such a domain. Therefore multimedia are apt for teacher education. In Figure 3 an illustration of such a program, in the form of a multimedia case, is pictured.

The MUST (Multimedia in Science and Technology) multimedia-case ‘Kleur & Licht’ [Colour & Light] is a multimedia-program for pre-service teachers. The MUST-project is a joint venture on behalf of three Teacher Education Colleges, the National Institute for Curriculum Development and the University of Twente in the Netherlands. The project aims at developing multimedia-cases and support tools for Dutch teacher education.

In the ‘Colour & Light’ production the overall theme is the learning process that starts from pupil’s pre-concept.

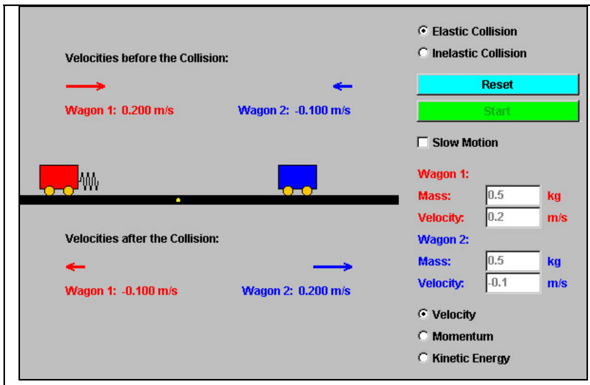
URL: http://projects.edte.utwente.nl/crc/must/

Figure 3: Multimedia – MUST multimedia-case ‘Kleur & Licht’

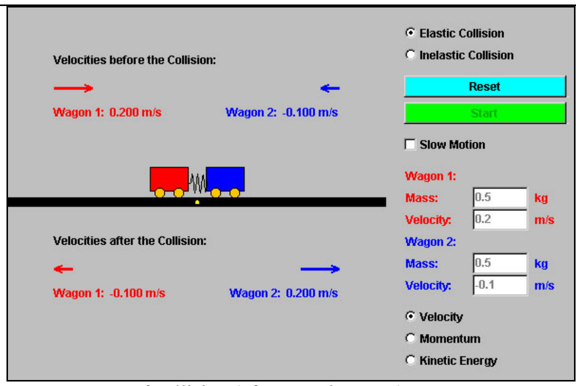
Simulations

Simulations are programs that contain a model of a system or a process (De Jong & Van Joolingen, 1998). The manipulation of variables is essential for learning with simulations. Allessi and Trollip (2001) give a simple but clear distinction between two types of simulations. Either, simulations are *about something* or *about how to do something* (p.214*)*. The former (physical simulations) focuses on an object or a phenomenon, the latter (procedural simulations), concentrates on a sequence of actions to reach a goal. Physical simulations may have a time component, which implies that users run a simulation, for example, about photosynthesis, as the system unfolds. Time is not a factor in for example a simulation about 'The influence of the number of foxes on the population of rabbits', because the learner may iteratively manipulate the variables, by going back to a default option and start the process with other values.

Simulations are sometimes perceived as archetypes for the power computer technology may bring to education and are therefore often associated with constructivist orientations. However, simulations may also designed with a behavioristic orientation in mind. Despite of the orientation, the educational potential of computer simulations is high, because simulations optimally use the interactive possibilities of computer technology. Moreover, simulations allow to handle situations that would be too dangerous or time-consuming in real life. The flight simulator, such as 'Microsoft Flightsimulator 2000' is a well-known example of a simulation that enable pilots to train crash scenario's. An example of a physical simulation is pictured in Figure 4.



note. Starting point of the simulation:



note. Moment of collision (after pressing start):

These physical simulations are programs which focus on an object. Above, two screen captures of such a simulation are presented about 'elastic and inelastic collision'.

In the left figure the learner can change the variables 'Mass' and 'Velocity' of the red and the blue wagon. By pressing the 'Start-button', the learner can see which consequences the adaptations have with regards to the course of the collision (right figure).

URL: (http://library.thinkquest.org/27948/collision.html

Figure 4: Simulations – a physical simulations about elastic and inelastic collision

Educational Games

Educational games are sometimes perceived as simulations. However, games neither necessarily are based on a model of reality, nor is playing a game mainly aimed at learning such a model. Nevertheless, sometimes the distinction is difficult. For example, high quality business *games* are best classified as simulations, because a model of reality ground their operation. But there are also computer games, for example combat games that are only designed for entertainment and do not have any educational value. Games are difficult to define and may be best described by some characteristics such as: rules, points, winning and losing, coping with pressure, skill & luck and so on. Educational games have a (often hidden) learning purpose. The knowledge and skills are imparted entertainingly into the game. The new words *educatainment* or *funderstanding* refer to this integration of play and learning. That brings us to the most distinctive educational feature of games, their quality to arose high motivation amongst learners.

'Splat!' is an online educational game about number estimation. In this game the player helps the mop 'Greg Gunk' to make the yellow smiley 'Sunny Jim' disappear. In this game 'Sunny Jim' rotates around 'Greg Gunk'.

The player has to estimate the angle between the stalk of the mop and the position of 'Sunny Jim'. After entering this angle in the fill-box on the screen, 'Greg Gunk' makes the rotation and fires some green soap. If the estimated angle is correct then the green soap hits 'Sunny Jim'. After hitting 'Sunny Jim' for five times, the remainder time will be converted to points en the player enters the next level of the game. So, the better the player estimates the angle between the stalk of the mop and the position of 'Sunny Jim', his or her score will be.

URL: http://www.numeracyresources.co.uk/sunny.html

Figure 5: Educational Games – 'Splat', on online game about number estimation

Tools

A broad class of digital learning materials consists of computer tools which are basically developed to facilitate teaching and learning. There are tools for writing, calculating, communicating and so on. These tools are not content-related, and most of them, such as word processing programs, are not designed with an educational purpose in mind. Some tools, such as 'De Junior Bos@tlas' [the Junior Atlas, see Figure 6] and 'De interactieve Flora van Nederland' [Interactive Flora of the Netherlands, see Figure 7], are especially designed for education. And there is also a gray area between general and educational purposes. So, there is a wide variety of computer tools that may serve educational purposes. An encompassing classification of tools is very difficult to formulate (Allessi & Trollip, 2001). In order to provide some structure, we label the computer tools in the following broad categories:

- databases and encyclopedias;
- electronic performance support systems [EPSS];
- communication and cooperative environment;
- new tutees.

Databases and encyclopedias

Databases and encyclopedias are topic-related collections of information. The emphasis of these tools is on quick information search and retrieval and not on (in-depth) learning. Although not always designed for educational purposes, the use databases and encyclopedias, also in non-digital form, have impacted education since a long time.

Thinking about geography without an atlas, or preparing a paper without an encyclopedia would be difficult. Adding the power of computer technology to these kind of tools has at least following advantages:

- access of information is quicker and there are a number of search-entries;
- up-date of information at a regular basis (WWW). Also on CD-ROM an up-date is much cheaper then reprinting complete volumes of for example an encyclopedia;
- information in the database on the web may be linked to all kind other online information sources;
- databases are sometimes modifiable, so they may become tailor-made.

The educational potential of digital databases on the web is indisputable, because of the easy access to enormous amounts of information. However, the use of databases requires elaborated search and interpretation skills of the users, otherwise they may get lost in cyberspace. Therefore there is a growing amount of databases designed with a specials educational purpose in mind. In Figure 6 and Figure 7 we present two examples.

'De Junior Bos@tlas' is a tool with a clear educational purpose, published by the Dutch educational publisher 'Wolters-Noordhoff. It is a digital atlas, , available in three versions: (a) Topography of The Netherlands; (b) Topography of Europe and (c) Topography of The World.

The tool is especially designed and developed for primary geography education. The colorful program consists of five main-modules, which are (1) a practice module, (2) a quiz-module, (3) a game-module, (4) search-module and finally (5) a view-module. These five modules can be used to learn more of the topography of The Netherlands, Europe and the World.

Figure 6: Database and encyclopedias – 'De Junior Bos@tlas'

'De interactieve Flora' [Interactive Flora] is a digital determination tool for secondary Dutch Science education.

The Interactive Flora is an integral part of the Dutch textbook for Primary Science education 'Biology for you' ['Biology for you'], published by the Dutch educational publisher 'Malmberg'.

Students can use this Interactive Flora to determine, analyze and label different kinds of plants and flowers by means of the computer.

Figure 7: Database and encyclopedias – 'De interactieve Flora van Nederland'

Electronic Performance Support Systems [EPSS]

According to Gery (1991) an EPSS provides integrated information, advice and learning opportunities to improve user performance. Stevens and Stevens (1995, p.238) define an EPSS as a 'computer-based tool designed to support access to job or task information by providing any or all of the following: training, reference information and expert advice, on demand as needed by the worker.' In spite of the fact that there are many names and descriptions given to an EPSS, the most important function of an EPSS is to improve the job or task performance by means of a computer. Based on the different descriptions for an EPSS, Nieveen (1997) defines an EPSS as follows: 'An EPSS is a computer-based system which provides integrated support in the format of any or all of the following: job aids (including conceptual and procedural information and advice), communication aids and learning opportunities, in order to improve the user performance.' An example of an EPSS to support teachers' task performance is presented below.

CASCADE-SEA (Computer Assisted Curriculum Analysis, Design and Evaluate for Science Education in Africa) is a project developed at the faculty Educational Technology of the University of Twente. The project aims towards learning more about how the computer can play a supporting role in curriculum development and support teacher learning. CASCADE-SEA focuses on improvement of secondary level science and mathematics curricula in the southern African region. The support, offered by CASCADE-SEA can among others be seen as: creation of teacher guides and lesson plans, help less-confident teachers understand how they can improve the quality of the lessons they teach.

URL: http://projects.edte.utwente.nl/crc/seasite/

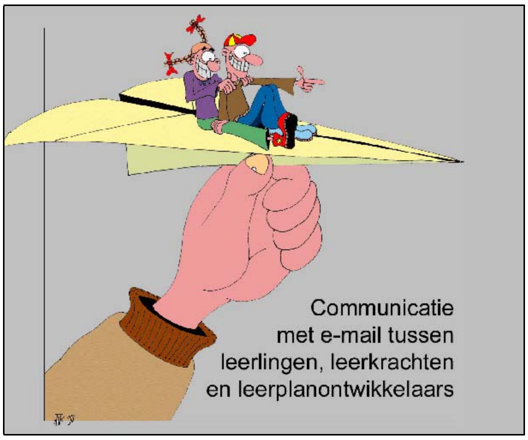
Figure 8: Electronic Performance Support Systems – 'Cascade-Sea'

Communication and collaborative environments

Maybe the most salient factor of the internet is its functionality as communication medium. E-mail, bulletin boards, chat-rooms and audio- and video-conferencing are devices that facilitate all kinds of communication forms and patterns amongst people. Most of these devices do not have a strong association with education. But, communication and collaboration programs can potentially be powerful educational tools, when they met the following requirements (Weber, 1999):

- There is an educationally relevant issue;
- This issue is placed within an educational context in which teaching and learning principles are applied;
- An institution (school, company, university etc.) provides the infrastructure and takes the educational responsibility.

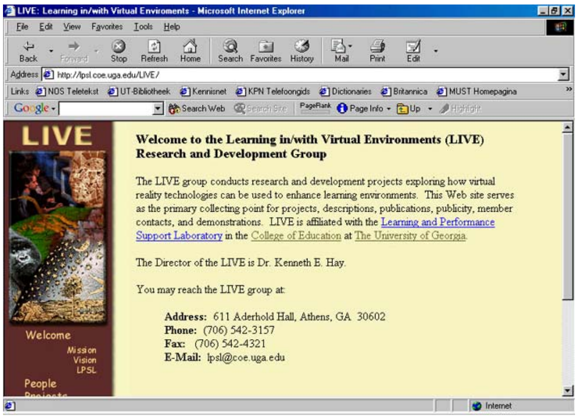
An essential feature of communication and collaborative environments is that they permit learning beyond school and country borders. Well known are the various climate and weather projects in which students from different countries communicate about and learn from each other's weather reports. Examples of communication and collaboration tools are pictured in Figure 9 and Figure 10.



'Kid E-mail' is a Dutch project, focused on communication between pupils, teachers en curriculum-developers.
The developers of this project decided to deploy E-mail when pupils are working on problem solving design-activities. Pupils can use E-mail to ask other pupils or teachers to support them during the task performance. For this 'Kid E-mail' project, a series of lessons have been developed.

URL: http://to-www.to.utwente.nl/e-mail_in_klas/

Figure 9: Communication and collaboration environments - 'Kid E-mail'



The 'Learning In/with Virtual Environments' (LIVE) Research and Development group conducts research and development projects exploring how virtual reality technologies can be used to enhance learning environments.

An example of a LIVE-project, is 'The Virtual Solar Collaborative Support Web Site'. This is a web-site that supports student-teacher and student-student communication, collaboration, collection of resources, , assembling collaborative projects, course organization and administration, and a mechanism to turn in assignments.

URL: http://lpsl.coe.uga.edu/LIVE/

Figure 10: Communication and collaborative environments – 'The Live-project'

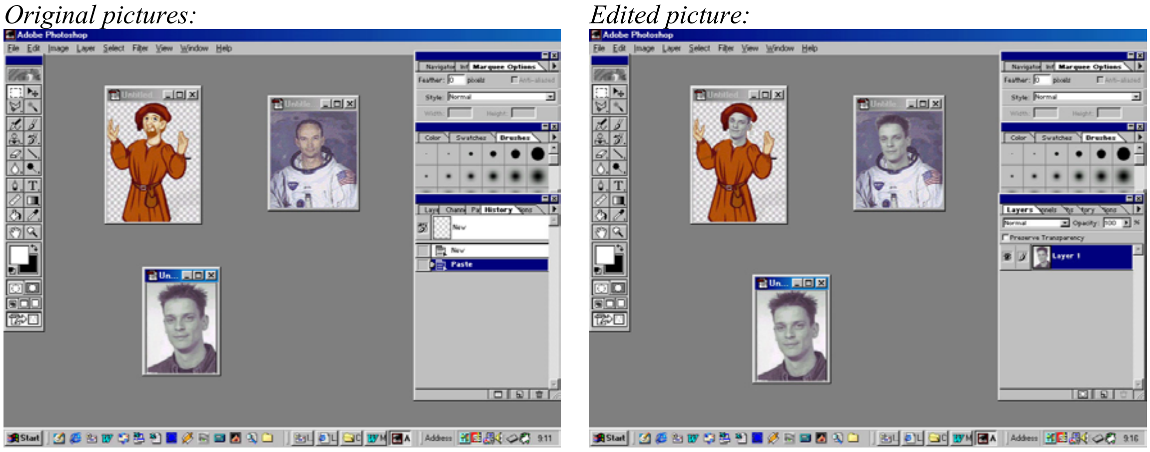
Especially in distance education but also in campus-programs of universities, there is a growing use of electronic or digital learning environments. Characteristic for these learning environments is that they provide the technical facilities (hardware, software and telecommunication-infrastructure) that support (cf. Droste, 2000; Collis, 1996):

- The process of learning;
- The communication, necessary for learning;
- The organization of learning.

The new tutees

The new tutees are programs in which the content or the way of action has to be delivered by the users. There are different types of these tools, namely: tools that are used to create, edit, arrange and complement text, music and fixed or moving pictures (Microsoft Word, Adobe PhotoShop, see Figure 11) and tools that are used to develop new programs, like computer programming and authoring languages (HTML-editors, Microsoft Visual Basic, Macromedia Authorware, C++).

Original pictures: *Edited picture:*



An example of a new tutee is 'Adobe PhotoShop'. This software package can be used to create, edit and arrange pictures. The figures above illustrate how a Drawing tool can be used to edit some historical figures, like 'Martin Luther', 'Napoleon' and a figure out the Dark ages and replace the original heads by the head of another person. The figure on the left contains the Photoshop environment with the original pictures. The Figure on the right is an example of the edited pictures.

Figure 11: A New Tutee – 'Adobe PhotoShop'

Implications for the curriculum

In this section we explore the implications different types of digital materials may emit in a curriculum framework. The attention is focused on the innovative potential of the materials. This potential is closely aligned to the role of the teacher and the learner. Moreover, attention is paid to a real-life context of learning and, if relevant, the content covered in the materials.

Enrichment and individual student needs

As stated earlier *drill and practice programs* do not have an innovative image. However, perceived in a broader curricular framework, these materials may support an educational practice that is more attuned to the needs of individual students. The big advantage of drill and practice programs is that students can carry out the tasks at their own pace without much assistance of the teacher. Moreover, especially in the more sophisticated programs, extensive and tailor-made feedback can be provided. Especially for slow learners, who need more then average practice to master certain knowledge and skills, drill and practice programs are perfect (and patient) means.

Drill and practice programs generally do not place the content in a real-life context. Only content with a clear 'right-wrong' structure is suitable for drill and practice programs. So, the innovative potential of these programs lies in the possibilities to attune instruction to individual students needs. It gives teachers the possibility to concentrate on 'higher-order teaching tasks', because the computer takes over the simple routine correction of answers and provision of new exercises.

Tutorials are most akin to textbooks. An important difference is that a textbook series covers a large part of the curriculum, whereas the scope of a tutorial is much smaller. For example, tutorials in the form of

Java-applets (See Figure 2), serve as interactive illustrations of topics in the mathematics syllabus instead of covering large parts of this syllabus.

From a perspective of curriculum innovation, tutorials merely substitute and elaborate some functions the textbook fulfill. They may be perceived as a means to attune education more to individual student needs. Especially for learning to handle new software, tutorials makes an instructor or teacher redundant. However, tutorials are not the types of digital learning materials that are closely related to curriculum innovation, because the role of the teacher and learner usually do not change dramatically, and many tutorials are closely related to traditional (school) subjects. Consequently, they do not bring real-life contexts to education.

Both drill and practice programs and tutorials bring forth the capacity to individualize education. However, the innovative potential of these programs is limited within the traditional setting of schooling. So, these programs may enrich options within the curriculum but they cannot be supportive to alter the curriculum fundamentally.

From individual instruction to self-directed learning

Multimedia programs designed for educational purposes often contain a large amount of information. Contrary to a tutorial there is no pre-structured path to go from the beginning tot the end of the program. The random sequence of multimedia programs offer a high amount of learner-control in reaching goals and answering questions. Paradoxically, this freedom for the learners has also important implications for the role of the teacher. The large amounts of information in a multimedia program may easily overwhelm the students. So, the role of the teacher is to provide adequate guidance and scaffolding to ensure in-depth information processing. It is also the teacher's task to guide student learning processes, taking into account student capabilities, interest and motivation. But the teacher should also warrant that the requirements of the curriculum are met.

Another characteristic of a multimedia program is that a substantial part of the information is partly codified in (moving) pictures in stead of text. How learning processes with support of non-text materials in multimedia programs proceed is not a well-researched field, yet. Consequently, there is hardly any knowledge base for teachers to rely on when incorporating these programs into their curriculum. Communities of practice seems to be a feasible professional development arrangement to acquire such a knowledge base, because these communities may develop a knowledge base that is grounded in practice.

The content coverage of multimedia programs is rather small, the educational value lies more in the thorough and multifaceted way the content is presented. Multimedia are apt to bring real world information and problems to school settings, because the designers of these programs are not hindered by a fix amount of pages as is the case in textbooks design, nor do they have to bother about a predefined sequence of information. Moreover, the use of video and stills are more fit to bring an outdoor school spirit into the program.

Simulations (and games) are also characterized by the high amount of learner control. Moreover, in the way these programs react in the user actions often shows an intelligent interaction between man and machine. Contrary to most of the multimedia programs, the information in a simulation is almost always well-defined and limited to the model to be learned or features of the process to be simulated. Therefore, the role of the teacher is not helping learners to find their way in an high and loosely connected amount of information, but the teacher needs to support the students to make sense of their actions. Otherwise working with a simulation may have a trial and error character, and do not evoke in-depth processing of information leading to high quality learning. Simulations with underlying conceptual models are frequently found in the sciences and in economy. Traditionally these subjects are taught in a rather context-free way with emphasis on mathematical procedures to describe the relationships in the models. In simulations, the information is more context-bound and the task of the learner is to build intuitively an understanding of the model underlying the specific context. Teachers, however, have no experience, neither from their own high school period, nor from their preservice education program with this kind of knowledge building. Therefore guiding the learning processes with simulations is an unfamiliar task for teachers. This holds especially true for conceptual simulations, in procedural simulations, such as a flight simulator, are more conveniently incorporated in professional training programs and working routine of instructors.

Beyond curriculum…. ?

Computer tools in education may refer to a complete different line of thinking about the function of ICT in teaching-learning processes. The computer is no longer viewed as means to deliver information but as a tool to extend the cognitive power of the human mind. Computer can calculate much better, and store larger amounts of information and retrieve this information more effectively then human beings. Using the computer as a tool implies that people achieve results that would be otherwise beyond their reach. Including computer tools in education implies that there is a swift from learning *from* computer to learning *with* computers (cf. Jonassen & Reeves, 1996). The integration of ICT in learning refers to students entering into an intellectual partnership with technologies (Jonassen, Myres & McKillop, 1996). Learning is perceived as a research and discovery activity guided by the questions of the learner and promoting in-depth understanding. Also the way evidence of learning is given differs widely from traditional paper and pencil tests. In digital portfolio's students presents in hypermedia environment what they have learned.

This revolutionary perspective asks for a rethinking of the curriculum concept. In this view a curriculum is no longer a *plan* for learning to be implemented by the teacher and followed by the students. On the contrary, the learners become the designers of their own curriculum. However, this does not imply that there is no significant role of teacher. Experiences with students surfing the Internet for educational purposes show that they need modeling and scaffolding from teachers. Otherwise they get lost in cyberspace, and, despite all the good intentions, learning turn to a negative and demotivating experience. So the role of the teacher becomes very prominent, because a pre-defined curriculum is absent. But, teachers do not have experiences nor professional routines to guide learning processes in open environments. It seems that teacher need to go through knowledge construction processes with computer technology themselves, before they may develop ideas how productively guide student learning in technology-rich open learning environments. University-school partnerships in which researchers and teachers collaboratively develop and investigate such environments seems to be a viable option to reconcile utopist ideas with down-to-earth practice.

The revolutionary character of learning *with* technology is not only to be found in the role of the learner, but also in the absence of content divided according to the lines of academic disciplines. Especially the idea that students are engaged in authentic learning means that the content is situated in real-life contexts and therefore emphasize cross-curriculum learning. Tools, such as databases, collaborative workspaces and all kinds of new tutees have the potential to support radical educational change, however, whether this potential becomes reality depends on actions of human beings and not on technologies, how sophisticated they may be. Also the most technologically advanced educational tools may be used in very traditional way.

Summary and conclusions

This chapter was focused on the role of digital curriculum materials in curriculum reform. In order to structure the line of reasoning a typology of digital materials was presented, in which short descriptions are given of the different types and each description is followed by an example. Subsequently, the impact the materials may have on the curriculum is discussed along lines of the role of the teacher and learner, context-richness and the content issues.

An overall conclusion of this chapter is that the type of digital material alone does not make a difference in education, but the way teachers and learners use the materials is the issue that counts. However, specific characteristics of digital materials determines the direction of innovative use. For example drill and practice programs may be helpful to individualize instruction and make it more teacher-independent. In this way these types of materials are supportive to enact a curriculum more attuned to individual students needs.

Multimedia programs and simulations allow students to pursue authentic learning tasks. However, there is a growing evidence that teacher support is indispensable to provoke in-depth learning. How teachers should provide this support effectively without harming self-directed learning is a largely unresolved issue yet.

Technology as a many-sided information and communication tool has the potential to alter education completely. Student use of these tools make achievements possible that would otherwise be far beyond their reach. Solving real-life problems by means of collaborative groupwork with the use of computer tools makes a curriculum based on separate academic disciplines outdated. However how to organize, guide, and evaluate learning processes on a daily basis in which computer tools play a dominant role is a white spot in curriculum development and research. But the idea that the simple availability and accessibility of all-kinds of information and communication tools would solve persistent issues in education turned out to be largely naïve. We think time has come for thorough developmental research projects in which practitioners and researcher work together to design and evaluate the curriculum of the future. Such projects seeks for an understanding that goes far beyond quick and fuzzy fixes, and ask for long term commitment of the participants.

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