

DIGITALIZATION OF EUROPE: A NEW CHALLENGE FOR EDUCATION

Vladimír Bureš, Daniela Ponce, Pavel Čech

University of Hradec Králové, Czech Republic

Email: vladimir.bures@uhk.cz; daniela.ponce@uhk.cz; pavel.cech@uhk.cz

Abstract

Digital television broadcasting has become a reality in most countries in the European Union (EU) as well as in other developed countries outside the EU. Interactive digital television (iDTV), as a relatively easy way to use technology, brings many challenges and opportunities into the field of education, i.e. formation and utilization of learning via TV, called t-learning. T-learning has many characteristics (i.e. technological or pedagogical aspects) that differentiate this type of education from other well elaborated approaches (e-learning, face-to-face learning, classroom learning, etc.). These characteristics include learners' motivation, lean back interactivity, and combination of education and entertainment known as edutainment. The main attention is paid to interactive applications (iAV applications) that have to contain relevant study content and to be based on appropriate principles. Therefore, comparative analysis, analogy, generalization and other methods were used while studying different problems related to t-learning. The paper presents results and outcomes of the international scientific project Enhanced Learning Unlimited that were achieved in areas such as human-television interaction, learner-centered education or iAV applications development.

Key words: *Gagné's approach, iDTV, lifecycle of t-learning course, project ELU, t-learning.*

Introduction

Digital broadcasting becomes a reality in many European countries and also worldwide. After Great Britain as first country, which introduced digital broadcasting in 1998, Sweden, which introduced digital broadcasting in 1999 or Germany as the first country which transferred from analogue to digital broadcasting by so-called "isle method", digitalization in Europe is getting to countries in Central and Eastern Europe. Arrival of digital television has brought new opportunities for viewers who can make their interaction with television by requesting and obtaining additional information, selecting different view angles of camera, playing games or accessing internet and e-mails. Enhanced possibilities of interactivity bring also a chance to exploit interactive digital television (iDTV) for education, i.e. to put into practice a new form of education called t-learning. On the path leading to the implementation of t-learning, i.e. complete development of educational content and smooth realization of educational process, it is necessary to overcome many obstacles of different types, e.g. cultural, technological, psychological, social, organizational, or pedagogical ones (Atwere & Bates, 2003).

T-learning is based on the usage of interactive applications (iAV applications) which are broadcasted to the viewer together with the audio and video signal. Creation of iAV applications can be done in environments for iAV applications development already available on current market. Comparison of selected products was conducted and, consequently, the most suitable tools for initial creation of simple iAV educational applications were used.

Since this paper contains presentation of results and new knowledge about this domain which were reached during the solution of the international project Enhanced Learning Unlimited (ELU), following chapters provide outline of key aspects of iDTV, depiction of digital television technology, analysis of selected tools for development of educational content, description of the pedagogical approach selected for a particular t-learning course, and specification of the process of iAV application development.

Educational aspects of iDTV technology

As the process of education is strongly influenced by utilized technology, a brief introduction to digital television technology follows.

Digital television technology

From the technological point of view it is important to assure that beside the main audio visual (AV) signal all data necessary for launching iAV application will be broadcasted. The way of including iAV application into broadcasting time of a viewer is shown in Figure 1 (taken from (ELU, 2008)). The main signal containing for example movie (DVB stream) is broadcasted through space. This signal is received on the broadcasting channel by TV receiver or set-top box, then processed and displayed on TV screen.

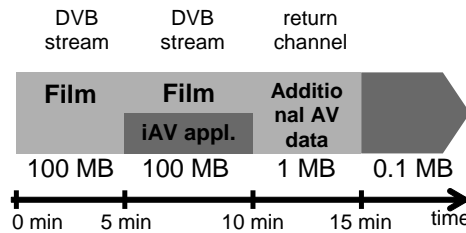


Figure 1. Data transfer towards user.

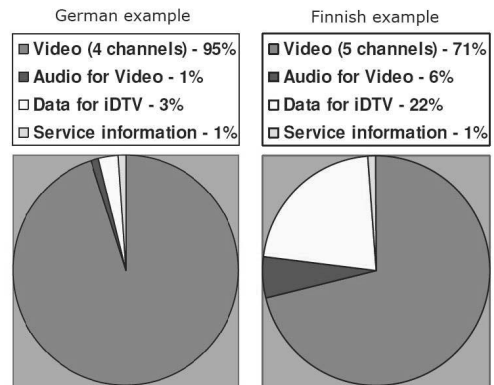


Figure 2. Content of main broadcasting channel.

Apart from broadcasting channel it is possible to use also return channel with some limitations (e.g. incomparably lesser data limit). However, the main broadcasting channel has its own limitations, too. Absolute majority of the communication capacity of the channel is occupied by the AV signal itself (i.e. by movie displayed on TV screen). It means that only a fraction of the channel capacity can be used for transfer of data related to iAV application. Leeway for iAV applications varies by individual broadcasters; illustrative situations in Germany and in Finland are shown in figure 2 (taken from (ELU, 2008)). This aspect of iDTV, posing requirements on size of iAV applications, has to be respected during their development.

That is why the systemic approach to the opportunity to educate TV viewers with the help of iDTV is essential. Isolated solution of the problem how to select a suitable way of iAV application development should be preceded by consideration of all constraints related to the whole process of communication in the frame of iDTV (see Figure 3 taken from (ELU, 2008)).

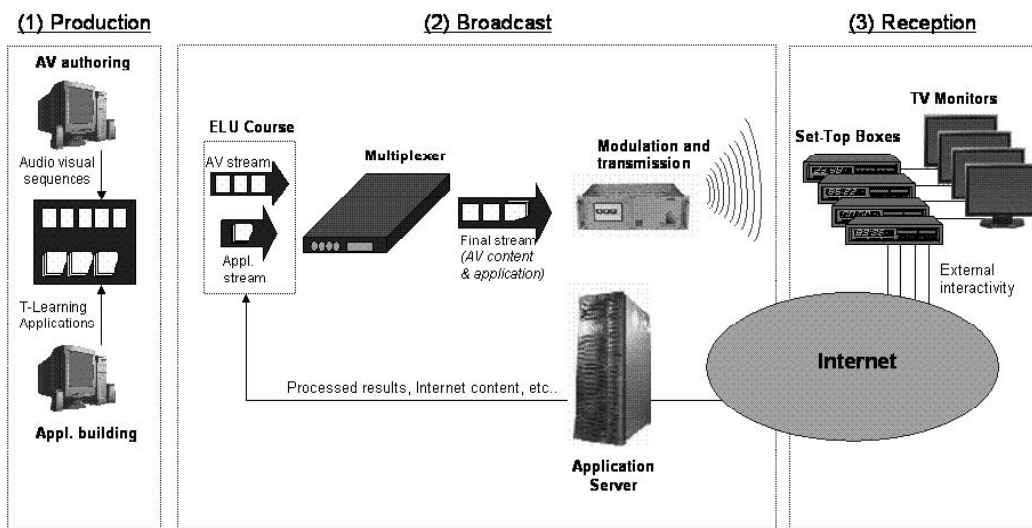


Figure 3. Process of the communication in the frame of iDTV.

The process starts at the production side by creation of a video and an educational iAV application. Afterwards, the broadcaster joins these two intermediate products with the help of a multiplexer and broadcasts the resulting product towards the user using selected technology (terrestrially, cable or satellite). Communication process does not terminate at the viewer side thanks to return channel. In case of the global interactivity, i.e. there is a feedback from the viewer to the broadcaster (see below), the viewer can send data back to the broadcasting organization. It is evident from the description of the communication process that to use iDTV means to work within several environments. Each environment uses different tools or methods, nevertheless, together they enable the whole communication and education process to be completed. These environments are:

- broadcasting environment at broadcaster side,
- receiving environment at home (e.g. set-top boxes),
- iAV application development environment and content authoring tool,
- simulation and testing environment.

Key aspects of iDTV

Soon after the first experiments with television broadcasting at the break of 20s/30s of the last century, opportunities to use television as educational medium were identified. Digitalization leads to a qualitatively new situation because iDTV has potential to widen possibilities of education at home. An important role is played by key elements of iDTV, such as:

- Availability – TV sets are currently more widespread in European households than PCs (e.g. only 58 % of EU-25 households had a personal computer at home in 2005 (Eurostat, 2008), while 96 % of EU-15 households already had at least one TV in 2000 (Statistisches Bundesamt Deutschland, 2008)),
- Ease of use – relatively long history of TV usage has made the manipulation with TV equipment common for all generations, from youngsters to elderly, and
- Interactivity – iDTV offers interaction at local level (within iAV application) as well as at global level (via return channel) in several forms (Jensen, 2005).

From the education point of view it is essential that broadcasted image data are the principal educational material (in compliance with traditional view on education by means of television), and furthermore they are enriched with applications implementing additional pedagogical functions. It follows that t-learning works primarily with broadcasted data, and secondarily with data requested

by user. Thus the interactivity level depends on the viewer and technologies available to her/him. Another important aspect from the pedagogical point of view is so-called lazy interactivity which is determined by lower level of concentration and simple way of interaction by remote control (with no keyboard). iDTV based education therefore leads to interconnection of two, so far often separated, areas – education and entertainment, so-called edutainment.

Analysis of development tools

No single environment is currently available so that an iAV application can be completely developed by its solely usage. Therefore, it is necessary to use several tools at the same time. It is important to carefully select these tools so that development of iAV application can be performed if not effectively, then at least more or less smoothly. The following section contains description of two categories of environments (for iAV application development and content authoring) and detailed analysis of two concrete products that belong to these categories.

Types of development tools

Although the constituent environments form together a single complex system, that is to say, they are interconnected and impose various conditions and restrictions at each other. From the development of educational applications point of view, the most important environments are environment for iAV applications development (iAVAD environment), content authoring tool (CA tool) and environment for simulation and testing. Relationship between iAVAD environment and CA tool is represented in Figure 4.

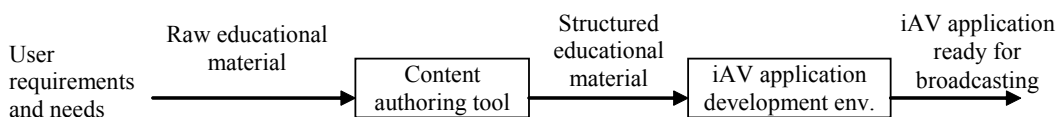


Figure 4. Relation between content authoring tool and environment for iAV application development.

CA tool processes data and metadata for iAV applications. It does not create iAV application itself, but it gives structure to the content of iAV application. In some cases CA tool can be extended into a full content management system. CA tool has to fulfill some requirements. For example, it is reasonable to await that output of CA tool will be compatible with the iAVAD environment with automatic or at least user-friendly export from CA tool into iAVAD environment. It is also recommendable that CA tool support SCORM-type formats.

iAVAD environment translates the structured learning material into iAV application which can be run on set-top box. iAVAD environment usually has user-friendly interface, it is capable to emulate iAV application and thus to simulate the resulting appearance and behaviour of iAV application and it is extendible with further functionalities. Some relatively affordable solutions are:

- Cardinal Systems (Cardinal Systems, 2006),
- Icareus iTV Suite (Icareus, 2006),
- JAME Author (Fraunhofer-Institut, 2008),
- MIT-xperts iDesigner (MIT-xperts, 2008),
- Alticast (Alticast, 2008), and others.

Requirements regarding iAVAD environment

When selecting an iAVAD environment, it is necessary to judge how the system meets specific requirements of its future users. These requirements can be grouped in the following way (based on (ELU, 2008)):

a. Functional requirements

- iAV application generator
- The main function of the environment should be to produce the final iAV application for iDTV to be broadcasted.
- iAV application emulator
- Emulator serves as tester and simulator of the future product in the form required by the platform on which set-top box runs (multimedia home platform, MHP).
- code editor
- The resulting code should be open to editing so user can work on it easily and modify it.
- data backup and recovery
- iAV application should be automatically saved at local disc before testing is started. In case of any problems caused by emulation of iAV application original data can be safely recovered.

b. Non-functional requirements

- Structured input data format, preferably XML
- Input data format should be structured (XML as the best option) because structured data are important for MHP application development.
- Output format MHP
- Output should have format that can be broadcasted for iDTV, that is, on MHP platform. Suitable MHP-Java classes are created on the basis of structured XML input.
- Optimization of iAV application
- Size of the created application should be optimized to occupy as small part of the limited capacity of the broadcasting channel as possible.
- Return channel usage
- In case of need, the iAV application has to be able to use return channel. The content of iAV application should be able to acquire or to supply data through return channel.
- Easy use
- User should be able to work with the environment without advanced programming skills or after a short training. For example, import of structured XML data or usage of emulator should be simple and intuitive.
- Price
- Price of the environment has to be acceptable for user. It should be possible to purchase a basic version of environment which can be extended later on.
- Hot-line service
- While using the development environment, user will most probably encounter some problems which s/he will need a help in. Hot-line service is more than necessary in such cases.

In order to demonstrate differences between various solutions of environments for iAV application development two products (iDesigner 2.1, (MIT-xperts, 2008), and Cardinal Studio 4, (Cardinal Systems, 2006)) were selected, analyzed, and compared. This comparison was based on an enterprise version of iDesigner and the trial version of Cardinal Studio available on the website of Cardinal Systems.

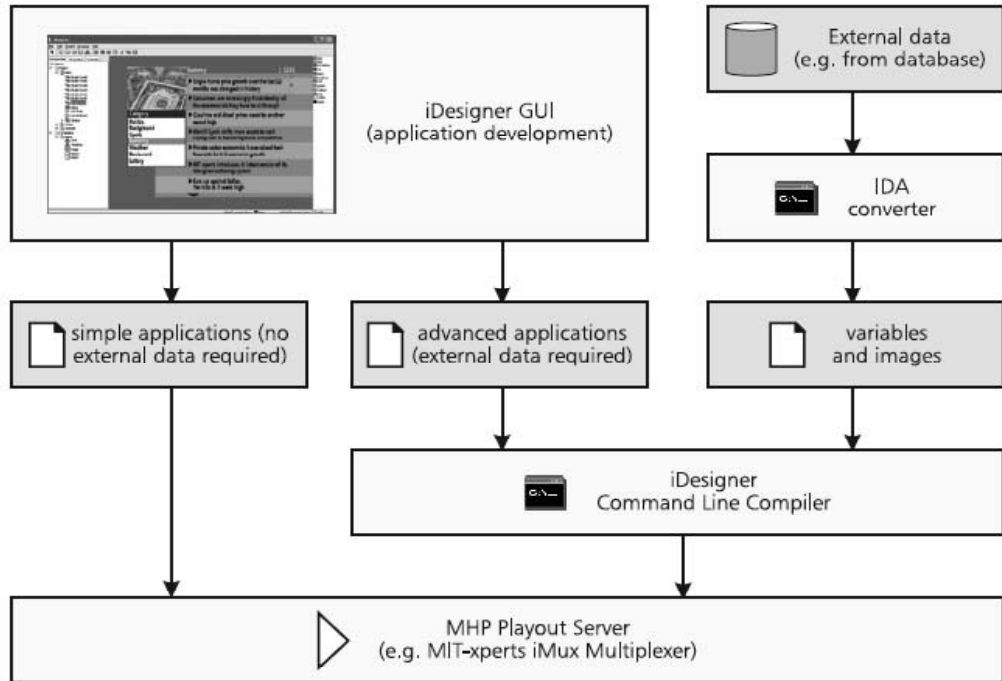


Figure 5. Process of iAV applications development in iDesigner environment.

Environment

Although both products have user-friendly environment, differences regarding the way of iAV application development exist. iDesigner is more intuitive and easier to use, with a smart solution of interactivity. Project is divided into several pages on which various components can be placed. Pages represent screens between which the user can move. Structure and behaviour of selected pages can be grouped into a template which can be repeatedly reused. It is possible to declare global variables used for dynamic change of pages or their content. Using simple programming language with pre-defined functions can be enhanced the usage of variables. Pre-defined functions are used to modify variables as reactions to events. Usage of variables and simple routines makes development of basic iAV applications (Sudoku, Memory or Logic games) easy. The process of iAV applications development in iDesigner environment is shown in figure 5 (taken from (MIT-xperts, 2008)).

In comparison to iDesigner, the Cardinal Studio is more complex. A developer needs much more time to master it. Project is divided into acts and layers. Similarly to iDesigner, acts and layers can be combined as pages and templates. However, iDesigner pages and templates are organized into hierarchical tree structure in comparison with a list of Cardinal acts and layers and thus switching between pages in iDesigner is simpler. No variables or short scripts similar to those available in iDesigner can be defined in Cardinal. Nevertheless, in Cardinal we can find a feature allowing realization of interactivity: behaviours can be defined as reactions to selected events. Time-line is also a useful functionality which enables to order acts and layers in time. No such functionality is available in iDesigner.

Components and extendibility options

The Cardinal environment offers more components than iDesigner. Both environments allow usage of plug-ins and creation of user-defined components. Components are written in Java as Java Bean objects and they can be easily created according to examples available in both environments. The use of internal programming language (in the case of iDesigner) may break the application logic into small and difficult-to-maintain fragments. Usage of plug-ins is more systematic, and therefore more suitable for complex applications. The Cardinal environment is more sophisticated in this regard.

In both environments it is possible to work with data; however, an elaborated example is missing. It would better explain possibilities of working with data not only in the given environment, but in digital television generally. Cardinal offers components for realization of return channel leading to a given server. iDesigner assures return channel by different means. iDesigner comes with return channel component together with return channel server as a separate product. Here, license policy of iDesigner has to be mentioned. It allows purchase of product in one of three different suites offering various functionalities. With such strategy user can use the suite of product s/he just needs and avoid thus wasting financial sources on the purchase of a complete package.

Examples, tutorials and documentation

Both products are equipped with help, tutorials and examples. Examples delivered with iDesigner are more practical than those delivered with Cardinal, and they include games and sort-of-news iAV application (weather forecast, world news). For both Cardinal and iDesigner standard user manuals as well as technical manual (in the form of Java Doc) and the examples mentioned above are available.

Summary

The iDesigner environment has several advantages, like practical examples which can be easily modified and reused for various projects or study. Especially simple iAV applications that can be created using the internal programming language are very effective. Relatively simpler environment and control and therefore shorter induction time mean another advantage. Disadvantages of iDesigner include proprietary programming language although its usage can make creation of interactivity in applications easier. Furthermore, iDesigner offers less components and use of return channel is conditioned by purchase of another product.

Cardinal is a more complex solution requiring longer induction time. Its advantages include encompassment of components for work with return channel in one tool. A more complicated work with components during design of iAV applications can be considered as a small disadvantage. Sophisticated features of Cardinal make it intended for professional developers of extensive iAV applications.

Educational content of iAV applications

iAV applications may have various goals, for example to entertain, to inform or to educate. In the frame of the ELU project the attention was paid to educational iAV applications, i.e. to t-learning courses. Every educational activity should be based on a pedagogical approach. Many pedagogical approaches from cognitive or social constructivism to behaviourism exist (e.g. (Piaget, 1977) or (Skinner, 1976). After a thorough selection (ELU, 2008) we have focused on the usage of an instructional pedagogical approach by R. Gagné.

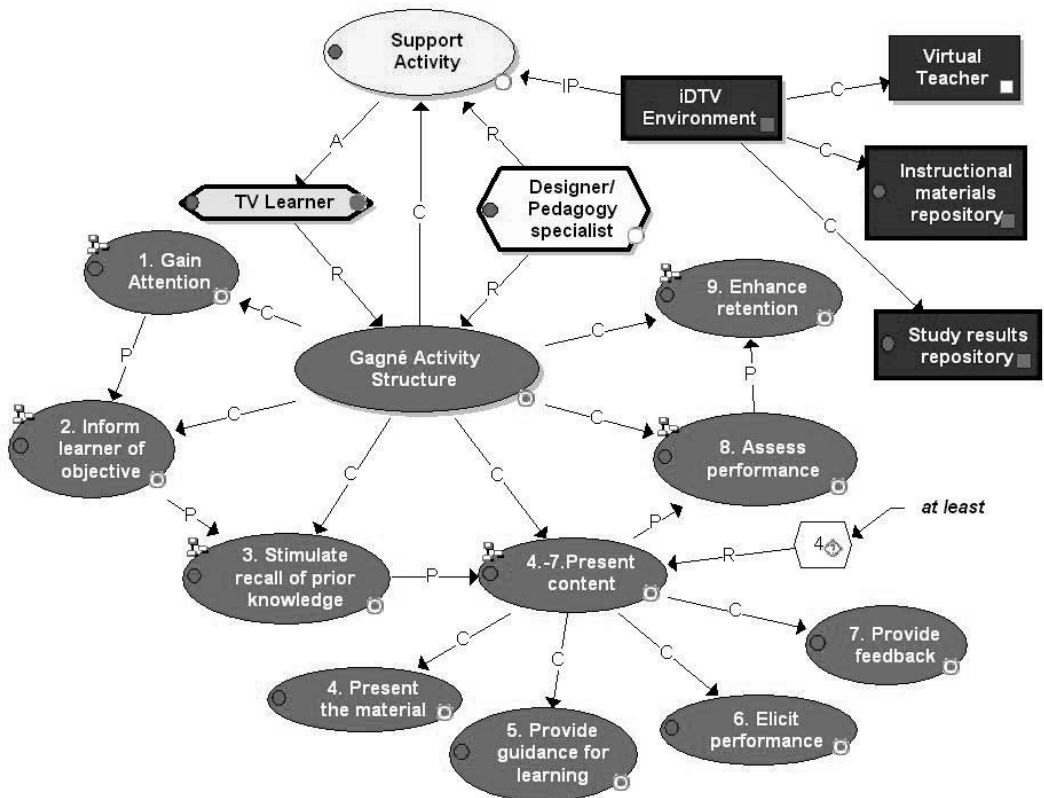


Figure 6. Gagné's pedagogical approach.

Gagné's pedagogical approach is based on a way of information processing and therefore it was suitable for selected t-learning courses (with ICT topics where specific skills need to be developed and exercised – (Olševičová, 2007)). Pedagogical approach by R. Gagné can be specified as a sequence of nine different learning activities (Gagné, 1985) – see Figure 6:

1. gaining attention,
2. informing the learner of the objective,
3. stimulating recall of prerequisite learned capabilities,
4. presenting the stimulus material,
5. providing learning guidance,
6. eliciting performance, involving response,
7. providing feedback about performance correctness,
8. assessing the performance,
9. enhancing retention and transfer of knowledge.

Realization method of t-learning courses

The complexity of t-learning course creation requires splitting the process into several phases. Here, the analogy from the field of systems engineering (software engineering concretely) can be applied (Pfleeger & Atlee, 2005). The reason is that the emphasis on differences at both conceptual and technical level has to be taken into consideration during the process of development.

Development phases

In the case of t-learning course creation we can distinguish particular phases by questions “What?”, “How?” and “By what means?”. Interconnection of all three phases is shown in the figure 7.

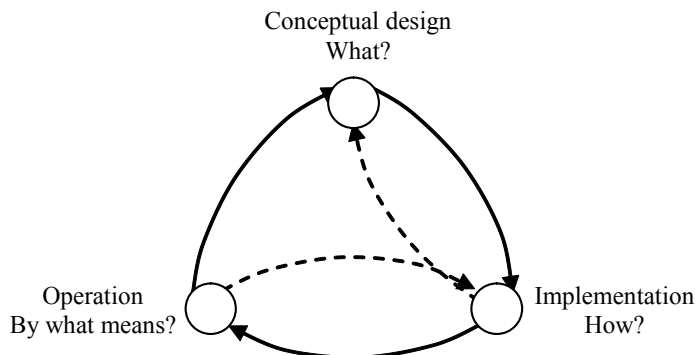


Figure 7. Development phases of t-learning application.

Many universal tools for development of iAV applications utilizable for each individual phase have already been and are being developed; however, none of them is primarily intended for development of t-learning applications. T-learning application thus has to be developed from scratch with no link to pedagogical approach and with no consideration of specific requirements of such category of applications.

Realization process of t-learning application

The t-learning course lifecycle was simulated using third-party tools. Three types of different tools were used, one for each development phase. Interconnection between the tools was guaranteed by the IMS LD specification (IMS, 2008) which defines basic concepts for educational content creation. These tools were:

1. Conceptual design – **MOT Plus** (MOT Plus, 2008)
2. Implementation phase – **Reload** (Reload, 2008)
3. Operation phase – **CopperCore** (CopperCore, 2008)

All mentioned applications are specified for the PC platform. Outcome of the first and second phases is a course, or more precisely Unit of Learning at the A level according to the IMS LD specification (after conceptual phase), and at B and C levels (in the second phase of modelling). Individual phases and tools used are described in the following sections.

Conceptual design phase of t-learning course

Answering the question “What?” means to deal with future iAV application at the conceptual level. Here, pedagogical goals, sequences of educational activities, roles of course participants, requirements regarding support activities, tools and resources are considered. In the case of a t-learning course, the conceptual design should reflect the selected pedagogical approach that becomes a meta-level at which learning activities are specified in general. These general learning activities are made particular by realization of a concrete t-learning course. Creation of conceptual design is a task for instructor. The only technical skill s/he needs to master is the notation of the specification which is used for conceptual design formulation. Because of its nature, the conceptual design can be used for t-learning and e-learning type of course. Differences follow from the purpose and pedagogical goals of the course. It is possible to create the conceptual design by usage of a formal modelling language. Similarly to UML used for conceptual design in the process of information systems development (Booch et al., 2005), the IMS LD specification plays the same role in the case of t-learning courses.

The tool selected for the first phase was MOT Plus. This tool was developed in the research centre LICEF Research centre at the Université du Québec. It is a quite simple object-oriented graphical editor which allows creation of models from various areas. It supports notation according to the IMS LD specification which makes it utilizable for modelling of educational content at the conceptual level. MOT Plus enables representation of particular objects comprising the educational content along with their relations. Multi-level model projection can be used for displaying selected parts of the model according to the level of their elaboration. MOT Plus can be used for development of models in accordance with the level A of the IMS LD specification. The finalization has to be (and was) done with the help of other tools.

In the ELU project MOT Plus was used for development of the conceptual design at meta-level. Meta-level reflects selected pedagogical approach (Gagné's approach in this case). Afterwards, the conceptual design was enhanced for purposes of the particular course (e.g. introduction to Internet). Gagné's nine basic steps were fragmented to specific activities. Therefore, the conceptual design only served as a framework which represented general pedagogical approach and its relation to specific activities, educational goals and tools. The outcome from this tool can be seen in Figure 6. This phase also served for verification of the possibility that conceptual design can be created by teachers, i.e. people without deep technical knowledge.

Implementation phase of t-learning course

The question "How?" belongs to the implementation phase. At this point the specification of the concrete educational content of activities formulated in the phase of conceptual design of the course has to be done. It is necessary to select the right form for content presentation. During this phase a formal notation of completion rules and conditions was created (e.g. when a course part is considered as completed or when the following course part should become active or any other actions and control structures enabling course progress). Opposite to the conceptual design, implementation is oriented towards a concrete platform and selected learning environment. Familiarity with the platform and selected learning environment are requirements that assign the implementation process to technical personnel. The main task of the instructor in this phase is to supply the course content.

Within the implementation phase it is necessary to take into consideration specific features and limitation of the given platform. In the case of t-learning courses, the platform is iDTV with a number of limiting factors. From the technical point of view, the most important factors are limited interactivity set by the remote control, display and resolution capability of TV receiver, broadcasting method and feedback possibilities. From the pedagogical point of view, the basic limiting factor is the attitude of viewers/learners to education by way of TV broadcasting. Long-shaped attitude of viewers to TV as to a passive entertainment predetermines this way of education for non-formal purposes.

RELOAD (Reusable E-learning Object Authoring and Delivery) was the tool selected to support the second phase. It is a form-based editor of educational content created according to the IMS LD specification. This tool was developed at the University in Bolton and Strathclyde. RELOAD can be used for creation of courses at A, B and C levels according to the IMS LD specification. RELOAD can also be connected to MOT Plus by means of import of the conceptual model to RELOAD and its enhancement by metadata, attributes or conditions for particular elements. In the ELU project RELOAD was also used for enhancement of the content in form of HTML and XML documents. RELOAD offers relatively intuitive interface that enables connection of single activities to documents and determination of further parameters. In some cases (e.g. when the content is represented by tests or quizzes) specific marks have to be created. All described activities and processes and necessary knowledge of HTML, XML and some details of the IMS LD specification reduce the possibility of a course completion, which is feasible for technically skilled specialists only.

Operation phase of t-learning course

Educational environment is the answer to the question "By what means will the course be operated?". During this last phase the course is put into operation and it is operated in a specific

educational environment. Putting into operation includes also tasks such as validation and quality control (Mikulecká, 2007), publication of course, creation of user profiles, and assignment of users to roles existing in the course. Course operation means the phase of course usage which implies control of correct and safe operation. The main responsibility for the activities of the third phase resides on the administrator of the educational environment.

CopperCore Runtime Engine serves as an environment for launching courses developed according to the IMS LD specification. This tool is intended for PC platform and offers validation and publication of courses. In the ELU project, the purpose of its utilization was to simulate runtime environment that should be created for iDTV platform. Following the IMS LD specification partially restricts previous phases from platform specific limitations. However, it will be sufficient if iDTV environment supports the IMS LD specification.

Conclusion

iDTV brings new opportunities in many areas; one of them is education. Effective exploitation of this new medium is conditioned by overcoming of several problems. One of such problems is for example selection of suitable environment for iAV applications development which will provide for creation of iAV applications with parameters required. Several products are currently available on the market. Selection of suitable products has to be guided by various criteria with price, functionality range, support service and environment customizability as the most important ones. iDesigner environment turned out to be the suitable product for beginner developer of iAV applications thanks to its simple environment and samples provided it is developer-friendly and easy-to-master. iAV educational applications have to match with existing theoretic pedagogical approaches. One of them is the nine-step-approach of R. Gagné. However, it is obvious that selection of a particular pedagogical principle depends on the content of iAV application. It is recommendable to follow the lifecycle of software applications development during the process of educational iAV application creation. The paper presented the realization of t-learning course development phases simulated by available tools such as MOT Plus, Reload or CopperCore.

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Advised by Jaroslava Mikulecka,
University of Hradec Králové, Czech Republic

Vladimír Bures	Assitant professor at University of Hradec Králové, Rokitanskeho 62, Hradec Králové, 500 03 Czech Republic. Phone: +420 493 331 270. E-mail: vladimir.bures@uhk.cz Website: http://www.uhk.cz/eng/
Daniela Ponce	Assitant professor at University of Hradec Králové, Rokitanskeho 62, Hradec Králové, 500 03 Czech Republic. Phone: +420 493 331 225. E-mail: daniela.ponce@uhk.cz Website: http://www.uhk.cz/eng/
Pavel Čech	Assitant professor at University of Hradec Králové, Rokitanskeho 62, Hradec Králové, 500 03 Czech Republic. Phone: +420 493 331 269 E-mail: pavel.cech@uhk.cz Website: http://www.uhk.cz/eng/