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MODELLING AND CONTENT PRODUCTION OF DISTANCE LEARNING CONCEPT FOR INTERACTIVE DIGITAL TELEVISION

Päivi Aarreniemi-Jokipelto

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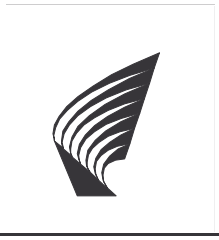

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ABSTRACT OF DOCTORAL DISSERTATION

Author: Päivi Aarreniemi-Jokipelto

Name of the dissertation:
Modelling and Content Production of Distance learning Concept for Interactive Digital Television

Date of the dissertation: December 18, 2006

Monograph

Department: Computer Science and Engineering
Laboratory: Industrial Information Technology

Opponent: Professor Tapio Varis, Ph.D.
Supervisor: Professor Juha Tuominen, Ph.D.
Instructor: Professor Seppo Kalli, Ph.D.

Abstract:

The objective of the research has been to gain an understanding of T-learning and to create a model that suggests how to support the learning process via iTV and how to produce content for T-learning. The research includes four empirical studies and a survey. The conclusions of the studies provide the ground for the building of the theoretical and conceptual T-learning artefact. The research also aims to define the areas where T-learning is suitable for use.

Content production is crucial in T-learning. TV as a medium has special requirements for content production of a T-learning service. In the current DTV environment, moreover, the content producer has to consider the following issues: limited screen, remote control of a STB as the only control device, navigation, scrolling is not allowed, and writing.

According to the empirical studies, T-learning can be used in at least the following situations and cases: formal and informal learning, assessment, synchronous and asynchronous communication, multi-channel communication, and communal learning. In the empirical studies, target groups were; adults working as well as learning, children, and deaf.

Keywords: T-learning, distance learning, educational technology, digital TV, iTV, MHP, DVB-HTML, IPTV

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VÄITÖSKIRJAN TIIVISTELMÄ

Tekijä Päivi Aarreniemi-Jokipelto

Väitöskirjan nimi

Vuorovaikutteisen digitaalisen television välityksellä toteutettavan opetuksen malli ja sisällöntuotanto

Väitöstilaisuuden päivämäärä 18.12.2006

Monografia

Osasto Tietotekniikan osasto
Laboratorio Teollisuuden tietotekniikan laboratorio

Vastaväittäjä Professori Tapio Varis
Työn valvoja Professori Juha Tuominen
Työn ohjaaja Professori Seppo Kalli

Tiivistelmä

Tutkimuksen tavoitteena oli luoda T-oppimismalli siitä, kuinka opetusta voidaan toteuttaa vuorovaikutteisen digitaalisen television välityksellä ja kuinka oppimissisältöjä voidaan tuottaa T-oppimiseen. Tutkimukseen kuului neljä empiiristä kenttäkokeilua ja haastattelututkimus. Tutkimuksen johtopäätökset luovat pohjan teoreettis-käsitteellisen T-oppimismallin rakentamiselle. Tutkimus pyrki myös empiirisen aineiston avulla määrittelemään alueita, joissa vuorovaikutteista digitaalista televisiota voidaan käyttää oppimisessa.

Sisältötuotanto on tärkeää T-oppimisessa. TV välineenä luo erityishaasteita T-oppimisen sisällöntuotannolle. Sisällöntuottaja joutuu ratkaisemaan mm. seuraavat rajoitukset: TV-ruudun rajoitettu koko, digisovittimen kaukosäädin ainoana ohjauslaitteena, navigointi ja kirjoittaminen.

Empiirisen aineiston perusteella vuorovaikutteista digitaalista televisiota voidaan käyttää ainakin seuraavissa tilanteissa ja opiskelijaryhmillä: formaali ja informaali oppiminen, oppimisen arviointi, yhteisöllinen oppiminen, monikanavaiset oppimistoteutukset, asynkroninen ja synkroninen keskustelu, joko osana TV-ohjelmaa tai erillisenä oppimistoteutuksena, sekä aikuisten ja lasten oppimisessa että viittomakielisessä opetuksessa. Empiiriset kokeet sisälsivät sekä video- että tekstipohjaista materiaalia.

Asiasanat T-oppiminen, etäopetus, koulutusteknologia, digitaalinen televisio, vuorovaikutteinen televisio, MHP, DVB-HTML, IPTV

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PREFACE

This work has been developed as a part of the research activities of the Industrial IT Laboratory at Helsinki University of Technology in the years 2001-2006. The key projects relevant for the creation of the thesis were the Motive, Sign language in T-learning, Communal learning experience through digital TV, and Current state of T-learning projects.

I would like to express my deep gratitude to Professor Juha Tuominen, the head of the laboratory, my teacher, and thesis supervisor. I sincerely appreciate his support during my studies. I would like to thank very deeply Professor Seppo Kalli for all his advice during the studies. Without all the long discussions, advice, and encourage, this would not have been possible.

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TABLE OF CONTENT

ABBREVIATIONS

AC-3	Digital Audio Compression
ADSL	Asymmetric Digital Subscriber Line
API	Application Programming Interface
ARIB	Association of Radio Industries and Business
ATSC	Advanced Television Systems Committee
A/V	Audio/Video
BC	Broadcast Channel
BSP	Broadcast Service Provider
CA	Conditional Access
CAI	Computer Assisted Instruction
CBE	Computer Based Education
CMHN	Consumer Multimedia Home Network
COFDM	Coded Orthogonal Frequency Division Multiplexing
DIL	Distributed Interactive Learning
DPL	Distributed Passive Learning
DRM	Digital Right Management
DTV	Digital Television
DVB	Digital Video Broadcasting
DVB-C	Digital Video Broadcasting Cable
DVB-H	Digital Video Broadcasting Handhelds
DVB-J	Digital Video Broadcasting Java
DVB-J API	Digital Video Broadcasting Java Application Programming Interface
DVB-HTML	Digital Video Broadcasting – HyperText Markup Language
DVB-S	Digital Video Broadcasting Satellite
DVB-T	Digital Video Broadcasting Terrestrial
EBU	European Broadcast Union
EPG	Electronic Program Guide
ETSI	European Telecommunications Standards Institute
FCC	US Federal Communications
HD	High Definition
HDTV	High Definition Television
HTML	HyperText Markup Language
HTTPS	HyperText Transfer Protocol Secure
IC	Interaction Channel
ICT	Information Communication Technology
IDTV	Interactive Digital Television
IP	Internet Protocol
IPTV	Internet Protocol TV
ISDN	Integrated Services Digital Network
ISP	Interactive Service Provider
ITS	Intelligent Tutoring Systems
ITU	International Telecommunications Union
ITU-T	International Telecommunication Union Telecommunication Standardization Sector
JVM	Java Virtual Machine
LCD	Liquid Crystal Display
LDGE	Local Demands for Global Enterprising
LOM	Learning Object Metadata
MAKEP	Mutually Authenticated Key Exchange Protocol
MBps	Megabits per Second
MCCS	Multi Channel Communication System
MHP	Multimedia Home Platform
MHP API	Multimedia Home Platform Application Programming Interface
MMS	Multimedia Messaging Service
MPE	Multiprotocol Encapsulation
MPEG-2	Moving Picture Expert Group, part 2
MPEG-2 TS	Moving Picture Expert Group, part 2 Transport Stream
MySQL	My Structured Query Language
PBL	Problem-Based Learning
PDA	Persona Digital Assistant
PHP	Hypertext Preprocessor

PKI	Public Key Infrastructure
PMM	Protection Management Mechanism
SSM	Soft System Methodology
STB	Set-Top-Box
TCP	Transmission Control Protocol
T-learning	TV-based Interactive Learning
TS	Transport Stream
UNITE	University-Industry Television
VCS	Value Creating System
VEMiTV	Validation and Development of an Interactive Television based Educational Model
VLE	Virtual Learning Environment
VSAT	Very Small Aperture Terminal
WBE	Web-Based Education
XHTML	Extensible HyperText Markup Language
XML	Extensible Markup Language
YLE	Yleisradio, Finnish Broadcasting Company

DEFINITIONS

Aspect ratio refers to the width-to-height ratio of the picture frame. TV broadcasts with a 4:3 aspect ratio and digital TV broadcasts with a 16:9 ratio.

An **asset** refers to an electronic presentation of learning resources, such as text, video, image.

Asynchronous learning allows learners and teachers to participate to learning activities at a time which is most suitable for their own working needs (Falchikov, 2001).

Audio-Description service consists of adding to a television programme an audio track where a narrator describes what is happening on-screen for persons who are blind or have severe visual impairments.

Authentication includes the identification and authorization of the students.

Blended learning or hybrid learning refers to learning environments that combine aspects of online and face-to-face instructions.

The **broadcast channel** refers to a unidirectional, broadband, point-to-multipoint channel which may include video, audio and data. The broadcast channel is established between a broadcast services provider and users.

Building is a process of constructing a model for a specific purpose.

Collaboration occurs, when more than just one person works on a single problem-solving task (Teasley et al., 1993, Marttunen et al., 2005).

Constructions refer to entities that produce solutions to explicit problems.

The **constructive approach** refers to problem solving through construction models, diagrams, plans, and organizations

Constructs form the language of a domain in constructive approach. **Constructs** in the problem definition of the thesis refer also to a property of a thing in a construction process.

Cross-media refers to the use of more than one medium.

Data availability refers to identification of viewers and access right control.

Data integrity ensures that the data has not been modified (Elbaz et al., 2005) and it consists of completeness, trustworthiness, and validity of information (Lugmayr et al., 2004).

Digital rights management system (DRMS) refers to techniques and mechanisms for protecting content to warrant intellectual property rights.

Digital Television (DTV) refers to the transmission of signals in a digital form.

Distance learning refers to learning and education that do not require attendance at lectures. Former methods of distance education were correspondence courses and television programmes. Nowadays, the use of information communication technology provides many media solutions. Distance learning can be a combination of different media or can be combined with traditional lectures.

Educational programmes refer to the use of a broadcasted video form of educational material.

Educational technology refers to the technology used in learning and education.

Edutainment (education + entertainment) refers to education or learning material in which features of entertainment have been used.

Effectiveness means that the user is able to carry out the intended task.

Efficiency refers to the implied time in usability.

E-learning refers to Electronic learning, where information communication technologies (ICT) are used as media to facilitate learning and education. ICT includes, for example, the usage of the Internet, videoconferencing, DVD, videos, cassettes, radio, and television.

The **Enhanced Broadcast** profile combines digital broadcast of audio and video with transmitted applications.

Evaluation determines how well the artefact is performed in constructive approach.

Formal learning refers to learning organized by a school and leading to a formal qualification.

The **full interactivity** is using a bidirectional interaction channel to and from the source of the device.

Functions in the problem definition of the thesis refers to what is needed in an iTV platform and learning environment to facilitate learning according to the field studies.

Heuristic evaluation refers to an informal method of usability where evaluators are trying to find out good and bad issues concerning the interface by looking at it (Nielsen et al., 1990).

Hybrid learning or blended learning refers to learning environments that combine aspects of online and face-to-face instructions.

Informal learning exists in everyday situations and does not lead to any formal qualification.

Information and Communication Technology (ICT) includes technologies required by society in learning to transmit information and to communicate, for example, through the Internet, digital TV, and mobile phones.

An **instantiation** is the realization of an artefact in the environment.

The **interaction channel** refers to a bidirectional channel from a user to an interactive service provider for interaction purposes.

The **Interactive Broadcast** profile combines digital broadcast of audio and video with transmitted applications in the MHP profile.

Interactive Digital Television (iDTV) is required to deliver services the viewers need and value. iDTV allows the viewer to have a more active role than just passively watch a television. This is a feature of great significance for T-learning.

Interactive Television (iTV) is a two way TV in which the viewer can make programming choices and produce user input.

The **interlacing** refers to the way the lines on television screen are shown to the viewer and affect the user's vision of colours and fonts.

The **Internet Access** profile in the MHP standard is intended for the provisioning of Internet services.

An **interview** refers to a conversation between interviewer and respondent with the purpose of eliciting certain information from the respondent.

As its best, **learning** can be seen as a research process that produces new insight and knowledge (Hakkarianen et al., 2001). However, knowledge has to go through learners' own processing, which may result in learning (Koli et al., 2003).

Learning environment is "the physical or virtual setting in which learning takes place" (Kaplan-Leiserson, 2005). The components of a learning environment are, for example, place, space, and community. The purpose of a learning environment is to facilitate learning.

Learning process is "an individual's development process, during which particular skills or knowledge are acquired". The learning process requires an active role from a student. Furthermore, learning is planned, and goal-directed (Koli et al., 2003), and consists of several learning situations.

Lifelong learning "is a continuous process that motivates and empowers individuals – it assists them to acquire new knowledge, skills and understanding that can be applied confidently in new circumstances and environments" (Gooley et al., 2001). Lifelong learning does not end in graduation, but continues throughout the individual's life.

Local interactivity does not include a return path.

A **method** is a set of steps used to perform a task in constructive approach.

A **model** is a set of propositions expressing relationships among constructs in constructive approach.

Non-repudiation means that users are unable to deny having carried out operations.

On-demand, pull services, are using a transparent *Transmission Control Protocol/Internet Protocol (TCP/IP)* communication between the server and the STB (Jaeger et al., 2000).

Online community refers to the communication and social interaction which is seen in the Internet and iTV learning systems.

Partial role of T-learning refers to the use of iTV as a one of the media to enable learning.

The **pedagogic requirements** refer to the pedagogic utility and functionalities of a learning environment.

Platform refers to an application intended to facilitate learning and education. It includes different kind of technical functionalities, to deliver learning material and to allow communication.

Protection management mechanisms (PMM) refers to the methods, possibilities, and techniques to warrant intellectual rights on services and aims to increase data security by preventing unauthorized access and misuse of data through the digital value chain. PMM consists of *Conditional access (CA)*, *Digital right management (DRM)*, and security.

The **pull**, **on-demand services**, are using a transparent *Transmission Control Protocol/Internet Protocol (TCP/IP)* communication between the server and the STB (Jaeger et al., 2000).

The **push service** is based on a data carousel mechanism.

The **questionnaire** refers to structured or unstructured questions in a paper or electronic form intended to be responded to by selected people.

In usability **satisfaction** defines how acceptable the system is to the users (Faulkner, 2000)

Scrambling is a method that uses cryptographic algorithm with secret encrypting keys to encrypt source programme and only the viewer withholding the decryption key can descramble the received scrambled programme and reconstruct the original TS.

Secrecy means that users can have access only to the objects for which they have received authorization.

Simple interactivity is using a unidirectional interaction channel.

In cellular delivery systems, seamless mobility may achieved by so-called **soft handover**. It means that a receiver which is synchronized to a single frequency and is using one or more IP services, switches to another signal seamlessly without any service breaks.

Substitute role of T-learning refers to the situation when the whole learning process is planned as a T-learning service.

Subtitling service adds subtitles to the programme so that the audio track of the programme can be read from the subtitles.

Supplementary role of T-learning refers to the situation when T-learning is used to provide additional, extra learning services or material.

In **synchronous learning** participants do not need to be present in the same place, but real time is required.

The **technical requirements** refer to the technical utility and functionalities of the system, but usability is recognized as one of the issues to be paid attention to in the implementation.

Things in the problem definition of the thesis refers to the features of T-learning phenomena recognised during the construction process.

Time slicing means here that IP datagrams are transmitted as data bursts in small time slots.

T-learning lifecycle refers to the chain which includes functions from content production to the consuming of T-learning services.

Triangulation refers to the combination of several research methodologies and data collection techniques in the study of the same phenomenon.

Usability refers to “the effectiveness, efficiency and satisfaction with which specified users can achieve specified goals in particular environment” (ISO DIS 9241-11).

Utility means whether the system’s functionality can do what is needed. It refers e.g. to useful, serviceful, or helpful of the artefact.

FIGURES

1 Introduction

The discipline of this thesis is educational technology. Educational technology as a discipline is relatively new and has no strong tradition. During the last two decades, it has looked for its position between the fields of pedagogy and technology. Usually researchers in educational technology have a background in a single discipline: computing, education, or psychology. Educational technology research performed in Computer Science is usually focused on innovative use of technology in the learning process, when the focus in education is pedagogic. In this thesis the technology used is *interactive television (iTV)* technology and it is used to enable innovative *televised learning (T-Learning)*.

The overall quality of a system is a sum of usability and quality attributes. In addition to usability, meaning how well users can use functionalities of a system, issues related to utility also need to be considered when developing a system. **Utility** means whether the system's functionality can do what is needed. A system should be feasible in practice with respect to cost, maintainable, and suitable for users' needs. "Educational software has high utility if students learn from it" (Nielsen, 1993).

Similarly, a T-learning system requires quality attributes and usability, but also functionalities to enable learning. A T-learning system consists of two parts:

- a learning platform
- a learning environment.

The **learning platform** refers to a technical system or applications to facilitate learning and education. The requirements of a platform are defined in this thesis as a developed T-learning model. The requirements need to be fulfilled with the help of technology and taken into account in the implementation of the technology used to facilitate T-learning. The **technical requirements** refer to the technical utility and functionalities of the system, but usability is recognized as one of the issues to be paid attention to in the implementation.

Similarly to the platform, the learning environment also serves to facilitate learning. However, the **learning environment** considers the functionalities and the features from the learning and pedagogic points of view. A learning environment consists of components which affect learning in interaction with relevant individual and cultural differences. The pedagogic requirements of a learning environment are defined in this thesis as a developed T-learning model. It defines the components required for a learning environment to facilitate learning via iTV. The **pedagogic requirements** refer to the pedagogic utility and functionalities of a learning environment.

This thesis benefits from the results and experiences across several disciplines. First, distance learning has existed for decades, and this prior work has paved the way for learning via iTV. Second, the thesis is also connected to design sciences. The mission of a design science is to solve construction problems. This thesis aims to solve construction problems related to T-learning. Third, the students' expectations in using television as a medium should be recognized. People are used to television as an easy-to-use medium, which should also be the objective in implementing T-learning services.

T-learning is also affected by educational policy. During recent years, one of the core issues in the Finnish educational policy has been the emphasis on Information and Communication Technology *(ICT)* (Järvelä, 2004). In Finland, the Ministry of Education has the *Information Society Program for Education, Training and Research 2004 – 2006* (Ministry of Education, 2004) and the aims of the programme until 2007 include:

- "Appropriate use of ICT in learning and teaching is part of everyday school life".
- "Electronic materials are to be of a high quality, pedagogically justified, serve different user groups and be openly available".

The educational policy is outside the scope of this thesis.

Public education is regulated by Finnish laws, but the legal issues involved are outside the scope of this thesis. T-learning is also affected by the European Union. The Council of the European Union says in its resolution on lifelong learning the following (EU Council, 2002):

"Lifelong learning facilitates free mobility for European citizens and allows the achievement of the goals and aspirations of European Union countries (i.e. to become more prosperous, competitive, tolerant and democratic). It should enable all persons to acquire the necessary knowledge to take part as active citizens in the knowledge society and the labour market."

There is an ongoing shift from self-contained education to lifelong learning. **Lifelong learning** "is a continuous process that motivates and empowers individuals – it assists them to acquire new knowledge, skills and understanding that can be applied confidently in new circumstances and environments" (Gooley et al., 2001). Education is no longer a once-in-a-lifetime experience that happens during childhood or early adulthood but rather a continuous lifelong process. Over time, educational needs change and skills and knowledge have to be updated. More full-time employees are aiming to advance their career position or building a new career. A new interest group for education is older persons who have finished their fulltime employment and have the time to pursue educational activities for personal fulfilment. Distance learning and learning on the job are important in lifelong learning.

1.1 Contemporary elements in E-learning

Distance learning refers to learning and education that do not require attendance at lectures in a classroom. It needs to have a delivery mode, which means that a course needs to be delivered via television, videocassette disc, film, radio, computer networks, other devices, in a paper form or a combination of these. The definition of distance learning varies and is understood and interpreted differently by different groups and in different contexts. The definitions vary in the inclusion and role of teachers and peers and distance learning does not in every case have start and end dates. The term distance learning may also be used interchangeably with distance education or may refer to the desired outcome of distance education. **"**The definition of distance education is broader than and entails the definition of E-learning" (Kaplan-Leiserson, 2005, Neal et al., 2005). Distance learning and traditional learning are not mutually exclusive. Most distance learning is actually **blended learning** or **hybrid learning**, which refers to learning environments that combine aspects of online and face-to-face instructions. In this thesis, distance learning refers to learning which does not require attendance in a classroom, but can include also face-to-face lectures. Distance learning is seen to be more than just the delivering of the learning material and it includes also 'student - student' interaction and 'student - teacher' interaction.

There are differences concerning the origin of distance learning. The roots of distance learning are said to be in the 1700s in the USA (Harper et al., 2004) and in the 1800s in England (Neal et al., 2005).

Table 1 illustrates the history of distance learning.

Table 1: History of distance learning (Harper et al., 2004)

Years	Characteristics
1700 - 1900	• Use of mail to deliver course material
1920 - 1960	• Correspondence education • Use of radio and television for correspondence education
1970 -1980	• Use of pre-recorded video recordings • Use of cassette recordings • Limited number of broadcast channels • Mainly used in research and sciences to share information
1980-1990	• Teleconferencing • Video conferencing • Less expensive video discs • Cable networks start programming for K-12 students • More televised programmes
1990 - Present	• Less expensive computers • Greater access to technology • Internet in classrooms • More educational institutions and businesses utilize distance learning • Computer-based training (CBTs) • Synchronous and asynchronous communication

The foundation of distance learning was in the early 1700s when correspondence students and teachers exchanged information through the postal system. The information included assignments, notes, and tests. The reasons for the correspondence courses were the desire to educate and entertain people (Harper et al., 2004). In 1890, many states in the USA passed laws to require young people to attend school. Because of problems such as low attendance and high dropout rate, schools began to offer correspondence education. In 1890, the Onward and Upward Association provided correspondence courses in over 100 branches, including several overseas (Spikins, 1991). In the year 1892, the University of Chicago organized a separate correspondence study department (Harper et al., 2004). The first correspondence courses share many elements of modern distance learning:

- Information was often presented using textbooks produced by the correspondence college.
- Students carried out the assignments which were evaluated by a tutor by post.
- Often students took a public examination, set by university schools examination boards or a professional institute.
- Students could acquire just about any skills or qualification by this means, in languages, accountancy, painting, and engineering.
- The courses were aimed at those who strayed from conventional educational path, because
    - needs were not shared by enough people in the area
    - jobs prevented people from attending face-to-face courses.

E-learning refers to the use of computer science in education. Students are allowed to choose the time, place, and pace of education. *Information and Communication Technology (ICT)* includes learning technology required by the Knowledge Society to transmit information and communicate via the Internet, *digital television (DTV)*, and mobile phones. ICT emphasized the importance of communication in learning.

1.2 Limitations of analogue TV and problems in current E-learning

1.2.1 Limitations for learning with TV

Figure 1 illustrates the limitations of analogue TV for learning.

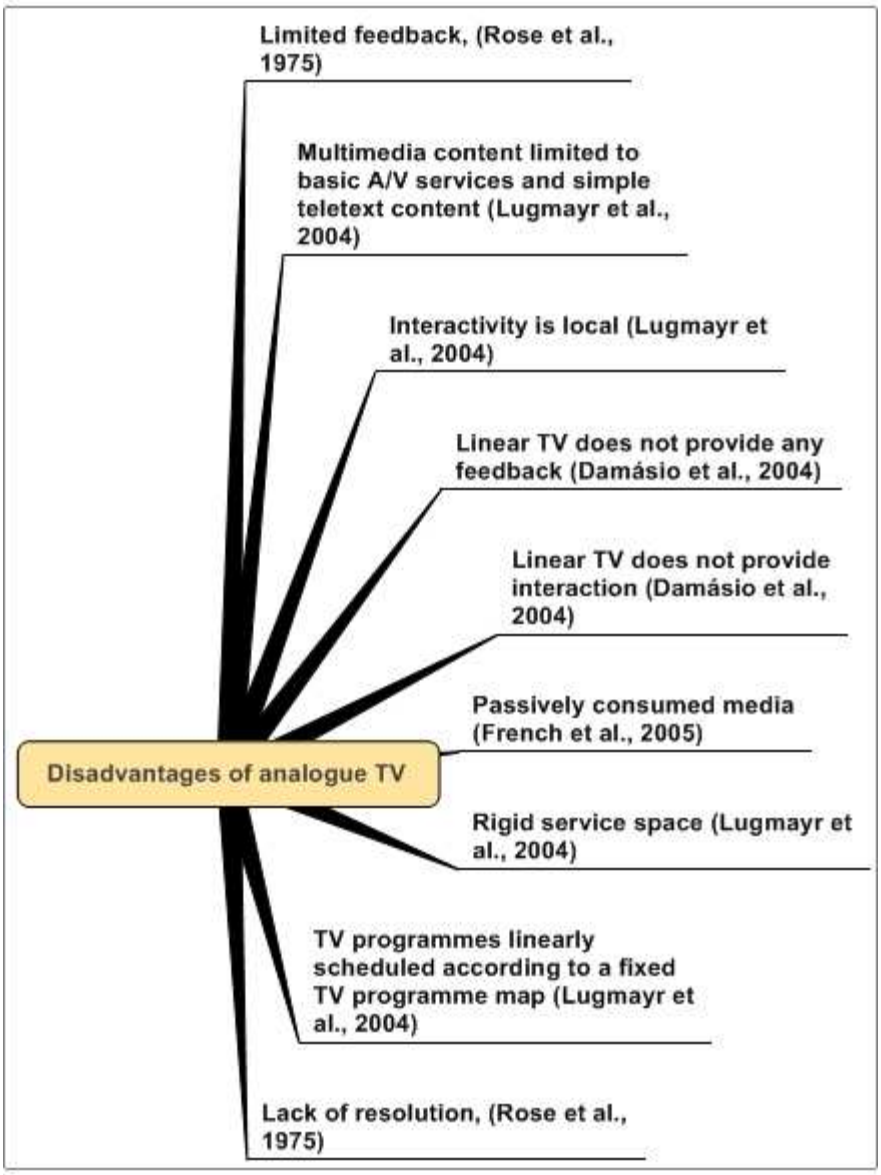


Figure 1: Limitations of analogue TV

In the learning context the limitations of analogue TV mean both the missing of interaction and community and the students' passive role. In the thesis an attempt is made to look for a solution with the help of iTV. The solutions are illustrated in Chapters 6 and 7.

Because of ubiquity and ease of operation, iTV could become the key way of accessing:

- education
- information.

1.2.2 Problems in current E-learning

Access to computers is seen as the major problem in ICT (Peraton et al., 2000). More than 50 per cent of the world's population does not have access to the Internet (Lee et al., 2002). Internet availability at schools is also limited because of the lack of competence among teachers (Varis, 2005 B). In addition to the students' inadequate Internet connections, Internet courses have faced problems due to difficulties with downloading audiovisual files (Hentea et al., 2003, Pahwa et al., 2005). Other problems are the inability to deliver true high-quality video and to adjust to the user's preferences. Web-based learning also has the following problems (Baas et al., 2001):

- Users get lost in the maze of hyperlinks on the Internet.
- The speed of the Internet connection is limited.
- Maintaining of a Web-based course implies much overhead.
- Being on line costs money.

Based on the study of 144 U.S. companies, technology infrastructure is one of the barriers to the adoption of E-learning (Simmons, 2003). In addition to fast Internet connections, the real E-learning revolution requires flexibility in providing different media (Varis, 2005) and it has been suggested that a media mix to Web-based learning could solve the problem (Baas et al., 2001).

Nowadays, many of the models for integrating ICT into education are based on once in a lifetime learning models and the traditional classroom model of organizing education (Pulkkinen, 2004). Because the Knowledge Society is constantly changing the world, it has new kinds of requirements for education including the following:

- demand for widening the access to education for all
- continuous lifelong learning
- formal education alongside working life
- availability
- connections
- interaction.

Most workers need to broaden their academic knowledge after their graduation (Sakai et al., 2002), which makes lifelong learning and the widening access to learning important to Knowledge Society. However, E-learning has not penetrated the lifelong learning market as much as has been expected.

The following problems have been noted in distance learning (Sakai et al., 2003):

- the opportunity to easily ask questions due to the distance between a teacher and students
- the difficulty of solving a question among students
- the possibility of too many students' taking a class simultaneously.

In the thesis an attempt is made to seek the solution to some of the problems of E-learning with the help of iTV. In the thesis the suitability of iTV is studied to widen the access to education for all, to enable formal education alongside working life, and to enable interaction in learning via iTV.

1.3 Research problem

Analogue broadcasting has been used for educational purposes for years. iTV technology provides a set of new features that can be exploited for learning purposes, but there is no experience of constructing an iTV learning system or facilitating learning via iTV. Small-scale T-learning experiments have been carried out, but models of how to facilitate and support learning via iTV are lacking.

The research problem was determined as follows:

- How to construct a T-learning model in which:
    - The T-learning model describes T-learning; it has to recognise the main functions with the help of field studies and create constructs for the things needed in learning via iTV
    - The T-learning model is customised according to different student groups' requirements
    - The T-learning model is usable in informal and formal learning

The **model** aims to inform the design and production of T-learning materials and services. **Functions** in the first statement refers to what is needed in an iTV platform and learning environment to facilitate learning according to the field studies. **Things** refers to the features of T-learning phenomena recognised during the construction process. **Constructs** refers to a property of a thing.

The main research methodology is constructive. The main research objectives were to gain an understanding of T-learning, to create a model that suggests how to support the learning process via iTV, and how to produce suitable content for use via iTV. The research was carried out in parallel in two dimensions. The dimensions are analogous with March et al., 1995, Hevner et al., 2004, and Järvinen, 2004, who state that design science consists of two basic activities: building and evaluation. The first dimension, building, entails the construction of the T-learning artefact. The conclusions of the empirical studies enable the theoretical and conceptual T-learning artefact to be built. The second dimension is evaluation. It means defining the areas where T-learning is suitable for use.

The main research question of the research is stated:

- Which kinds of T-learning theories, models, and frameworks ought to be developed to describe and understand the conclusions and the observation results from the field studies?

Minor research questions stemming from the main problem are:

- How do students, pedagogy, and technology affect the construction of the iTV learning model, according to the conclusions from the field studies?
- How do the conclusions from the field studies suggest that learning can best be supported and content produced?

The results of this study aim at adding to the body of scientific knowledge of T-learning. The research is very topical, as the changeover from analogue to digital broadcasting in Finland will happen in the year 2007. Bates (2003) has noted that despite the more than 25 years of experience of using educational broadcasting there is only a small number of pedagogical studies on early pioneering developments to draw upon to help understand how learners may best learn through this medium. There is also limited research addressing interactivity.

Figure 2 represents the theoretical and conceptual framework of the research. The theoretical foundation of the study relies mainly on research on televised learning and DTV technology. As Järvinen (2004) states, the motivation behind the building of a new artefact is either in the lack of an artefact or the low quality of the outcomes of the old artefact. The theoretical televised learning framework is the existing knowledge on learning, performed mainly via analogue broadcasting in this research. DTV technologies enable new features to be used in learning via television. The empirical field studies have two functions: first, they test in practice the T-learning artefacts that have been created, and second, the conclusions of the field studies enable a new theoretical T-learning framework to be constructed.

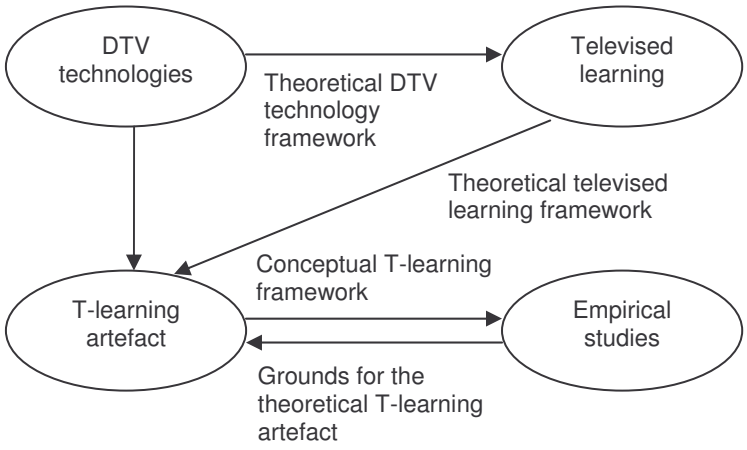


Figure 2: The theoretical framework for the research

1.4 Research methods

The research framework of the thesis is based on Järvinen & Järvinen's taxonomy of research methods (see Figure 3). The research methodology is constructive and it uses the innovation-building and evaluating approach. In addition, the research carried out includes empirical studies used in the theory-creating approach, which in turn utilises a conceptual-analytical approach.

In this thesis, a method called **triangulation** is utilised. Triangulation refers to the combination of several research methodologies and data collection techniques in the study of the same phenomenon. A reason for triangulation is that it can be difficult to gain a complete and holistic picture about a research subject with the help of one research method (Eskola et al., 2005). In this research each field and survey study has contributed an additional piece to the puzzle of the creation of the T-learning model and in that way they complement each other. The other reason for triangulation was a lack of information relating to T-learning. The number of field studies was limited and the author aimed to get different kinds of results from the studies.

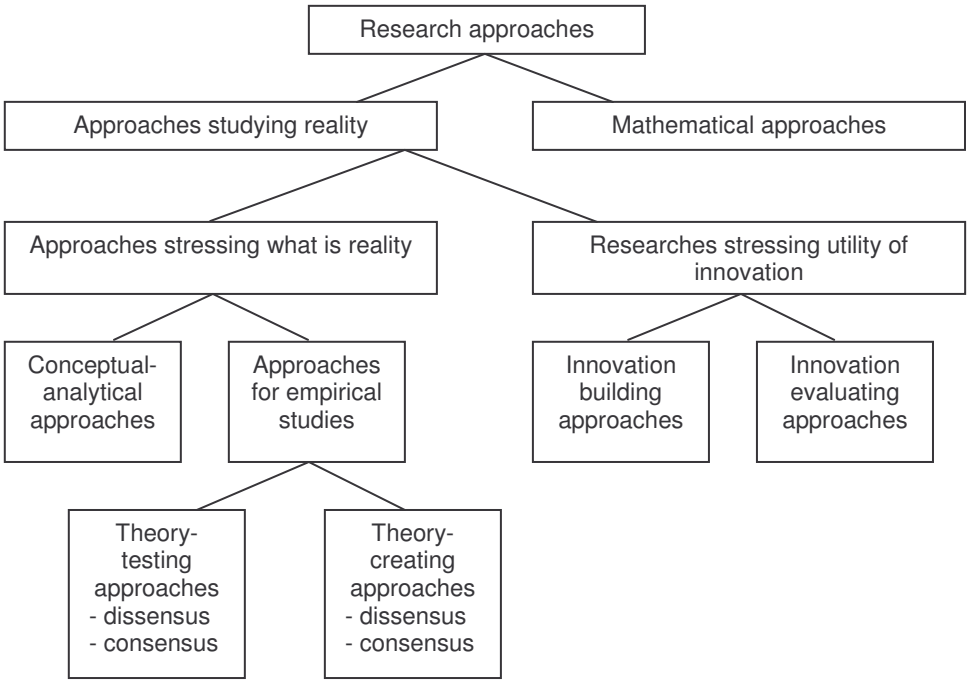


Figure 3: Järvinen & Järvinen's taxonomy of research methods (Järvinen, 2004)

1.4.1 Constructive approach

"Working in a new medium gives us a chance to encounter and solve problems that have never been confronted before" (Quesenbery et al., 2005). The constructive approach is widely used in technical sciences, design sciences, mathematics, operations analysis, and clinical medicine.

The constructive approach refers to problem solving through construction models, diagrams, plans, and organizations (Kasanen et al., 1993). Creation of a new innovation is typical of constructive research. **Constructions** refer to entities that produce solutions to explicit problems. It is characteristic of the solutions that their usability can be demonstrated through the implementation of the solution. The constructive research can be viewed as a type of applied study.

"The constructive approach may be characterised by dividing the research process into phases, the order of which may, of course, vary from case to case" (Kasanen et al., 1993):

1. Find a practically relevant problem which also has research potential
2. Obtain a general and comprehensive understanding of the topic
3. Innovate, e.g. construct a solution
4. Demonstrate that the solution works
5. Show the theoretical connections and the research contribution of the solution concept
6. Examine the scope of applicability of the solution

Design science consists of two basic activities: build and evaluate (Järvinen, 2001). **Building** refers to a process to construct an innovation or artefact for a specific purpose. Typical attributes associated with the constructive research are creative, innovative, and heuristic (Olkkonen, 1994). **Evaluation** determines how well the artefact is performed. In the evaluation of a new construct, model, method, or instantiation, it can be asked whether it is in some sense better than the old one. The primary criterion for assessing the results of technical applied studies is their practical usefulness, where the criteria for the "goodness" of

the solutions may vary depending on the technology sector (Niiniluoto, 1985). “The main condition of validity for constructions is clearly that they work (e.g. solve the problem in question)” (Kasanen et al., 1993). In addition, a working construction should be relevant, simple, and easy to use. Furthermore, the usage of a constructive approach should include description of the theory, illustrating the evidence, and generalization.

1.4.2 Construction of an artefact

The purpose of the construction is to achieve a transition from the initial state to the goal state (Järvinen, 2004). March et al. (1995) connect two models to the building process in constructive research. The first model represents the current situation as problem statements and the second model represents the desired situation as solution statements. The first describes how things are at the beginning and the second normative model describes how things ought to be in the goal state.

Figure 4: The building process (Järvinen, 2004)

The building process is divided into two parts: the specification process and the implementation process. The purpose of the specification process is to determine the goal state of the desired artefact under construction. In the implementation process the research question can be formulated as follows: Given certain initial and goal states and particular resources, how can we build an artefact satisfying the given specifications?

The outcomes of a construction are constructs, models, methods, and instantiations (March et al., 1995, Hevner et al., 2004, Järvinen, 2004). **Constructs** form the language of a domain. “Constructs are in some sense subordinate to models and methods” (Järvinen, 2004). A **model** is a set of propositions expressing relationships among constructs. A **method** is a set of steps used to perform a task. An **instantiation** is the realisation of an artefact in the environment.

Table 2 summarises the evaluation criteria of the building process. In the case of a totally new construct, model, method, or instantiation, a researcher could look for the potential benefits of the new construct in use. In the event that the construct, model, method, or instantiation already exists in a certain form, a researcher could ask: “is the construct, model, method, or instantiation in some sense better than the old one?” The phrase “*in some sense*” means a certain assessment criterion used in comparison” (Järvinen, 2004).

In design science progress is achieved when existing technologies are replaced by more effective ones. In this research the analogue TV technologies are replaced by interactive digital TV technologies. In design science the most important feature is to build and evaluate the **utility** of artefacts. Utility refers to e.g. the usefulness, serviceability, or helpfulness of the artefact. Utility is included in Järvinen’s taxonomy of research methods. In other words, the raw data are gathered and used to construct artefacts and add to their utility. Hevner et al. (2004) note that in design science empirical techniques can be used to evaluate the quality and effectiveness of artefacts. In this thesis empirical studies are also used to evaluate artefacts created earlier in the research.

Table 2: Evaluation of the building process with the old and totally new outcomes (Järvinen, 2004)

	March et al., 1995	**Van Aken, 2004**
An old outcome exists	Significant differences between the old construct, model, method, or instantiation and the new one, respectively	As March and Smith, plus a special emphasis on the tested and grounded technological rule in both the developed and extracted multiple case studies
A totally new research outcome	"Actual performance evaluation is not required at this stage"	The technological rule in the developed multiple case study with both positive (tested and grounded rules with both driving and blocking mechanisms) and negative results

1.4.3 Qualitative research

A common distinction of research methods is a classification into qualitative and quantitative methods. The framework of research methods of Järvinen (2004) does not support this distinction. In empirical studies, both the theory-testing and the theory-creating approaches can include qualitative and quantitative methods. This research applies both qualitative and quantitative methods in the empirical studies and theory creation, because it aims to gain a better picture of T-learning.

The most commonly used descriptive method in educational research is a survey, where interviews and questionnaires are used as data gathering techniques. An **interview** refers to a conversation between interviewer and respondent with the purpose of eliciting certain information from the respondent. The role of the interview in the constructive approach can be to find out the respondent's requirements concerning the new artefact or telling about the opportunities the respondent sees concerning the new artefacts (Järvinen, 2001). This was one of the reasons for the survey conducted for this research.

The **questionnaire** refers to structured or unstructured questions in a paper or electronic form intended to be responded to by selected people. It is the most common gathering technique in the survey studies. In the thesis, questionnaires are used in the constructive approach to evaluate the practical relevance of the constructed iTV learning environment.

The analysis of qualitative material can also include quantitative analytical techniques (Eskola et al., 2005).

1.4.4 Theory-creating and conceptual-analytical approach

This research also includes a theory-creating approach. Qualitative methods such as case studies, grounded theory, and phenomenography are included in the theory-creating approach (Järvinen, 2004). In this research field studies are used for theory creation.

In this context the notion of "theory" should be understood as a creation of the theoretical framework for learning via iTV. According to Webster et al., (2002), theories can be placed in a hierarchy from ad hoc classification systems (in which categories are used to summarise empirical observations), via taxonomies (in which the relationships between the categories can be described) and conceptual frameworks (in which propositions summarise explanations and predictions), to theoretical systems (in which laws are contained within axiomatic or formal theories). The final product of creating a theory from case studies may

be concepts, a conceptual framework, or propositions or a possible mid-range theory (Eisenhardt, 1989). Webster et al. (2002) go on to state that "the reasoning for propositions may come from three main sources: theoretical explanations for "why", past empirical findings, and practice or experience". If no past empirical research exists in the specific area of interest, empirical research in related areas can be presented as support.

Järvinen (2004) states that a new theory may be needed if there is no previous knowledge about a topic or if it can be assumed that there is a special or unique case or situation. The researcher has an opportunity to see or penetrate behind direct observations and try to find constructs and relationships in order to master the matter or phenomenon. The situation in this research was of this kind. There was not enough previous knowledge about T-learning. This research included an opportunity to use novel technologies and new functions and characteristics in learning via TV.

In the empirical research of this thesis raw data were gathered from the real world. The conclusions of the empirical studies are used to find constructs of T-learning. Järvinen (2004) continues: "the descriptive theory inductively derived from empirical generalisations shows what kinds of general regularities describe the phenomenon under study, if empirical observations of the phenomenon are correct and it behaves regularly." However, the main research approach is constructive, meaning that it deals with **normative** theories. Normative theories, models, and frameworks are usually emphasised in some kind of utility. The differentiation between descriptive and normative aspects corresponds to the philosophical distinction between "is" and "ought to". Conceptual-analytical research can try to answer a question: which kind of theory, model, or framework describes or explains phenomena (Järvinen, 2004)? The main research question of the thesis is: Which kinds of T-learning theories, models, and frameworks ought to be developed to describe and understand the conclusions and the observation results from the field studies?

Järvinen (2004) notes that theory-creating studies are very suitable for exploratory investigations, e.g. when there is no prior knowledge of an area of the real world or a phenomenon. The data can be facts on the first level (the number of messages sent), first-level concepts or opinions (students' opinions of DTV) or concepts on the second level (the researcher's interpretations of students' reviews).

Eierman et al. (1995) state that a theory needs to include:

- a boundary that describes the domain of interest
- key constructs within that domain
- the values those constructs can take on
- the relationships among key constructs.

1.5 Structure of this thesis

This thesis is organized in line with the following chapters, each one discussing different aspects of T-learning:

Chapter 1 "Introduction" serves as a background to distance learning and interactive television. It also presents the framework for the research and defines the research problem and methods.

Chapter 2 "Current status and future of T-learning in Finland" illustrates the performed survey in the Finnish T-learning scene.

Chapter 3 "Learning via television" defines the most important terms concerning learning from the thesis point of view. This chapter introduces the viewing habits impact in the evolution of T-learning and presents an overview of learning first from traditional television

and then from iTV. The chapter creates the televised learning framework of the research. The framework is utilised in Chapters 7 and 8.

Chapter 4 "Prerequisites for practical implementation of T-learning" describes some suitable technologies for T-learning purposes. It also introduces issues such as usability and security. The chapter creates the iTV framework of the research. The framework is utilised in Chapters 7 and 8.

Chapter 5 "Motive learning environment introduces the developed Motive learning environment used for implementing the Motive 1 and 2 field studies (see Sub-chapter 6.1 and 6.2. The developed T-learning models (see Chapters 7 and 8) are used in constructing the Motive learning environment.

Chapter 6 "T-learning field studies" presents the results of the four T-learning field studies. The first two field studies deal with the use of the Motive learning environment. The third field study concerns the use of sign language content in iTV. The fourth field study introduces instant messaging to produce an online community via iTV. The conclusions of the field studies enable a new theoretical T-learning framework to be constructed (see Chapters 7 and 8).

Chapter 7 "T-learning modelling" presents the developed T-learning model to inform the design and production of T-learning materials and services. The model builds on the conclusions of the four field studies. Chapters 2, 3, 4, and 5 are utilised.

Chapter 8 "T-learning system model" introduces the T-learning system model for DVB-HTML and IPTV. The model is a description of the iTV learning system including the technology of particular implementations. The chapter is based on the conclusions of the field studies and literature.

Chapter 9 "Content production" describes the general process of creating learning content and gives design guidelines for iTV. It uses the developed T-learning models during the process. Chapters 2, 3, 4, 5, 6, 7, and 8 are utilised in the chapter.

Chapter 10 "Discussion, conclusions, and future research objectives" presents the overall results, discussion, and conclusions, as well as the future of T-learning regarding this thesis.

2 Current status and future of T-learning in Finland

2.1 Introduction to the research

The Ministry of Transport and Communication in Finland launched the 2-year ArviD digital TV cluster programme in February 2004. The ArviD programme aims to support the smooth transition to the era of DTV. To find out the current status and the future of T-learning in Finland, the author performed a research study during the summer and autumn of 2004 (Aarreniemi-Jokipelto, 2005B). This section is based on her research. The research consisted of interviews.

2.2 Participants in the research

The interviews covered the following entities:

- Ministry of Education (Senior Counsellor)
- Finnish National Board of Education (Councellor of Education)
- education providers
    - municipal education (Principal)
    - vocational education (Education Manager)
    - polytechnic colleges (Head of Institution)
    - universities (Director, Vice President, Special Planner (2))
    - adult education colleges (Secretary General, Product and System Manager)
- DTV broadcasting companies
    - Public (Programme Manager, Multimedia Producer)
    - commercial (Chief of Development, Development Manager
    - local (Managing Director, Programme Manager)
- content producers (CEO, Producer)
- publishing companies (Sr Vice President, Publishing Manager in Adult Education)

2.3 Materials and methods

The information was gathered by means of interviews. The interviewees were chosen in co-operation with the organisation of the ArviD programme. The background idea in the selection was to choose participants from the whole value chain of T-learning; educational administration; education providers from schools and companies; broadcasting companies; content producers, and publishing companies.

The interviews covered the following subjects:

- current status of T-learning
- the role of T-learning as a learning environment in the future
- advantages and disadvantages of T-learning
- use areas of T-learning
- T-learning and edutainment
- content production of T-learning
- broadcasting channels for T-learning
- international and national co-operation in T-learning

The interviews were semi-structured. The questions were defined beforehand, but not followed strictly in the interview situations. The interviews took from one to one and half hours. The interviews were analysed with a thematic analysis method (Eskola et al., 2005). The themes extracted from the material are:

- current state and future of T-learning

- reasons for the use of DTV for learning purposes
- games and edutainment
- types of services
- content production
- devices
- T-learning and models.

2.4 Current state and future of T-learning

There were not many interactive educational services available. In Finland, interactive educational services were on the planning level during the research in the summer of 2004 and the interactive educational course of *Helsinki University of Technology (HUT)* was the only one in existence.

A real example of facilitating learning via iTV was found during the ArviD research. iTV facilitated learning for the father of a family at the same time as a daughter of the family studied a web-based course. Web-based learning demands sole use of the device being utilised and the device may be required for many hours in an evening. In this case, it would have been difficult to share a device, because both needed to study in the evenings and at weekends.

In the vision of the ArviD digital TV cluster programme it is stated that DTV should have found its role and established its position as citizens' channel for entertainment, participation, learning, and errands by 2010 (ArviD, 2004). Some of the interviewees felt that it is realistic as regards learning. Others felt that the vision was too optimistic, because even the termination of analogue broadcasting was felt to be according to a tight schedule.

Finland was seen as too small a country to have the chance to choose the DTV standard to be used, which also affects the penetration of MHP. Finland was said to be dependent on what is happening internationally, especially in Europe. A few interviewees were very sceptic about the future of MHP and about the penetration of DTV in general. One interviewee said that he will believe it when he sees that it has come true.

In the strategy of the Finnish National Board of Education DTV was already mentioned as early as the year 2004. An interviewee stated that "DTV was also mentioned in the vision of their school". Another interviewee stated that "they have a vision that half of their education will be mediated by 2010, so DTV, as one of the media, was seen as being realistic". Companies are following the development of digital TV for educational services carefully, but they have not received direct requests to utilise T-learning.

2.5 Reasons for the use of DTV for learning purposes

According to the interviews, the reasons for the use of DTV for learning purposes are:

- accessibility
- interactive services
- independence of time and place
- low threshold for starting use
- learning on demand.

Accessibility is the most important reason for using DTV for learning, according to the interviews. In addition, television, as an easy-to-use device, makes it easy to start the use of interactive services. It was also desired that digital TV services will stay as easy-to-use as traditional television services have been. Digital TV seems also to have the image of a familiar and secure device. Television has been a sub-device in learning for years; the threshold for starting using it for T-learning is low.

DTV can also play a role in serving as a connector between homes and schools. Communication between parents and schools can be facilitated with the help of DTV. Other advantages of iTV in education are that most people are accustomed to using TV, TV is an easy-to-use device, and the quality of the content assures a richer experience for the user. Additionally, iTV applications enable the user to interact with the content being broadcast. These results are similar to Damasio et al.'s (2004B) results; they state that whether the interaction means the "see more" possibility or personalisation tools, the fact is that the potential exists for using iTV as a learning tool. iTV can benefit individuals and groups of learners and has potential in informal, as well as formal settings. They found that iTV has potential to provide motivating, engaging, and effective learning media for everyone, whether the learning takes place at school, at home, or elsewhere.

It was also argued that learning was independent of time and place. One interviewee stated that "DTV supports E-learning and allows learning when the Internet is not available". DTV was stated as having greater importance compared to analogue broadcasting, because of the two-way and feedback features. The medium was seen as having great potential. TV was seen as appropriate for learning at different ages. Publishing companies have a lot of content for which they have copyright, which means books and electronic content. DTV could be an opportunity to connect part of their content to DTV.

2.6 Games and edutainment

According to the interviews, ITV was considered suitable for interactive and collaborative learning games, even though educational games were lacking. So far, there have not been any digital TV learning games in Finland. However, the amount of players of DTV entertainment games has been large, even with simple games. The game world is seen as an easy environment to enter and when people are used to digital TV and games, learning games might be easy to adapt. What kinds of games could be used in digital TV? As a simple example of a game, a combination of video and assignments was suggested, e.g. a video presenting animals could be connected to an assignment. After a student has watched the video, she can deal with an assignment related to the video. A similar concept was tested by HUT in early 2004. After students had studied learning material via digital TV, they answered multiple-choice questions. The HUT students liked the concept and they mentioned that the assignments have the character of a quiz, which makes them interesting (Aarreniemi-Jokipelto et al., 2004C).

Young people are used to entertainment and games, and thus the use of edutainment via DTV got positive feedback from the interviewees. It was believed that the number of games will increase in the future. Learning games were seen as a good way to learn. An interviewee stated that "voice, colour, and action are needed in youngsters' learning". Furthermore, entertainment was seen as being characteristic of TV, for example in the form of quizzes.

2.7 Types of services

In the ArviD research (Aarreniemi-Jokipelto et al., 2004D), DTV was mentioned as being suitable for the following subjects:

- science, technology
- representing physical and chemical features that are difficult to represent even in laboratory conditions
- representing functions of a device
- languages
- describing the stages of work
- practical subjects
- everything that does not require a physical presence.

An interviewee stated that “learning needs to be available when the students request it”. The services need to be on-demand services. Analogue broadcasting does not support the idea that the student is the most important part of the learning process. She went on to say that “if it is decided to start a new English programme in March, it is impossible to know in advance if there is any citizen who will want to study in March”. Another interviewee said that “it is important to start using new media, so it can be seen what works in practice”. Generally, it was felt that not only access to the services, but also the skills to use the services, should be guaranteed to everyone.

An interviewee stated that “the trends in E-learning are currently informal and corporate learning”. He argued that DTV is suitable for formal learning, but not for informal learning.

Interaction was seen as very important for learning. An interviewee stated that “currently students are impatient and they request immediate feedback”. DTV interaction was felt to be independent of time and facilitating a community was seen as important. Another interviewee felt that two-way interaction via iTV is technically a utopian idea.

An interviewee stated that “DTV is natural for social intercourse”. DTV was also seen as meaning educational equality in a situation where learning is not regionally available otherwise. An interviewee stated that “DTV serves lifelong learning and could be used for personalised learning in adult education”. Starting learning via DTV was seen as easy.

2.8 Content production

So-called “talking heads” are not desirable for use in the content of DTV. Organising learning is much more than just delivering the content. The content should also include interaction and on-demand services or the possibility of saving the content.

Content production for digital TV requires different kinds of skills and it is unreasonable to expect a teacher to have the time and resources to perform this task alone. Hence, content production demands co-operation between different experts in order to bring about the best possible results. One interviewee said that “there are enough A/V people in Finland”, but another argued that “there is too little research relating to the use of ICT in learning”. Co-operation partners in the case of Finland could be:

- YLE – school
- YLE – publishing company – content producer – school
- regional TV broadcaster – content producer – school
- commercial TV broadcaster – educational company.

YLE is seen as having a key role in T-learning. It is expected that YLE will produce and broadcast content, as has been the case in analogue broadcasting.

According to the interviews, there is demand for a learning channel, but in practice it is not possible because of the high fixed costs and lack of earning potential. Broadcasting is not a problem; in addition to public broadcasters, both commercial and regional broadcasters are interested in broadcasting learning content, if there is demand and someone is willing to pay.

As mentioned in Chapter 1, a new interest group for learning is older persons and full-time employees aiming to better their career position or build a new career. The requirements of these new student groups also need to be noted when planning T-learning.

According to the research (Aarreniemi-Jokipelto et al., 2004D) it is very important that digital TV is also considered as a learning environment in teacher education. Whether digital TV is exploited as a learning environment in practice depends on teachers and their commitment

to the use of new learning environments. On the other hand, teachers also have a very important role in motivating students to accept learning via digital TV.

An interviewee stated that “viewers are requesting a richer experience”. In practice it means new ways to connect technology and content. The old stories do not work any longer, but reality TV-like stories are in demand, according to an interviewee. What this means in the context of T-learning did not get any answers.

DTV was seen as being connectable to other devices and multi-channel use was seen as an opportunity. DTV was also seen as needing a tight form and being suitable for non-linear stories and the division of content into small pieces.

The services requested need to be recognised in content production. An interviewee stated that “if attempts are made to connect the service to a programme afterwards, it does not work”. It needs to be noticed in the script at an early stage of content production.

2.9 Devices

According to the research (Aarreniemi-Jokipelto et al., 2004C), it looks as if so far the available hardware has not been the most suitable for learning purposes. The STBs currently available are basic units, but the STBs that are required should make interaction possible. Additional requirements for STBs are the possibility of storing data on a hard disk and a broadband internet connection. The possibility of storing data on a hard disk could make it possible to e.g. download videos from the YLE database by using a particular search word. YLE has existing content that could facilitate learning on demand with the help of a broadband connection.

STB-compatible keyboards were also required for learning. So far, messages via digital TV have to be written using an on-screen virtual keyboard because of the lack of commercially available wired or wireless keyboards for MHP set-top boxes. The virtual keyboard looks like the sort of keyboard used in mobile phones, but is displayed on the television screen and can be operated with the help of the remote control of an STB. The virtual keyboard could be used e.g. in multiple-choice questions, but not to write essays.

None of the interviewed schools had any kind of STBs. One school had applied for money for STBs, but had not got any. Another interviewee predicts that media servers will be popular in some of the important market areas in five years’ time.

The convergence of devices makes possible the convergence of learning. The convergence of learning means that different devices can be used to support the learning process, e.g. digital TV, mobile devices, or Internet-based environments. The most appropriate device is the one which makes learning flexible and independent of time and place. However, there will always be a need for traditional face-to-face lectures as well.

An interviewee stated that “a PC is an investment, but it is not necessary to buy it if the services are available via DTV”. Currently, the biggest problem relating to T-learning was seen as the lack of devices.

2.10 T-learning and models

An interviewee defined **learning** as goal-setting and intellectual searching. T-learning was seen as a pedagogic challenge. How to guide and support this process was a question that was asked. The questions of how to start and take care of the learning process and finish a T-learning course also arose.

In the interviews models for content production, learning via iTV, and earning were requested. Some of the interviewees said that models would help with the use of media, because someone else would already have thought of how things should be done.

2.11 Conclusions

Figure 5 illustrates the utility of T-learning, according to the research.

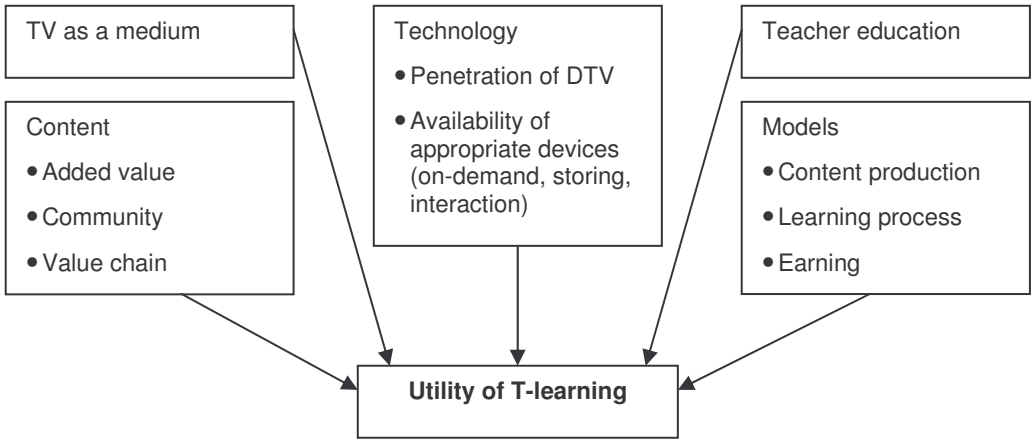


Figure 5: Utility of T-learning

The five main issues which affect the utility of T-learning are:

- TV as a medium
- technology
- content
- teacher education
- models.

TV as a medium has many advantages which affect the utility of T-learning. The main reason for the advantages seems to be the fact that almost everyone in Finland watches TV. They know how to use it. Even older people have the same experience. When people have used TV for years, it feels like an easy-to-use and familiar medium which can easily be used for new purposes. In this case the purpose of learning is not new, but there are simply new features in the content. Almost everyone knows that there has been school TV for years and some even have experience of studying via TV, so it feels even easier to start T-learning.

The penetration of DTV will affect the available services. If penetration is low, content producers will not produce content. An interviewee stated that “they are still waiting for an impulse from the market before they start producing content”. Another stated that “if there are opportunities to earn, there will be services”. The availability of appropriate devices affects the utility of T-learning, but also the penetration of DTV. If the devices cannot fulfil the requirements of users, they will not be willing to buy them. During the research there were no MHP STBs for cable broadcasting. Devices for on-demand services and storing content were also requested. Technology also makes possible multi-channel use, which was recognised by a few interviewees.

Content affects the utility of T-learning. Content needs to bring added value to students. What is added value to students can vary. It can be the chance to learn for one person or a visual experience with a high-quality video for another. Interaction is needed in community-building. Communities were seen as one of the key features of T-learning. Because content production needs different kinds of knowledge and experience, several participants are needed. It is important to recognise all the participants in the T-learning value chain. Furthermore, the value chain needs to be defined.

Teacher education affects the utility of T-learning. If teachers are not familiar with the potential and advantages of DTV, they will not use it in education. So far, T-learning has not

been recognised in teacher education. Teachers play a central role in the penetration of T-learning. If T-learning is not available, students have no chance to become familiar with it and gain experience in using it. It seems that teachers provide the opportunities and students choose from the available ones.

Several interviewees requested models and concepts for T-learning. Models for content production, the learning process, and earning were demanded. It was requested that the models should be field-tested, so that not everyone needs to make the same mistakes. It seems that the potential of DTV is not as widely known as was expected. According to an interviewee, negative articles in newspapers have affected not only willingness to use DTV, but also knowledge about DTV.

3 Learning via television

First, this chapter presents some definitions of learning, which are valid throughout the thesis. The definitions are used for example in Chapter 7. Second, it also presents shortly viewing habits impact in the evolution of T-learning. Third, the chapter presents an overview of learning from traditional television and describes examples. The described examples aim to be illustrative rather than comprehensive. Fourth, the existing T-learning experiments are presented. The purpose of the overviews is to illustrate the existing ways to use TV for learning and to describe the advantages and disadvantages of the use of TV. The chapter creates the theoretical televised learning framework for the T-learning artefact (see Figure 2).

3.1 Definitions

The object of teaching is learning. As its best, **learning** can be seen as a research process that produces new insight and knowledge (Hakkarianen et al., 2001). However, knowledge has to go through learners' own processing, which may result in learning (Koli et al., 2003). The thesis mainly uses the word 'learning' instead of 'education' to emphasize the students' active role in learning process.

Interactions are crucial in the development of human communication through distance learning (Ikehata et al., 2000, Sakai et al., 2002). A lack of 'student – teacher' interaction leaves the teacher unable to judge the students' progress and unable to adapt their teaching to the students' need (Hentea et al., 2003). For students, it results in confusion with the assignments and learning materials. In addition, ideally the interaction should be available at the perfect time. In **synchronous learning** participants do not need to be present in the same place, but real time is required. **Asynchronous learning** allows learners and teachers to participate to learning activities at a time which is most suitable for their own working needs (Falchikov, 2001).

Online community refers to the communication and social interaction which is seen in the Internet and iTV learning systems. The human need for affiliation is at least as important as the need for information the technology mediated communities provide (Eronen, 2005). The users need to feel the belonging and "feel that this is our thing" (Isomursu et al., 2004). The online community consists of (Preece, 2000):

- people who interact socially when they strive to satisfy their own needs
- a shared purpose, such as an interest, need, information exchange, or service that provides a reason for the community
- policies, in the form of tacit assumptions, rituals, protocols, rules, and laws that guide people's interactions
- computer systems, to support and mediate social interaction and facilitate a sense of togetherness.

The new technologies have solved the problem of physical location, but issues related to the evaluation of learning remain problematic (Chi, 2003). Methods of **assessing** a student's performance in distance learning courses vary. *Web-based education (WBE)* courses are commonly assessed by relying on email, reports, and homework in addition to secure online quizzes or chat room participation (Hentea et al., 2003). Planning the assessment should not only to take into account learning goals, but also the self-assessment and other needs of students.

Collaboration occurs, when more than just one person works on a single problem-solving task (Teasley et al., 1993, Marttunen et al., 2004). **Learning environments** are designed to assist collaborative knowledge building and interaction between learners. Learning environments may offer several opportunities for the learning process (Laukka, 2000). In the

context of web-based learning, the **learning process** is defined as learning that progresses in time and by degree.

3.2 Viewing habits impact in the evolution of T-learning

Table 3 illustrates the evolution of television viewing and characteristics of TV during the history of T-learning.

Table 3: The evolution of television viewing since 1930 (Carey, 2002, Looms, 2005)

Period	Characteristic for the viewing
1930-1945	• Viewers are sitting close to small screens • Screens are from 10" to 14" • One TV set per household • Few channels • Limited channel changing • Viewing in groups • A TV set costs as much as a car
1946-1955	• Screen is small • People invited family and friends to enjoy the medium • A TV set is a status symbol • A TV set costs more than a month's salary • TV watching in public places such as department stores and bars appears
1956-1975	• Screen size increases from 14" to 20" increasing the viewing distance • Viewing in groups • Colour TV emerges • The new sets are expensive
1975-1990	• Increase in the number of available channels • Remote control and VCR become widespread • VCRs are used for recording, but much of it is not watched • Families have more than one TV set • Group and individual viewing • Colour TV predominates
1991-2000	• Screen sizes increase • Multi-channel TV is widespread • VCRs are used for pre-recorded content • Game consoles and DVD players are connected to the TV sets • Families have TV sets in the kitchen and bedrooms • Broadcast media is immersive • Viewers multitask while watching • TV set re-emerges in public locations, such as offices, building lobbies, and airport waiting areas
2001-2005	• DTV • The personal video recorder (PVR) appears on the market

The viewing habits and characteristics of television have changed over the years. The changes affect services, also T-learning services. Television viewing has changed from group viewing in the early stage of television towards more individual viewing in 1970-1990. Since the 1990s, viewers have multitasked while watching and listening to television, when television has no longer had their undivided attention.

Sub-chapter 3.3 describes the examples of learning from traditional TV since 1962. In the period 1975-1990 VCR became widespread. It enabled recorded television lectures (see Sub-chapter 3.3.2. During the period 1991-2000, VCRs are used for pre-recorded content. The Pennsylvania State University has used pre-recorded television modules that are presented to the students by teaching assistants. During the period 2001-2005 DTV is characteristic for viewing. This means the appearance of the first T-learning experiments that are described in Sub-chapter 3.4. What is characteristic for viewing since 2006? We have possibility to use an interaction channel in T-learning. Chapter 6 illustrates what kind of T-learning services could be in use. No longer, viewers are not only viewing content passively, but instead they act in more active way. Via iTV they can form virtual communities in order to study together. No longer are the communities established in front of a TV set, but instead the members of the community can be spread out around the country.

3.3 Overview of learning from traditional television

The sub-chapter presents an overview of learning from traditional television. The described examples aim to be illustrative rather than comprehensive. The examples are chosen to illustrate different kinds of learning solutions from traditional television. “Looking to the past is often a good way to see to the future” (Schneiderman, 2002). The history of educational TV programmes is studied, to recognize the important issues concerning the future T-learning services.

Experimental teaching programmes were produced at the University of Iowa, Purdue University, and Kansas State College in the early 1930s and the first college credit courses were offered via broadcast television in the 1950s (Schlosser, 1996). The broadcast telecourse did not allow any live interaction between a teacher and a student. In the 1950s and 1960s, instructional television became common and is still in use (Neal et al., 2005). During the last 50 years, television has been a widely used educational medium.

The history includes various kinds of solutions to enable learning through television. There have been the following learning solutions:

- school / educational / instructional TV programmes
- recorded television lectures
- special equipped classrooms to connect distance and local students
- connection of distance and local students with TV screen
- edutainment
- iTV educational services.

T-learning services can be divided into two groups: traditional educational programmes and interactive learning services. The traditional educational services consist of:

- educational programmes
- recorded TV lectures
- connection of classrooms with especially equipped classrooms or a television screen.

3.3.1 Educational programmes

Educational programmes refer to the use of a broadcasted video form of educational material. There have been two types of recorded lectures. They were either delivered to the student by a postal service to be watched alone at home or the class has watched them with an assistant or by themselves. The remote and local classrooms were connected either with special equipped classrooms or with a television screen.

In Finland, the first school television programmes were broadcasted in 1963. According to the law, the *Finnish Broadcasting Company* (in Finnish *YLE*) has an obligation to provide educational programmes. During 2005 YLE has broadcasted about 400 hours of educational programmes on YLE Teema which is a DTV channel specializing in culture, education, and science. Currently the majority of programme services are implemented in a form of multimedia that includes TV, Internet services, and radio programmes.

In the USA, public television stations have provided support for local schools, usually in cooperation with state departments of education and other instructional television agents. The support has varied from station to station, but has included, for example (Spielvogel, 1987):

- broadcasts of programming designed specifically for classroom use
- instructional television, along with print schedules and lesson plans packaged into teacher guides for each series
- utilization workshops for teachers.

In Canada, the reason for the use of television at the University of Laval was that there was no time for personalized, individualized, and humanized instruction (Boulet, 1995). Boulet says that the use of television was relevant because learning how to manage a software project is not the same as it looks in the book. The television programmes teach issues that cannot be taught in books such as: attitude, discussion, and perception (Boulet, 1996, 1997). Students' feedback on the course has been very positive (Boulet, 1997).

The University of Laval have compared the television-based course to the partially via television-based course and to the traditional classroom course (Boulet et al., 1998, Boulet et al., 1998B, Boulet et al., 2002). However, it should be noted that the television-based course also included the use of a computer-based learning environment.

The data is gathered from 243 undergraduates in the three separate comparisons. Students were divided into three groups: *traditional classroom students (TCS)*, *partially television-based course students (PTS)*, and *fully television-based course students (FTC)* (Boulet et al., 1998A, 1998B, 2002). The results of the two first studies show that no decrease of learning is due to the change of the delivery mode towards full and partial use of television (Boulet et al., 1998, Boulet et al., 1998 B).

The significant findings of the third comparison include the following (Boulet et al., 2002).

- Regarding overall performance, the FTC outperformed the other groups in two units, and the FTC and the PTS outperformed the traditional classroom students in one out of 13 units.
- Regarding fundamentals, the FTC surpassed PTS and TCS in two out of 13 units.
- Regarding problem solving, the FTC students outperformed the other groups in one unit, and the FTC and PTS outperformed the TCS in one out of 13 units.
- Regarding social skills, there was an added value for the FTC in 8 units, and for PTS in 4 out of 13 units.

At the Oklahoma State University, television is used for part of a course. The Fortran I/O programming course has about 500 students per semester. The course was redesigned at

the beginning of the 1970s. After studying the new course, the students write better programs with less complaining, and the occurrence of low grades has been greatly reduce. The attitude towards the use of TV during the course had changed in a positive direction during the semester. Only 18,5 per cent of the students had a positive attitude towards instructional TV when they entered the course, while 63,5 per cent had a positive attitude towards instructional TV at the end of the course. 72,5 per cent passed the course with an 'A' or 'B' level (Bailey, 1972).

3.3.2 Recorded television lectures

The advantages of recorded lectures are: standardization of learning material and ability to handle large class sizes (Lemos, 1979). Recorded lectures have had two types of delivery mode:

- those delivered to students by postal service
- those watched at school.

During 1962-1963, it was required to teach the Fortran IV course eight times, due to the number of students at the State University of California. Because of this repetition it was decided to produce the course in a videotape form. An advantage of television teaching was the illusion of eye contact that could be established between the viewer and the teacher. The results of the study are based on the feedback from 340 students in two semesters, fall 1963 and spring 1964. The acceptance of television as a medium for the lectures was surprising positive. Especially well received was the use of a combination of the videotapes, supporting notes, student assistants, and reshowings. When compared the students of the videotape courses were compared with the earlier years' face-to-face students, learning proceeded as well with the videotaped course as it did when the course was taught in a classroom (Mara, 1964).

The Michigan State University had a two year project where eight instructional tapes were developed to transfer materials from a classroom lecture form to a videotape form. They suggest considering videotapes in learning if (Sawyer et al., 1986):

- There is a need to distribute a course over a wide geographical area.
- The content could be useful as a supplementary material for other courses.
- There is need for material for students regardless of availability of instructor.
- An instructor with appropriate expertise is not always available.
- The instructional techniques require the magic of television.

The Pennsylvania State University is using a form which includes short television modules that are presented to the students by teaching assistants. The professionally produced TV modules present concepts and techniques through a variety of visual ways. The series of the recorded television lectures play during less than half of the lecture time. The teaching assistants are responsible for answering questions in the viewing situations, guiding discussions and exercises, and administering quizzes (Robinson et al., 1989).

3.3.3 Connecting distance and local students with television

The connection of classrooms has been done with

- especially equipped classrooms
- a television screen.

The University of Derby has demonstrated the use of narrowcast interactive satellite TV with a five-studio Telepresence Teaching Centre for Interactive Distance Learning. It is transmitted in *Internet Protocol (IP)* via satellite to 22 classrooms located in five different university extension centres. In each classroom, every student has a telephone handset to

log in, to answer questions, and to converse with the teacher. The teacher is connected to the five classrooms and can put up a multiple choice question in PowerPoint or using a document camera for the students to read on the projection screen in each classroom. Students respond with the handsets and a pie-chart graphic of students is displayed on the teacher's screen. The teacher mouse-clicks a student's name and the student's telephone rings. Simultaneously, the return video switches to the classroom. The student picks up the handset and the teacher selects the "talking head" output to ask why she gave that particular answer (O´Hagan, 2001).

According to the ethnographic study (Zhao, 2002), connecting local and remote students with TV screen was not as successful as the face-to-face form. Instructors lost their connectedness with the remote side students and the technology restricted pedagogical choices. The monitors were fuzzy at the time and made it difficult to recognize students. Remote students did not learn as well as students in a regular class due to the limitations of technology mediated communication. Students had difficulties in seeing and hearing the local site and were not as engaged in the class activities. Local students had difficulty in speaking to the class; they hesitated to interrupt the instructor. Asking questions and making comments in the class became more formal because the lectures were recorded.

Interactive television classroom is also used in Iowa. A fibre optic system is used to connect the classrooms. Students' learning is compared between the traditional classrooms and the remote classrooms. According to the results, no differences in achievement exist between the two groups (Sorensen, 1996). Students reported to like best:

- interaction with students at the other sites
- new technology, new learning experience
- convenience, classes offered close to home
- increased access to learning opportunities.

The following are the highest-rated suggestions for improvement:

- improve microphones
- improve transportation of materials
- improve camera capabilities
- more opportunity for 1-on-1 student-teacher communication.

The University of Minnesota has established the *University-Industry Television (UNITE)* system to deliver regular courses to distant students. Special classrooms are equipped with television cameras, microphones, overhead document cameras and video playback capabilities. The completion rate of the remote-TV and the remote-live students was 79 per cent, whereas, for the campus student, it was 93 per cent. The average grade of the remote-TV students was A. The average grade for the traditional on-campus students was slightly better than B+ and for the remote-live students A-. It has been suggested the reasons for the better performance of remote-TV and remote-live students are these students' greater experience and maturity compared with the on-campus students (Lilja, 2001).

The engineering schools at Purdue University have televised and distributed lectures by broadcast and by videotape since 1958. A classroom has been equipped with television cameras and microphones. The lecture has been transmitted by local broadcast. The service has included an audio feedback to part of the remote students. The other part received lectures in a tape form. These two groups have been evaluated. The evaluation data is gathered from the 60 courses offered over eight academic semesters, fall 1973 through spring 1977. Over 1500 student responses have been processed. The following conclusions were made from the study (Anderson, 1978):

- Remote students learn from televised instruction and their technical skills are improved.
- Remote students who receive their instructions through recorded television lectures are generally less satisfied than the local students.
- Remote students who receive their instructions by television with an audio link back to the local classroom are slightly more satisfied with the experience than the remote students who receive their instructions by the videotape.

3.3.4 Use of television in developing countries

125 million people are still outside education system and nearly 1 billion are illiterate. However, ICT supports basic education in schools and provides formal education for outside education system children and adults in developing countries. Television is one of the used ICT media (Sanyal, 2001).

China has the largest educational TV in the world with the largest number of learners. The *Chinese Central Radio and TV University (CCRTVU)* provides a wide range of TV programmes through its provincial universities. It has over 80.000 hours of TV courses and educational programmes. It is planned that China's satellite TV education programme will cover 70 per cent of the country by the year 2000. China is planning to combine TV technology, education programmes, revision of basic curriculum of schools and the whole process of teaching through distance education (Sanyal, 2001).

In Mexico, Telesecundaria has transmitted live programmes through open public channels to television sets placed in distant classrooms since 1968. Television is used to carry out most of the education load. The Telesecundaria has permitted education to spread over populated rural areas with low enrolment rates. Telesecundaria is planned to enroll around 1.100.000 students by the year 2004 (Sanyal, 2001).

In Brazil the TV escola programme aims to improve the quality of teachers. By the end of 1999 it has provided primary schools with a kit consisting of a TV set, video recorder, and satellite dish. With the kit, the schools can watch and record programmes aimed at enriching the learning process and ensuring a continuous training of teachers (Sanyal, 2001).

In Egypt, the Centre of Technological Development and Decision-Making Support has produced 68 films. Nine thousand, four hundred and seventy-eight schools are equipped with receivers to receive the transmitted educational satellite channels in remote areas. The educational programmes use the Egyptian satellite and transmissions which started at the end of 1998. The programmes will cover primary education, preparatory education, secondary education, technical education, languages, and general knowledge (Sanyal, 2001).

3.4 T-Learning

In this Sub-chapter the existing T-learning experiments are presented. First, the existing formal T-learning scenarios and services are described. Second, the existing informal experiments and a model for a T-learning system are illustrated. Third, the advantages of DTV for T-learning are presented.

Television has been the most popular form of medium for distance learning over 50 years (Pahwa et al., 2005). Someone could ask, what about books? At least, it can be said that television has been an important medium in educational technology.

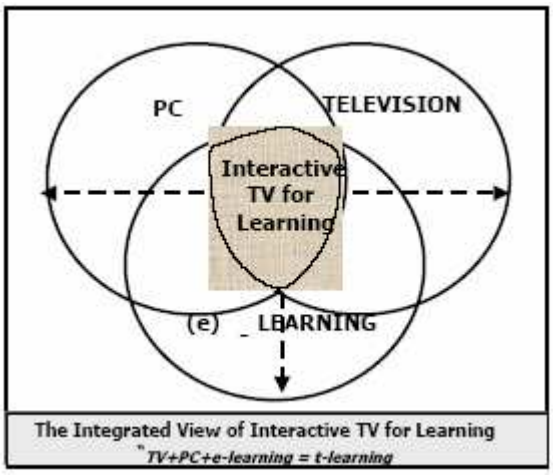


Figure 6: Convergence of PC, Television and E-learning

T-learning, in other words TV-based interactive learning, means having interactive access to video-rich learning materials, primarily within the home, through a television or a device more like a TV than a personal computer (Dosi et al., 2004). T-learning is also "considered as the convergence of two different technologies: Television and Computer technology (and more specifically the Internet)" as illustrated in Figure 6 (Lytras et al., 2002). In addition, T-learning is described as the convergence between *interactive TV (iTV)* and E-learning, the later understood as the use of computational technology to support training and educational activities (DiSessa, 2002, Damasio et al., 2004).

3.4.1 T-learning services

ITV learning services can be divided into the two groups:

- formal learning
- informal learning.

Formal learning refers to learning organised by a school and leading to a formal qualification.

Informal learning exists in everyday situations and does not lead to any formal qualification.

Focus group results indicate that language learners do not like iTV as a medium for formal learning, but rather use it as a form of entertainment in incidental learning (Fallahkhair et al., 2004). The learning material was authentic material, such as films and news. In contrast to the focus group results, the results of the field study of *Helsinki University of Technology (HUT)* prove that iTV can also facilitate formal learning and that adult students want to study via iTV. The learning material was produced and the learning process developed especially for the *Multimedia Home Platform (MHP)* based interactive learning environment.

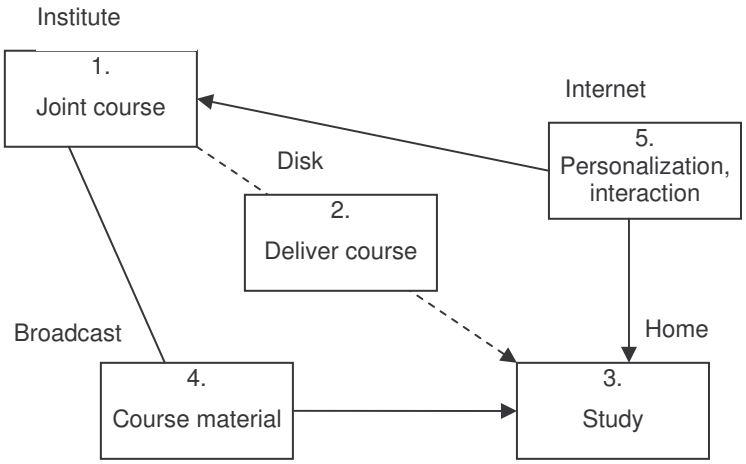


Figure 7: Student learning scenario (Hulsen et al., 2004)

Another example of formal learning is a student learning scenario which partly promotes learning via a broadcasting channel. A student learning scenario is illustrated in Figure 7 (Hulsen et al., 2004). According to the scenario, first students attend the course in a school. Second, the school delivers the course on a disc, such as DVD, to store the basic learning material. Third, the students study at home. Fourth, additional high-definition learning material is delivered via a broadcast network, *Digital Video Broadcasting (DVB)* or *Advanced Television Systems Committee (ATSC)*, and low-demanding material via the Internet. Fifth, the Internet is used for personalized content and interaction with the institute.

Third example of formal learning is a demonstration of interactive satellite remote education system. The purpose for the satellite-based distance learning is to provide a solution to reach the areas where terrestrial broadcast infrastructure does not exist. In order to enhance the video quality and reduce the channel, MPEG-4 was adopted for the demonstration of interactive satellite remote education system. The demonstration system can be used in satellite, terrestrial, and mobile multimedia broadcasting. Based on the demonstration, the researchers are convinced that the MPEG-4 solution is adequate for interactive satellite remote education (Lee et al., 2002).

3.4.2 Informal learning

McGivney (1999) states that informal learning is learning that takes place outside a dedicated learning environment and which arises from the activities and interests of individuals or groups, but which may not be recognised as learning. Smith (1999) states that “another path into the notion of informal learning is to view it simply as implicit learning”. He relates it to tacit knowledge that “which we know but cannot tell”.

An attempt for interactivity was made on the Winky-Dink and You programme (Damasio et al., 2004) using analogue broadcasting. It was a children’s programme broadcast on CBS (a national television network in the United States) from October 1953 until April 1957. The programme featured the illustrated adventures of a cartoon character called Winky-Dink and his dog Woofer. The interactivity was based on the Winky-Dink Kit which was sold from local stores or by mail. The kit included a clear piece of plastic to be placed over the television screen. Children at home were asked to help Winky-Dink out of problems by drawing whatever Winky needed; rope, bridge. They connected dots to create a bridge for Winky-Dink and traced letters at the bottom of the screen to read the secret messages in the broadcast (Jensen, 2004).

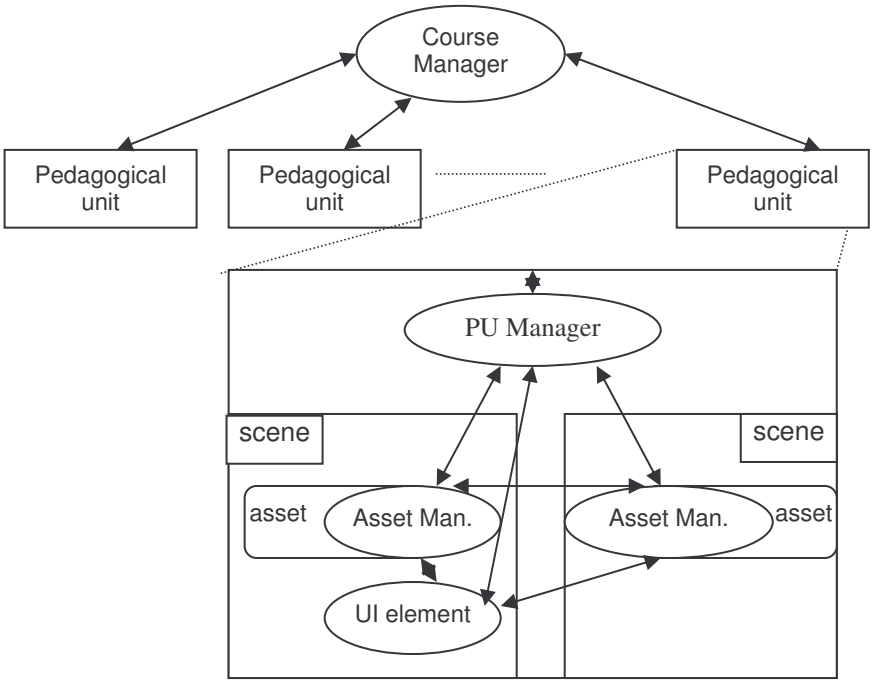


Figure 8: Structure of a course and the internals of a pedagogical unit

(López-Nores et al., 2005) have presented a model for a T-learning system illustrated in Figure 8. A course consists of multiple *pedagogical units (PU)*s. The course manager is responsible for launching the courses, handling runtime communications with the courses and making decisions about the sequencing of their PUs. The PU Manager looks after user inputs and controls the synchronized presentation of contents. An **asset** refers to an electronic presentation of learning resources, such as text, video, image. The Asset Manager is responsible for loading the necessary resources and controlling their presentation.

Characteristics for the model are indicated below.

- It is limited to the use of *Digital Video Broadcasting Java (DVB-J).*
- Assessment is based on self-assessment.
- There is no return channel.
- It is based on the idea that T-learning is limited totally to informal learning.
- It does not include tools for group work.

There has been an edutainment programme in Portugal. The “Barra Panda” is an edutainment programme and has offered, among other things, educational games (Damasio et al., 2004). The *Validation and development of an interactive Television based educational model (VEMiTV)* project developed an iTV application, Panda, for the experiment; it was based on the Microsoft TV platform and used the Metallic2026N STB. The experiment ran for four weeks in June 2003 and the application interface was totally based on animation. Students consisted of children aged from 9 to 10. According to the results, information flow and interaction with the tutor got more negative remarks from children, while graphics and interaction with characters were the most appreciated areas. Children’s satisfaction rates were high (97,25 points in a scale of 100), which indicates a clear ability of the technology to work, at least, as an informal and complementary learning medium (Damasio et al., 2004 B).

3.4.3 Reasons for using iTV for learning

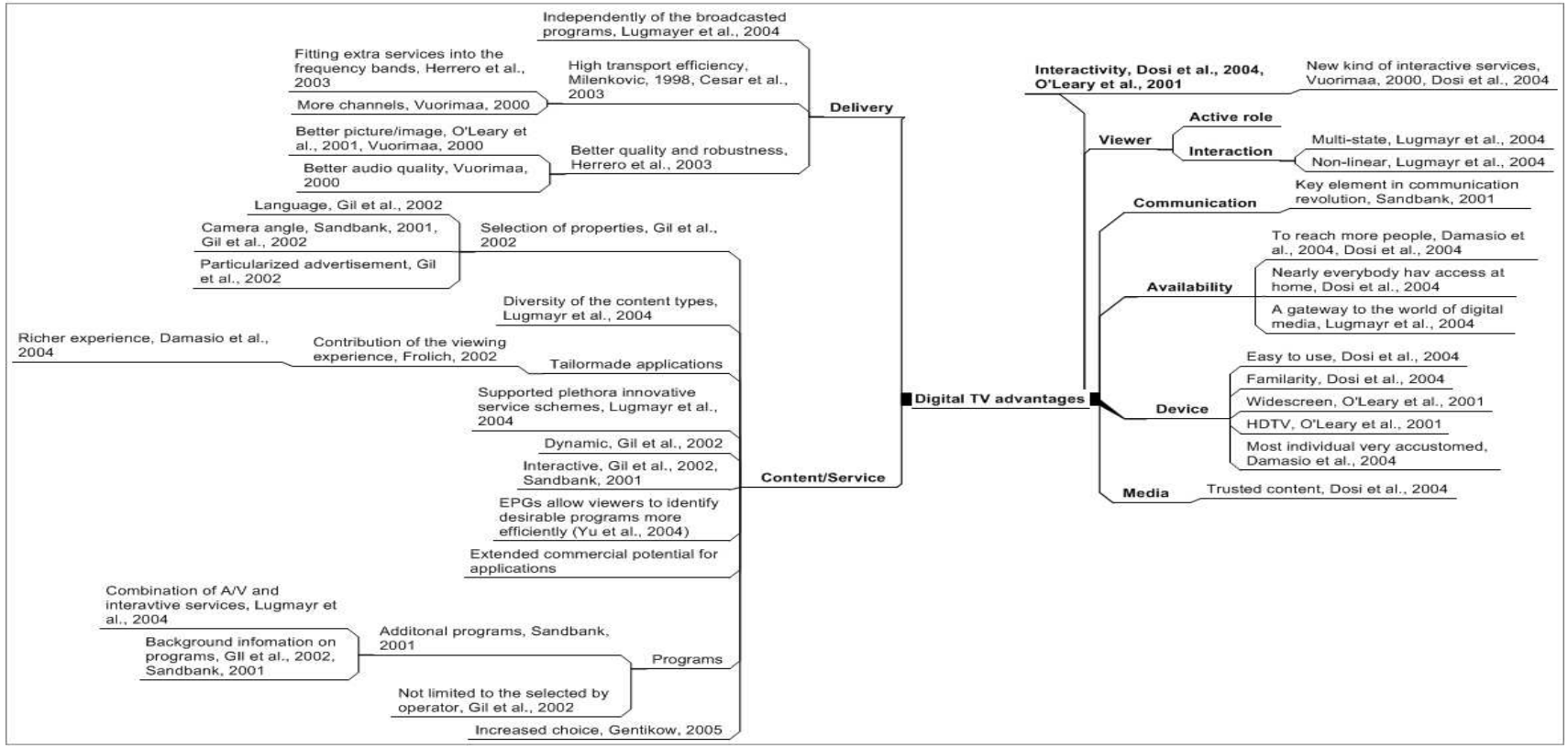


Figure 9: Advantages of DTV

Figure 9 illustrates the advantages of DTV according to the literature. Television is one of the most important communication media to reach people around the world, including people from different cultures, languages, and ages (Fortes et al., 2005).

The advantages of DTV are illustrated in the previous figure. What are the most important advantages of DTV in T-learning context?

Reasons to use DTV for learning purposes are (Aarreniemi-Jokipelto, 2005 B):

- Wide penetration of DTV
- Interactive services
- Independency on time and place
- Low threshold to start using
- Learning on-demand

According to the research (see Chapter 2), accessibility is the most important reason to use DTV for learning purposes (Aarreniemi-Jokipelto, 2005 B). DTV can be considered easy-access medium because the coverage area of DTV is 99,9 percent of continental Finland in the end of 2005. Increased access means opportunity to study aside with work and other duties. ITV is considered a key to reach the widest audiences (López-Nores et al., 2004, Eguia et al., 2005). It may offer online learning services to people who cannot afford to buy a computer, do not have an Internet access, or lack the knowledge to use computer. The average penetration of personal computers is not expected to go beyond 70 % in the short to medium term (pjb Associates, 1999).

Television has been a sub-device in learning for years; the threshold to start using it for T-learning is low. DTV can also have a role to serve as a connector between homes and schools. With help of DTV communication between parents and schools can be enabled (Aarreniemi-Jokipelto, 2005 B).

Other advantages of iTV in education include that most people are accustomed to TV use, TV is an easy-to-use device, and the quality of the content assures a richer experience for the user (Damasio et al., 2004B, Dosi et al., 2004). Also, iTV applications enable the user to interact with the content being broadcasted. Whether the interaction means “see more” possibility or personalization tools, the fact is that potential exists for usage of iTV as a learning tool (Damasio et al., 2004B). iTV can benefit individuals and group of learners and has potential for informal as well as formal settings (Luckin, 2002). She says that iTV has potential for motivating, engaging, and effective learning media for everyone, whether learning exists at school, at home, or elsewhere.

3.5 Conclusions

In Finland, the educational programmes have mostly been TV programmes with no interaction possibility. In the year 2001, no educational programmes were available via iTV. In the early stage of the research, it was seen that iTV has potential to serve learning. The main advantages of TV were availability, interaction, and community. In the year 2003, Bates (Bates, 2003) made same kind of conclusions relating to the potential of T-learning.

From the years 1998 to 2002, an EU project had analyzed the issues concerning digital TV-based interactive learning in the home. Parts of the key conclusions of the T-learning study are (Bates, 2003):

- “The study has identified that there is a big potential for utilising the various interactive digital TV solutions for increasing learning opportunities in the home, particularly as an alternative solution to utilising an Internet-enabled computer”.

- “Despite there being more than 25 years of experience using educational broadcasting there is still limited pedagogical research for early pioneering developments to draw upon to help understand how best learners may learn through this medium. There is also limited research addressing interactivity and learning to draw upon from other e-learning developments”.
- “Creating a demand for interactive digital TV learning service has to be based around the development of a sustainable model particularly when the service utilises consumer-based devices”.

3.5.1 Television as a medium

According to the literature review, television as a medium was generally liked by students and their attitude towards television had become more positive while studying via TV. Educational TV programmes and recorded lectures had not decreased outcomes of learning and students’ achievement. In some cases, distance-learning students had even better marks than local students. The results were not as good when classrooms were connected only with the help of TV screen, but in some cases the connection of classrooms has worked well.

In the year 2001, no mention of other forms of interactive learning performed via TV, aside from connecting classes with special equipped classrooms, was found in the literature. Equipping classrooms with television cameras and microphones was not seen in this thesis research as a suitable solution for future T-learning services because the aim of the study was to find a solution to allow students to study at home at the time suitable for them.

The entertainment role is connected to the T-learning services generally (López-Nores et al., 2005 A, B). However, television as a medium has been widely used for formal learning and studied by many researchers. According to interviews (see Chapter 2) in the thesis research, edutainment and formal learning are believed to be appropriate for DTV because of the collaborative character of TV, even though edutainment types of services do not exist in Finland. According the same research, the number of players of entertainment games (other than educational games), has been high even with simple games. When people are used to other games, learning games are easy to adopt.

3.5.2 Presentation of the new concept

A student learning scenario is illustrated in Figure 7 (Hulsen et al., 2004). The scenario uses television only for broadcasting course material. The scenario is limited from the T-learning point of view, because it does not consider the other requirements of T-learning.

López-Nores et al., 2005 present a model for a T-learning system, illustrated in Figure 8. The model has many restrictions, as described in Section 3.4.2.

The most important new concepts for the new T-learning model are the use of an interaction channel and the advantages this channel provides. T-learning is performed via **interactive** digital television. In learning this means e.g.:

- communication between students and between a student and a teacher
- guidance of learning process
- group and graded assignments
- graded assessment
- in addition to informal learning, also formal learning
- community.

Models of how to facilitate and support learning via iTV are lacking. The thesis aims to show how to facilitate and support learning via iTV (see Chapters 7 and 8).

Figure 10 illustrates T-learning as a convergence of IP, television, and mobile technologies.

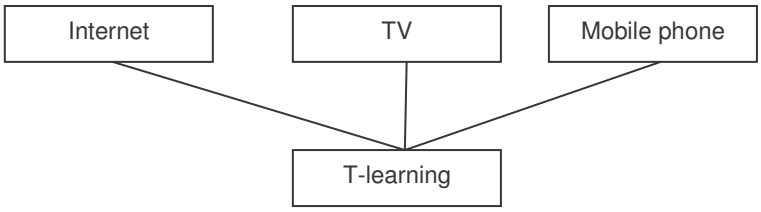


Figure 10: T-learning as convergence of IP, television, and mobile technologies

It is impossible to find one and only one suitable technology and device for every learning situation. In addition, new devices may be accepted by the viewers, and these should also be recognized in T-learning. The convergence of devices allows the convergence of learning. The **convergence of learning** means that different devices, such as iTV, mobile devices, or the Internet are used to support learning process. The most appropriate device is the one which best suits the students and the studied subject, and supports the learning process.

According to the literature review (Chapter 3), iTV can be combined with different technologies, such as IP and mobile technologies. Therefore, it was necessary to create a new definition for T-learning for this thesis. The definition is:

T-learning is seen as a convergence of cross media. Television or device suitable for viewing broadcasted contents is seen as the primary medium and the others, such as mobile phones and PCs are secondary media (Aarreniemi-Jokipelto, 2005A).

Cross-media refers to the use of more than one medium. In addition to iTV technologies, in this thesis T-learning includes technologies like mobile technology and *Internet Protocol (IP)* (RFC 791, 1981). The definition means that Internet television is not considered as T-learning because the primary medium is a PC and the content is not broadcasted.

A student is seen as having an active role in her learning process in this study. It differs from Rey-López et al.'s (2006) viewpoint. They state that in T-learning a student is usually more passive than in E-learning. However, according to the empirical studies of this research, combinations of technical and pedagogic issues enable a student to be active in learning via iTV. Learning is not just delivering content, but it requires active work towards the defined goals from a student.

4 Prerequisites for practical implementation of T-learning

The relevance of this chapter is to gain understanding of prerequisites for practical implementation of T-learning. The themes are limited to those important for the performed research. The themes are:

- transmission of material via television
- interaction in T-learning via digital television
- usability
- security, integrity, and authentication
- digital television value chain/net
- digital television standards.

During the research, it has been recognized that at least these themes need to be considered in the implementation of T-learning.

"Technology has made possible the revolution in distance education and new learning solutions that have important implications for the accreditation of educational institutions and assurance of quality in such circumstances" (Varis, 2005). New technologies and devices in iTV support users' information needs, social activities, and entertainment-related activities (Eronen, 2005), all of which also have a role in T-learning. The general trend is the rapid emergence of new technologies and devices. However, technology maturation takes time. Technology maturation might take from 15 to 20 years to be popularized and disseminated to the technical community in large (Redwine et al., 1985).

4.1 Transmission of material via television

The material needed to be transmitted may vary from videos to audio, text, and animations. In this chapter different transmission possibilities are presented.

4.1.1 Transmission in analogue television

Traditionally the broadcasted content on analogue networks has been videos which have had the *Phase Alternation by Line (PAL)* form. In the learning context, examples of this are traditional educational programmes, which do not include any interaction via television.

4.1.2 Transmission in digital television

Digital television (DTV) refers to the transmission of signals in a digital form. Digital TV is "about more than clearer pictures and better sound; it's about the eventual convergence of television, telephony, the Internet and the PC into a single box, with a promise of extraordinary access to all kinds of information and interactive communication unimaginable" (Parker, 1999).

Broadcasters have used digital technology for storage of material for years. Digital transmission was the only way to fit extra services into the frequency bands already saturated with analogue TV services. Broadcasting using digital transport streams allows operators to mix traditional *audio/video (A/V)* contents with binary data. Thus, it is possible to deliver multimedia software applications in a DTV or a *set-top-box (STB)*. The applications might be synchronized with traditional contents, implement interaction with users, and provide return channels for communication with content providers. The key difference between digital and analogue television is the new level of interactivity the digital broadcasting allows. In T-learning, the learning material and assignments are delivered to the students via the broadcasting channel, but the interaction channel can be used in responding to assignments, communication, or on-demand services.

The MPEG-2 standard is the basic technology for realizing digitalization in broadcast services. Figure 11 illustrates the basic block diagram of a DTV system.

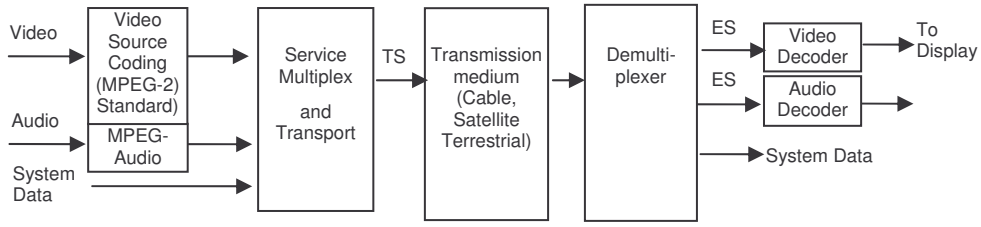


Figure 11: Basic block diagram of a DTV system

The video source coding encodes the video into the MPEG-2 videos and the audio source coding encodes the audio into MPEG-1 audio. The service multiplexes and transport bundles the video and audio elementary streams into a single *transport stream (TS)* enabling the multi-streaming feature for DTV. It divides the ESs data into data packets, identifies each packet type uniquely and multiplexes packets into the TS. In addition, the time stamps and data required to enable the synchronized play back of the ESs are included in the TS. Both the *Digital Video Broadcasting (DVB)* and *Advanced Television Systems Committee (ATSC)* employ the MPEG-2 TS syntax (ISO/IEC 13818-1, 2000, ISO/IEC 13818-2, 2000) for the packetization and multiplexing of video, audio, and data streams. TS is transported over the transmission medium, cable, satellite, or terrestrial, to the receivers.

The decoder of the receiver-end de-multiplexes the TS into the ESs, decodes and plays back the corresponding ESs. The synchronization between the audio and video streams is gained with assigning the timestamps to the video and audio access units. The timestamps include the information about when a video and an audio access unit should be decoded and presented (Azimi et al., 2001).

What new features does DTV bring to the learning material and assignments? Text TV has been a popular service in Europe (Vuorimaa et al., 2000). No information was found regarding the use of analogue text TV for learning purposes. The newest version of the text TV standard (ETS 300 706, 1997) allows the use of hyperlinks activated by the colour keys of the remote control. Analogue text TV content has consisted of text and simple character graphics. In DTV, the teletext service may contain more advanced graphics, still images, sound, and animation. In practice, the only limitations of the amount of content are the available bandwidth of the broadcast channel and the memory of the STB.

4.2 Interaction in T-learning via digital television

Interactivity means that the viewer is allowed to actively influence the behaviour of broadcasted television, services and applications. It can be accomplished by means of a remote control by sending data via an interactive channel or by fetching information via teletext. This creates a context that provides new possibilities for learning when compared with traditional educational programmes on analogue television. Viewers have had a form of interactive broadcast services for years with the teletext service. **Interactive television** refers to the particular form of television in which the viewer can produce user input. Interaction is the most important requirement of T-learning.

4.2.1 Standardisation issues for interactivity

To enable interactive services in DTV, co-operative efforts in standardization, development of techniques, implementation of service platforms, and construction of service models for interactive services have been required (Kim et al., 2000).

The *International Telecommunication Union Telecommunication Standardization Sector (ITU-T)* produces recommendations, which define how telecommunication networks operate and interwork. An important example of ITU recommendations in the DTV field is *Basic principles for a Worldwide Common Family of Systems for the Provision of Interactive TV Services (ITU-T Rec. J.110, 1997).*

The **broadcast channel** refers to a unidirectional, broadband, point-to-multipoint channel which may include video, audio and data. The broadcast channel is established between a broadcast services provider and users. In addition, it may include a forward interaction path.

The **interaction channel** refers to a bidirectional channel from a user to an interactive service provider for interaction purposes. In addition, the interaction channel could carry a user selected broadcast services. In general, the interaction channel consists of a return interaction path (return channel) and a forward interaction path. The **return interaction path** is defined as a multiple point-to-point communication channel from the user to the interactive service provider. The **forward interaction path** refers to an individual communications channel from the interactive service provider to a user. It may also be embedded into a broadcast channel.

4.2.2 Reference model for the interaction channel

The next figure illustrates the functional reference model for interactive services.

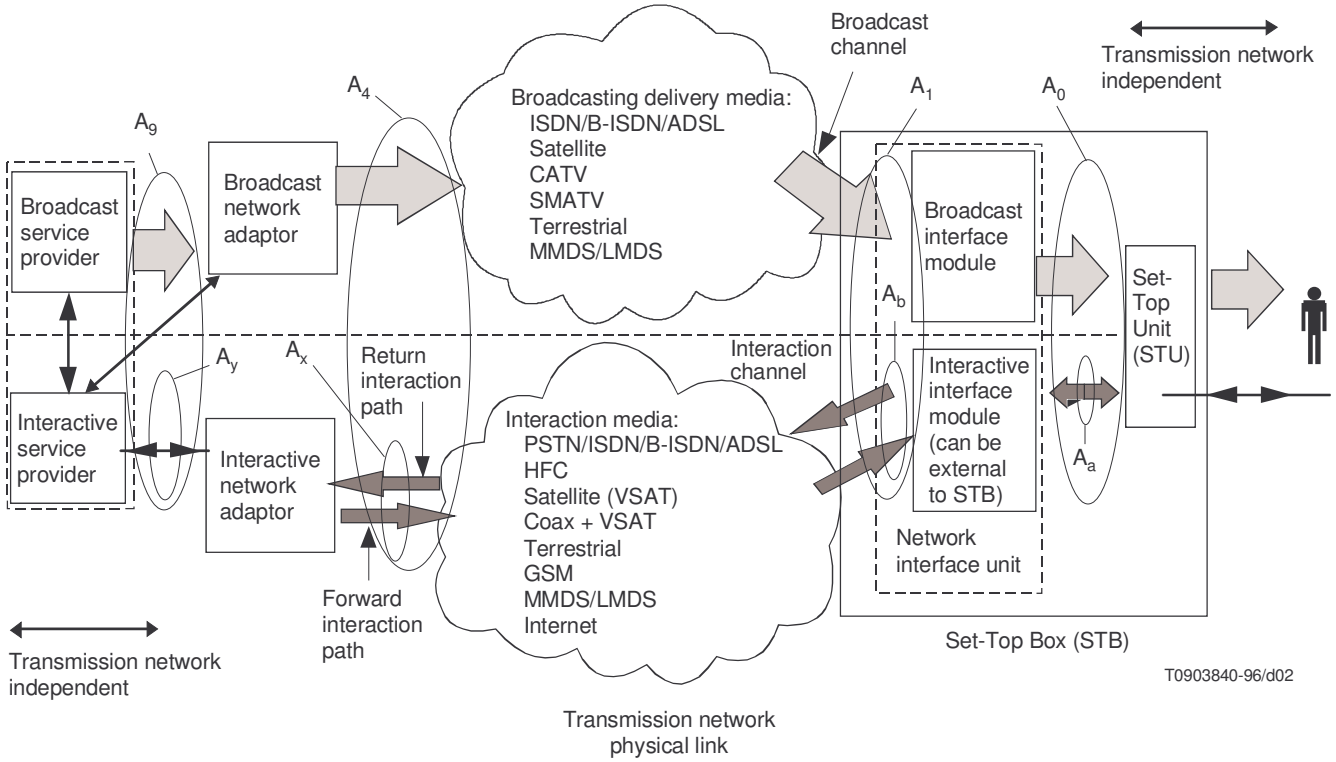


Figure 12: Functional reference model for interactive television services (ITU-T J.110, 1997)

There are several interfaces within the interactive system. Interfaces are related to specific areas where it is proposed that standards should be developed. The recommendation suggests a very discipline separation between a network dependent and network-independent interface (Sandbank, 2001).

The network-independent interfaces are:

Aa Set-top unit to interactive interface module
A0: Set-top unit to network interface unit
Ay: Interactive network adapter to service provider's system
A9: Interactive and broadcast network adaptors to interactive service and broadcast service provider's systems

The network-dependent interfaces are:

Ab: Interactive interface module to interaction media
A1: Network interface unit to broadcast and interaction media
Ax: Interaction media to interactive network adaptor
A4: Interaction media and broadcast media to interactive network and broadcast network adaptors

Interactivity can be:

- local interaction
- simple interaction
- full interaction.

Local interactivity does not include a return path and **simple** interactivity is using a unidirectional interaction channel. The **fullest** form of interactivity is using a bidirectional interaction channel to and from the source of the device. Local interactivity was inspired by the analogue television teletext system, however including STBs additional features because of the enhanced graphical and processing capabilities (O'Leary et al., 2001).

The basic requirement of the interaction channel is to enable the user to respond in some way to the interactive service, for example to participate in an educational service.

A higher level of interactivity might require that the user who has responded to an interactive service, to receive an acknowledgement when they have made a credit card purchase via the basic interaction channel. It is typical that the credit card purchase process involves an acknowledgement phase. The interactivity requires a two-way interaction channel, one in the reverse direction, the other to the forward direction.

A further level of interactivity exists when the consumer requests further information on particular topics from the source of the service, or from a central database via the source of the interactive service. This could require that the forward channel be broadband.

4.2.3 Interaction models

The future interaction TV project has defined interaction models based on the consumers' involvement degree and the available hardware (Lugmayr et al., 2002):

- weak interactivity
- hybrid interactivity
- collaborative interactivity
- strong interactivity.

Weak interactivity is based on a simple remote control. The **hybrid interactivity** can be integrated by PDAs, web-cameras, and speech interfaces. **Collaborative interactivity** enables community creation and is emphasized in social aspects. **Strong interactivity** is based on the use of several communication channels, either between devices or between consumers. From the learning point of view, collaborative interactivity is one of the goals in the field studies presented later in this thesis.

4.3 Usability

The International Organization for Standardization refers to **usability** as the effectiveness, efficiency and satisfaction with which specified users can achieve specified goals in particular environment (ISO DIS 9241-11, 1998). **Effectiveness** means that the user is able to carry out the intended task, **efficiency** refers to the implied time, and **satisfaction** defines how acceptable the system is to the users (Faulkner, 2000). In learning, bad usability affects the learning process and time is wasted with the system, instead of learning. Furthermore, people refuse to use a rigid, slow, and unpleasant system interface (Costabile et al., 2005) and interrupt the course.

T-learning has also requirement of usability. However, no consolidated evaluation methodology for E-learning systems exists yet (Costabile et al., 2005), neither for T-learning. The evaluation should include both the pedagogic effectiveness and usability of the system. Usability evaluation techniques are the following:

- testing
- inspection
- inquiry.

An example is **heuristic evaluation** which refers to an informal method of usability where evaluators are trying to find out good and bad issues concerning the interface by looking at it (Nielsen et al., 1990). It is a widely accepted evaluation method. A short list of heuristics serves as a checklist in heuristic evaluation. They are for example the following:

- use simple and natural dialogue
- speak the user's language
- minimize user memory load
- be consistent
- provide feedback
- provide clearly marked exits
- provide shortcuts
- provide good error messages
- prevent errors.

Advantages of the heuristic evaluation are (Mankoff et al., 2003, Nielsen et al., 1990):

- widely used
- inexpensive
- quick
- intuitive and easy to motivate people to do it
- does not require advance planning
- can be used early in the development process.

Problematic in heuristic evaluation is the use of a small number of principles in different kinds of systems. Sometimes the method identifies problems without providing direct suggestions on how to solve the problems. Despite the progress in 'human-computer'

interaction, restrictions are causing decreasing effectiveness and efficiency of a system (Granic et al., 2002).

Expert evaluation method and observation in simulation environment was used as a usability evaluation technique in the Instant Messaging field study (see Sub-chapter 6.4). Expert evaluation in an IPTV environment was used in the Sign langue field study (see Sub-chapter 6.3).

4.3.1 Usability guidelines for iTV

There exist few usability guidelines for iTV, but none especially for the use of iTV for learning purposes. The existing guidelines on the design of digital television services are the following:

- Style guide for the design of interactive television services for elderly viewers (Carmichael, 1999)
- Interactive television style guide (BBC, 2002)
- A guide for digital TV service producers (Rinnetmäki et al., 2004)
- Guidelines for the design of accessible information and communication technology systems, television (RNIB, 2005)
- Guidelines for designing easy-to-use interactive television services (Ahonen et al., 2006)

The news recommendations are derived from the user requirements analyses, results of the heuristic user evaluation of present iTV news applications, and usability tests of the developed iTV news. The guidelines include the following (Brecht et al., 2005).

- Text is the most important form of presentation information, because:
  - speed of the perception is regulated by the user
  - reading a text is faster than watching a video.
- Still images should be used as a supplementary to the text.
- Video and audio sequences should be presented as supplementary to the text
- The duration of video and audio sequences should be visualized in the form of a progress bar.
- The applications should be broadcast as a permanent “24/7” service.
- Full screen mode is suitable for presentation.

BBC has produced general guidelines for navigation in iTV. A navigational interface should have for example the following objects (BBC, 2002).

- Tell the viewer where they are, how they got there, where they can go next.
- Provide feedback after an executed command.
- Teach the viewer to use the service in seconds.
- Present predictable and consistent navigational devices.
- Encourage freedom of movement rather than limited predetermined paths.
- Provide quick escape in the form of an exit route.

There is a loose logic which covers the use of colour key navigation. The logic changes in different applications, but the following organization should be consistent (BBC, 2002).

- The red key provides a relevant link to whatever content is on screen. It can also be used for contextual shortcuts, to launch an enhanced service or toggle full screen.
- The green key can provide customization or access to communication tools. It can be very flexible in different applications.

- The yellow key is the most flexible key. It fills in for controls that are difficult to access.
- The blue key provides access to fixed textual information or to sections of a service. It may also return the viewer to the home page or provide a main menu.

4.4 Security, integrity and authentication

This sub-chapter describes security, integrity, and authentication. The themes of the sub-chapter are important because they affect students' desire to study in a learning environment. In the Chapter 7 is shown how they are used in T-learning context.

There are four main groups involved in E-learning security (Weippl, 2004):

- content authors
- teachers
- managers/department chairs
- students.

Content authors' essential requirements regarding security are listed below.

- Students must be able to rely on the correctness of the content.
- Students want to read unobserved.
- Protection against unauthorized use.
- Protection against unauthorized modification and reuse.
- Protection against destruction and loss of data.

Teachers should attach great importance to security, because students' confidence in the availability, non-repudiation, and security of the E-learning environment is the precondition for the use of the environment. It is important that only the course participants have access to the communication forums; students have a choice to use pseudonyms in the conversations with other students, and preventing cheating attempts.

It is the managers' responsibility to ensure that everybody involved in teaching is notified of the benefit of security, so that security issues can be developed and implemented in an organization. Students are mainly concerned about privacy and availability, but privacy expectations may vary depending on the culture.

Protection management mechanisms (PMM) refers to the methods, possibilities, and techniques to warrant intellectual rights on services and aims to increase data security by preventing unauthorized access and misuse of data through the digital value chain. PMM consists of *Conditional access (CA)*, *Digital right management (DRM)*, and security.

4.4.1 Conditional Access

"The primary purpose of a CA system for broadcasting is to determine which individual receivers/set-top decoders shall be able to deliver particular programme services, or individual programmes, to the viewers" (EBU Project Group, 1995). The two most common CA solutions are smartcard technology and renting of the equipment containing specific decryption hardware from the broadcast service provider. An advantage of smart cards is that extremely long cryptographic keys can be stored in secret zones of the smart card and they are replaceable at anytime.

In the Pay-TV system, the CA is used to prevent unauthorized access to A/V streams, allowing access to services based on payment. Customers need to buy a smart-card and insert it into DTV equipment. It contains a key for decrypting the A/V stream encrypted with a *public key infrastructure (PKI)* mechanism. The most important parts of the CA are

scrambling algorithm and key distribution (Jiang et al., 2004). The security of the CA depends merely on them.

In CA, some of the programme information in scrambled and the authorized subscriber can descramble the programme with cooperation of a smartcard and a STB. **Scrambling** is a method that uses cryptographic algorithm with secret encrypting keys to encrypt source programme and only the viewer withholding the decryption key can descramble the received scrambled programme and reconstruct the original TS. Because many of the DTV broadcasting in unidirectional, such as satellite or cable (Kogan et al., 2003), there is no authentication between the head-end and the subscriber on line, thus the service providers utilizes authentication between a STB and a smart card to protect their benefits. Key exchange is vital to enable secure communication.

4.4.2 Digital Rights Management System

Digital rights management system (DRMS) refers to techniques and mechanisms for protecting content to warrant intellectual property rights. The main purpose of software/hardware architectures facilitating DRM is to provide digital data content in a way which is convenient for consumers, and also safe and secure from content providers' point of view.

4.4.3 Security

Security has several definitions. In the context of health care information systems, it includes: data availability, data integrity, and data privacy (Niiranen et al., 2002). The basic security requirements in the context of E-learning are (Weippl, 2005):

- secrecy
- non-repudiation
- data availability
- data integrity.

Secrecy means that users can have access only to the objects for which they have received authorization. **Non-repudiation** means that users are unable to deny having carried out operations. Whenever students' grades are changed in the database, it must be possible to reliably trace who has made the changes.

Data availability includes identification of viewers and access right control. Reliable identification of viewers is required for providing access to data and services to securely authenticated users. It may base on simple login and password solutions or to be extended by smartcard readers or even biometric solutions. Users' productivity decreases dramatically if applications are not available or the system is too low. If a web-based learning environment is slow, users need more time to do their work, but they also become frustrated, which increases the negative effect on productivity (Weippl, 2005).

Data integrity ensures that the data has not been modified (Elbaz et al., 2005) and it consists of completeness, trustworthiness, and validity of information (Lugmayr et al., 2004). Data integrity is important for example in the assessment of learning. *Mutually authenticated key exchange protocol (MAKEP)* provides data integrity during the session by a secret key that is known only by the participants of a session (Shim, 2003). However, the protocol has been shown to be vulnerable, and improvements to overcome attacks have been suggested (Jan et al., 2004).

Authentication includes the identification and authorization of the students. Confidentiality guarantees the privacy of data (Elbaz et al., 2005) and data privacy is needed if systems are to be put into networked environment (Lugmayr et al., 2004).

Because technologies to collect and analyze personal information have been developed, privacy is becoming more valued in society (Song et al., 2001, Lee 2000). Mostly, the information gathering is done without the users' awareness (Lee et al., 2000). Keeping viewers' viewing preferences secret has become another important issue (Lee, 2000). A CA mechanism for Pay-TV to protect the customer privacy from abuse by both the outsiders and the service providers has been introduced (Song et al., 2003). Confidentiality guarantees the privacy of data (Elbaz et al., 2005). Both the broadcast and the return channel need to provide encryption facilities to warrant privacy. The *Digital Video Broadcasting (DVB)* supports *HyperText Transfer Protocol Secure (HTTPS)* as a protocol for secure communication between entities.

4.4.4 Electronic authentication

Electronic time-stamping technology is significant for electronic authentication system by proving that certain data existed during a specific time period, and that data was not changed after that time period. Furthermore, the audit log can be used to record the processing history of information systems (Morigaki et al., 2004).

4.5 Digital television value chain / net

Customers tend to make judgements at the level of the value-creating system as a whole, rather than at the level of the companies making it up, thus the perspective of strategic analysis needs to be broadened from individual companies to *value creating systems (VCS)*s (Parolini, 1999). The purpose of the value net is to describe VCSs. In value net perspective the VCSs are viewed as a set of activities instead of companies. The activities are presented from the final customers' point of view.

Few researches describe the participants of an iTV value chain. The DTV value chain includes the following participants (Pelkonen et al., 2002):

- content enablers
- enablers of added value services
- digital media
- broadcasting developers
- return channel operator
- end users
- technology providers
- financiers
- experts
- constructers of cooperative environment.

In the Argillander's value chain model (Argillander, 2003), the viewer is seen as a central part of the value net and the TV channel is seen in the middle of the net. The participants of the value net are divided into two groups: the ones, whose main operation area is television and those, who has television as one of the communication and service mediums.

Rissanen's value model (Rissanen et al., 2004) is presenting a value net model, which is based on the Pelkonen et al.'s and Argillander's model. It is a simplified model to describe the value net of different kinds of DTV services. The model includes functions in two dimensions. The vertical axel illustrates the value creation and the horizontal axel changes in time.

The described value chains/net were not perfect for T-learning. However, the idea that the VCSs are viewed as a set of activities is used later in Sub-chapter 9.1 to create a value net for T-learning.

4.6 Digital Television standards

DTV standards have emerged primarily from three organizations, *Digital Video Broadcasting Group (DVB)* in Europe, *Advanced Television Systems Committee (ATSC)* in North America, and the *Association of Radio Industries and Business (ARIB)* in Japan.

Table 4: Digital TV standards

Standard	System type	Modulation	Video coding	Audio coding	Adopted countries
DVB	DVB-S	COFDM	MPEG-2	MPEG-2/1 d AC-3 [1]	All European countries, New Zealand, Australia, Russia, etc.
	DVB-T				
	DVB-C				
ATSC	ATSC-T		MPEG-2	AC-3	North America, South Korea Taiwan, Mexico, Argentina etc.
	ATSC-C				
ISDB	ISDB-S		MPEG-2	MPEG-2, AAC	Japan
	ISDB-T				
	ISDB-C				

All three most common standards are based on the MPEG-2 video coding standard. There are strong similarities between the DVB and the ARIB standard (Sandbank, 2001).

The three standards differ in the approach to the API. Compared with DVB, ARIB has profiles to define more precisely the way the information is presented to the viewers. In DVB, profiles are associated with mandatory evolution to use Java for managing and controlling of the application.

4.6.1 Digital Video Broadcasting

As specifications are developed, they are submitted by DVB for publication to the *European Telecommunications Standards Institute (ETSI)*, which is the official body responsible for approval and publication of European telecommunications standards. Because the DVB standards are adopted by many countries outside Europe, they are also submitted to the *International Telecommunications Union (ITU)* where they have published essentially in the form of the parent ETSI standard.

DVB systems allow delivery of A/V content and multiple interactive services. The downloadable applications may be developed with any of the proprietary operating systems, such as OpenTV, Mediahighway, or MHP (Herrero et al. 2003).

Digital Video Broadcasting-Satellite (DVB-S) and *Digital Video Broadcasting-Cable (DVB-C)* transmissions have been used worldwide for nearly a decade. *Digital Video Broadcasting-*

[1] DVB compatibility, June 1999, TR 101 154

Terrestrial (DVB-T) offers to the viewer “plug and play” simplicity, while satellite and cable systems may require a new dish aerial or cable connection.

The extension of the DVB architecture consists of:

- a DVB broadcast service provider (BSP)
- a DVB interactive service provider (ISP)
- service providers (SPs)
- service editors (SEs)
- a broadcast channel
- a feedback channel
- the consumer multimedia home network (CMHN).

The BSP is used for the delivery of broadband MPEG-2 TSs over cable, terrestrial or satellite physical broadcast media to the TV-viewer. A BSP is responsible for the deployment of broadcast services over terrestrial, cable, or satellite channels.

For the value-added applications implementing the DVB interactive services, a feedback/return channel is available for two-way information change. The feedback/return channel is provided by the ISP through different wired and wireless networks. Typically, *Internet Protocol (IP)* based protocols are used in the feedback/return channel.

In the DVB architecture, the SPs are creating the content and working as partners in the feedback network. The SEs create the overall services and implement the applications delivered by the broadcasters. On the viewer side, the CMHN interconnects multimedia equipment in a home setting. The TV content multiplexed by BSPs into a high-bit-rate MPEG-2 TS is accessed by a viewer with a *Multimedia Home Platform (MHP)* compliant STB which is a standard part of the CMHN.

4.6.2 Multimedia Home Platform

The aim of the *Multimedia Home Platform (MHP)* is a change from a service provider that is dependent on its own proprietary hardware devices and applications, to a common defined hardware and software environment in which all applications from many different providers can be received in (Fötschl et al., 2002). MHP is an open standard and independent of operating system and hardware. Thus, an interaction and broadcast channels can be implemented with various technologies.

The core of the MHP specification is based around a platform called *Digital Video Broadcasting-Java (DVB-J)* including the *Java Virtual Machine (JVM)* as specified by Sun Microsystems.

The world’s first working DVB-MHP compliant transmission network was in Finland. Three multiplexes started to operate on August 27th, 2001, delivering 18 digital television channels and four radio channels. Finnish multiplex operator and digital television channels decided to run a programme guide and digital teletext services collectively to ensure similar basic functions that are easy to learn for the viewers (Digita, 2002, Herrero et al., 2003).

The MHP standard supports three profiles of services and applications:

- Enhanced Broadcast
- Interactive Broadcast
- Internet Access.

Enhanced Broadcast combines digital broadcast of audio and video with transmitted applications. The profile does not support the use of an interaction channel. However, it allows local interactivity with the input from a remote control. **Interactive Broadcast**

combines digital broadcast of audio and video with transmitted applications. It requires an interaction channel to allow interaction with the broadcaster or the application provider. The receivers are capable of providing for learning services, video on demand, and communication. **Internet Access** is intended for the provisioning of Internet services. In addition, it includes links between Internet services and broadcast services.

4.6.3 DVB-HTML standard

DVB has chosen *Extensible HyperText Markup Language (XHTML)* Modularization Standard (XHTML, 2004) to build its own language *Digital Video Broadcasting – HyperText Markup Language (DVB-HTML)*. Compared with the XHTML Modularization Standard, DVB-HTML includes some reductions and extensions because of the differences between a television and a computer, such as computing power, screen resolution, observation distance (Gil et al., 2002B). In addition, new information formats are introduced; MPEG-2-I-frame and video drip.

The DVB standard separates the content and decoration in a DVB-HTML document. The *World Wide Web Consortium Cascadian Style Sheet, level 2 (W3C CSS2)* standards (CSS2, 1998) have been adopted for DVB-HTML documents. CSS2 is a style sheet language that allows users to attach style (fonts, spacing) to structured documents.

4.6.4 Internet Protocol Television standard

Because of the convergence between IP based communication and broadcasting area, the IP-based broadcasting area will be an important key service in the near future (Son, 2003, Cho et al., 2004). *Internet Protocol Television (IPTV)* standard transmits A/V contents through IP network using streaming technologies. “IPTV is basically video on the Internet” (Jain, 2005). The main difference is that the content can be shown with the desired device: TV, PC, and mobile phones.

IPTV services differ from terrestrial, cable and satellite services. Traditionally, in broadcasting, STB receives all the channels, but IPTV cannot transfer all the channels simultaneously (Cho et al., 2004).

IPTV includes the convergence of communication, computing, and content. The convergence concerning communication and computing is well known, but not the convergence of content (Jain, 2005). In the future, it will not be acceptable that a video is not indexed and content-based accessed. According to Jain, the content will be “stored and accessed at different levels of granularities based on its semantics”.

4.6.5 Mobile terminals

Portability enabled by handheld devices can attract consumers and advertisers by enabling people to carry along such things as product information, electronic coupons, and store directions, to be on hand when needed (Ma et al., 2004).

A handheld iTV could be useful for following reasons:

- saving time, having time, making good use of time available
- accomplishing routine tasks more easily and effectively
- feeling in control
- feeling close to family and friends
- being accessible whenever and wherever time is available.

The following applications and features are identified as being most promising to be enabled on a handheld IDTV device (Ma et al., 2004):

- EPG/IPG with television control
- A/V recording, control, and management
- thematically-related supplementary information
- games, and other social comparison applications
- contextually-integrated T-Commerce.

The communication link between the DTV and the handheld device can be wireless, such as infrared or RF, e.g., 802.11, Bluetooth. The return channel may be implemented through a wireless service, a cable STB (reserved channel for upload), and/or via an Internet GW.

DVB-H stands for *Digital Video Broadcasting for Handhelds* (Henriksson, 2003). It is basically an extension to the older DVB-T standard. DVH-H allows hand held devices such as mobile phones and *personal digital assistants (PDA)*s to receive DVB programmes on the move. Because handheld devices are battery-loaded, the minimization of power consumption is a key requirement.

Mobility in DVB-T/H differs from mobility in cellular systems because of the unidirectional nature of the DVB-T/H networks and differences in the physical medium. In cellular delivery systems, seamless mobility may achieved by so-called **soft handover**. It means that a receiver which is synchronized to a single frequency and is using one or more IP services, switches to another signal seamlessly without any service breaks.

Time slicing is one of the main enhancements in the DVB-H standard. It is an extension of the DVB Data Broadcasting Profile, *Multiprotocol Encapsulation (MPE)* (EN 301 192, 2004) enabling a receiver to switch power off when no data are being received. **Time slicing** means here that IP datagrams are transmitted as data bursts in small time slots. This reduces power consumption by 90 per cent or more. The achieved power saving depends on the relation of the on-time to the off-time. If there are approximately ten or more bursted services in a DVB-H stream, the power saving could be 90 per cent. In time slicing, the data are sent in bursts with a higher bit rate compared with that of data transmission where the data is transmitted using a constant bandwidth. Time slicing brings advantages when considering handover in a unidirectional DVB-T/H network. When no data is being received, the receiver may measure signals in the adjacent cells and perform soft handover.

4.7 Summary

In T-learning transmission is needed. The learning content need to be delivered to the students via the broadcasting channel. Interaction is the most important requirement of T-learning. The interaction channel can be used in responding to assignments, communication, or on-demand services. Collaborative interactivity is one of the goals in the field studies, because collaboration is seen important for learning. Usability is crucial in learning. These issues as well as security, integrity, and authentication need to be considered in content production process to ensure that students are willing to use the learning environment. During the early stage of the research, it was realised that value net and DTV standards are also important in T-learning. This chapter creates the theoretical DTV framework for the T-learning artefact (see Figure 2).

5 Motive learning environment

The relevance of this chapter is to describe the design and implementation of the MHP-based Motive learning environment. It also serves as a description of the implementation of the T-learning artefact. The chapter describes the construction of the learning environment, the content production of the learning material that was used in the Motive field studies, the development of the content production tools, and the developed communication application (Aarreniemi-Jokipelto, 2004 A, Aarreniemi-Jokipelto et al., 2004 C, Aarreniemi-Jokipelto et al., 2005 C, 2005F). The constructive approach described in Section 1.4.1 has been used as a research method during the process. The solution takes advantage of the T-learning model (see Sub-chapter 7.2) and T-learning system model (see Sub-chapter 7.3). The author has been responsible for the creation of the solution, but the applications are programmed by researchers of *Industrial IT (INIT)* laboratory, if not stated otherwise.

5.1 Chosen standard

The MHP standard was chosen to be used in the T-learning research conducted in the *Industrial IT (INIT)* laboratory in the year 2001. It was not stated as a mandatory standard in Europe, but there were organizations, such as the *European Broadcasting Union (EBU)* who struggled to make it mandatory in EU countries. The EBU comments for the European Parliament's second reading of Proposed EU regulatory framework for electronic communication recommends: "with regard to migration to the MHP standard, efforts should be encouraged to migrate as soon as possible all digital television delivery for interactive and enhanced services to the MHP family" (EBU, 2001).

Erkki Liikanen, European Commissioner for Enterprise and Information Society in the year 2002 stated to all DVB members all over the world: "I urge you all to support MHP implementation in all possible ways across the world. Global take up of MHP can contribute to achieving critical mass and making MHP the natural choice for broadcasters and platform operators everywhere" (DVB-Schene, 2002).

No evidence of the use of the new teletext services for presenting text-based learning materials and assignments in DTV was found in the year 2001, when the author started this work. Up to that time, teletext services had been popular and the new teletext services in DTV even had new features. DVB-HTML was chosen to be used in the research. Thus, from this point to the end of this thesis, the author deliberately concentrates mainly on the use of MHP and DVB-HTML.

The IPTV standard is used in the end of this thesis alongside with the MHP and will also be used in future work. The penetration of MHP has suffered from the lack of STBs. Because the future of MHP was uncertain in the year 2005, IPTV was chosen to be used as another option for the T-learning artefact.

5.2 Motive learning environment

Motive was a project funded by the European Social Fund and administrated by the Industrial IT Laboratory of the Helsinki University of Technology. The author started her work in Motive in the autumn of 2001; the final field study was performed at the beginning of 2004. As iTV in general has developed significantly during this time, the differences will be highlighted in this chapter.

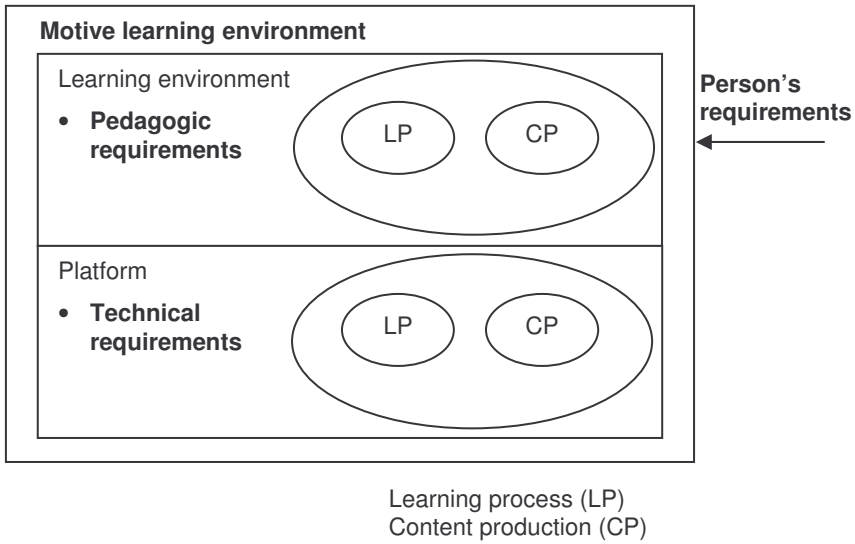


Figure 13: Connections between Motive learning environment and the T-learning model of iTV learning system

The Motive learning environment consists of two parts: learning environment and platform. There are three types of requirements for the Motive learning environment: technical, pedagogic, and personal. The technical requirements are for the platform and the pedagogic for the learning environment. The personal requirements affect the whole Motive learning environment. Figure 13 illustrates the connections of the T-learning model of an iTV learning system and the practical implementations in Motive. The iTV learning system in the T-learning model includes two subsystems: learning process and content production. In the Motive learning environment, both the learning environment and the platform include the same subsystems. The learning environment is affected by pedagogic requirements, which are the same as in the T-learning model. The platform is affected by technical requirements, which are the same as in the T-learning system. The learning environment looks at the system from the pedagogic point of view and the platform from the technical point of view. The whole Motive learning environment is affected by personal requirements, which are the same as in the T-learning model.

5.3 Applications and application lifecycle

The application lifecycles in the Motive learning system include two separate software development processes and maintenance of the applications, as illustrated in Figure 14.

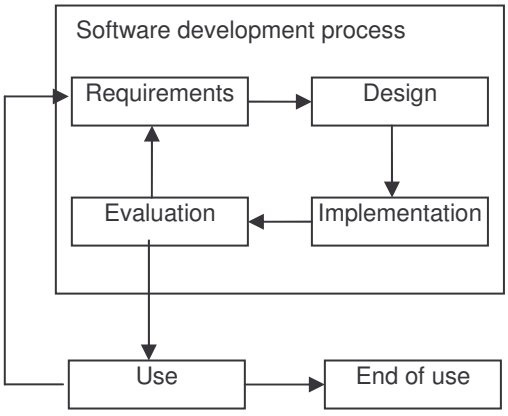


Figure 14: Software development process

The commercially available application alternatives for the DTV learning environment were evaluated. There were a few available commercial solutions for presenting content from companies such as Ortikon Interactive Ltd, Icareus Ltd, Sublime Software Ltd, and Sofia Digital Ltd. The ORTIKON ACE® Browser (Ortikon, 2005) was chosen as the base for the learning environment. The DVB-HTML Browser could be used for learning purposes with extensions, but it was recognized that the following parts and applications needed to be developed:

- database for learning material
- content production tool
- communication system.

No evidence of prior use of DVB-HTML for learning was found in the literature review. In the Motive research, interaction between students and between a student and a teacher was found to be possible with the use of the DTV, mobile phones, and the Internet, but needed programming because off-the-shelf solutions were not found. Because the STBs, scheduled to be launched the next year (2003), were not expected to include any control device other than a remote control, the use of mobile phones and the Internet was necessary. The virtual keyboard was expected to be the only device for writing messages in iTV. No solutions to the problems of storing and transferring learning material to different platforms were available. In addition, the learning material was required to be used in several courses; the possibility to reuse the material was required.

Figure 15 illustrates the devices used to study in the Motive learning environment. The devices are: a television, a MHP STB, and an STB remote control.

Figure 15: Devices used in the Motive learning environment

The developed software systems were:

- a multi-channel communication system
- a database for learning material, including a transfer to convert the content for different media; also usable as a content production tool.

The development process of the Motive learning environment started with the definition of the requirements. These requirements are based on those defined in the T-learning model of iTV learning system. The initial requirements are specified in Table 5.

Table 5: Requirements of Motive learning environment

Technical requirements	
Transmission Role of iTV technology Service availability	• iTV –the only technology in general • Multitechnologies in communication • Push service 24/7
Interaction / Communication	• One-way interaction • Two-way interaction • Interaction between several students and a teacher • Student-learning environment
Security	• Data integrity • Authentication
Accessibility	• Suitable, reliable technology • Content production tools • Open standards • Applications
Devices	• Control • Write • Make choices • Respond • Participation
Usability	• Learnability • Relevant information presented • Supportive images • Videos to support • Smoothly working devices • Clearly marked exits • Support learning • Valuable • Usable
Personal requirements	
Accessibility	• Technical accessibility: STBs
Motivation, expectations	• Target group used to WBE, • Working adult needing flexible choices
Pedagogic requirements	
Role of T-learning	• Substitute
Content in iTV	• Yes
Interaction in iTV	• Yes
Assessment in iTV	• Yes
Construction of knowledge in iTV	• Yes
Learning process in iTV	• Yes
Personalized learning	• No
Connected to a TV programme	• No

The Motive learning environment includes the two subsystems defined in the T-learning model.

- content production system
    - content production tools
    - learning material database
- learning process system
    - learning material
    - assignments
    - course structure
    - communication.

Next, the subsystems are described in more detail.

5.3.1 Content production system

When the production of the learning material began in Motive, good solutions to the problem of producing learning material were lacking from our list of requirements. The DVB-HTML standard existed for the presentation format, but the application was lacking, especially for the production and storing of learning material. Commercially available tools such as Macromedia Dreamweaver MX were tested, but text editors were found unsuitable because flexible usage of different media was not practical.

The content production system partially implements the *Learning Object Metadata (LOM)* – standard (IEEE, 2002). It was implemented to support the idea of the flexible use of learning materials in different media and courses.

A Motive software tool was developed to enable a Word document-based learning material to be converted to the DVB-HTML form. The raw material needs to be in the form of Microsoft Word XP or Microsoft Word 2000. The tool includes a DB for the storage of the learning material. The learning objects are stored with the help of the Motive Client seen in Figure 16.

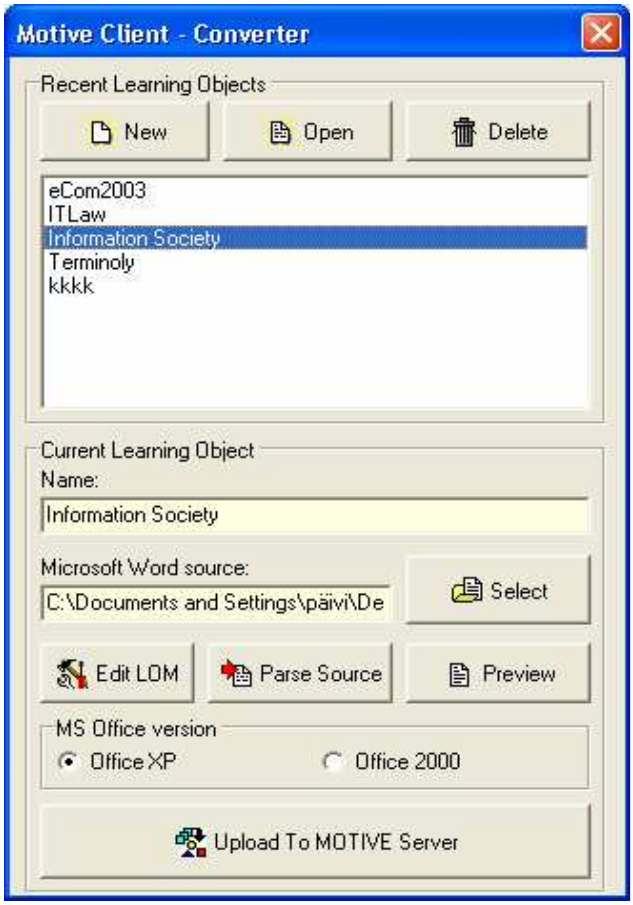


Figure 16: Motive client to store the learning material

The tool allows the use of images and different title levels. The images are attached to the document by marking their desired location in the text with a ##PIC exp.jpg## -tag; the

images must be stored in the same folder with the learning object file for full compatibility with the database.

From the Motive server, it is possible to select the desired learning object or to look at the LOM description of the learning objects. The Motive server includes a transfer tool also. With this, it is also possible to transfer *MS Word* / PC-based learning material to a number of other platforms, such as DTV, Internet, and mobile phones. The system knows the number of lines available in the end user platform. Features necessary to accommodate new devices can easily be added to the tool.

5.3.2 Information sub-system in the learning process system

The learning process system was divided into two parts: information system and communication system.

The main functions in the Motive information system were the presentation of learning material and assignments, and responding to assignments. Because the role of T-learning was a substitute of face-to-face lectures, all the content had to be presented via iTV. In addition, assessment was planned for performance via iTV.

In the presentation of learning material and assignments, the DVB-HTML Browser was used. Figure 17 illustrates an example of learning material.

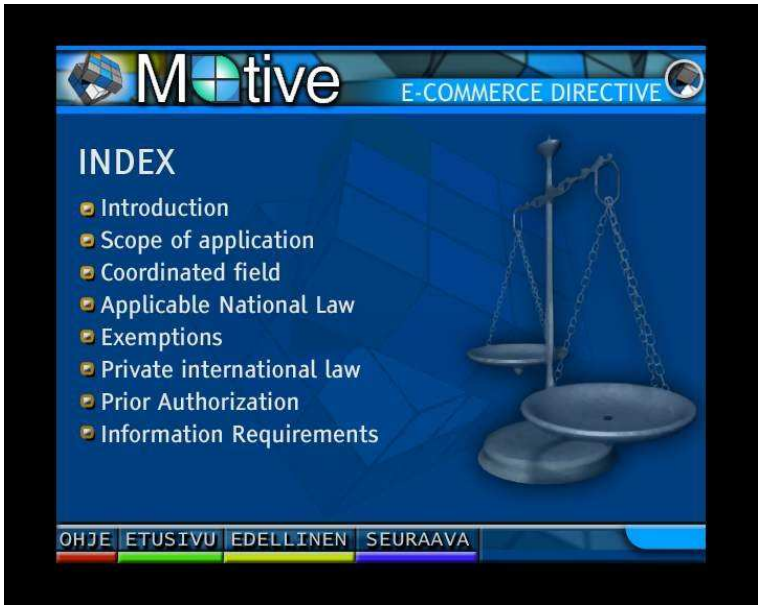
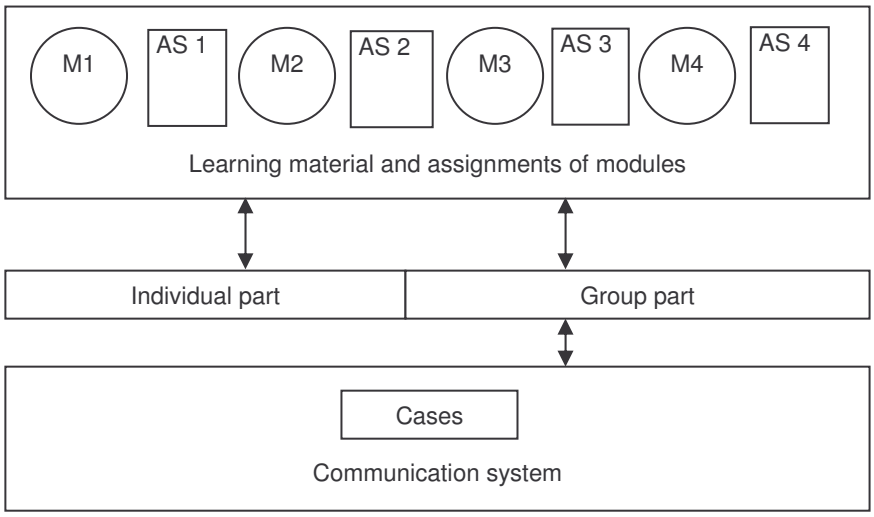


Figure 17: An example of the learning material

It was not planned to evaluate students by an exam at the end of course, but, instead, to assess the participant during the course. A number of the individual assignments was also to be used for the assessment. For this purpose, an assignment server was needed to store the students' responses for grading. The Motive learning environment utilizes a *My Structured Query Language (MySQL)* (MySQL, 2005) database to store the students' answers, because it is free and non-profit-making. For simplicity and structural clarity, separate database tables are used for both of the graded assignments. A *Hypertext Preprocessor (PHP)* (PHP, 2005) is used for accessing the MySQL database.

Figure 18 illustrates the course structure. Students had the freedom to study the modules at their own pace and order in the individual part of the course. The assignments in modules 1 and 2 were based on self-assessment, but assignments 3 and 4 were graded and used for

assessment. In the group part, the students worked in small groups, solving cases by following the inquiry learning theory.



M refers to a module and AS to an assignment

Figure 18: Structure of course

The course included two types of multiple-choice questions: self assessment and graded as illustrated in Figure 19.

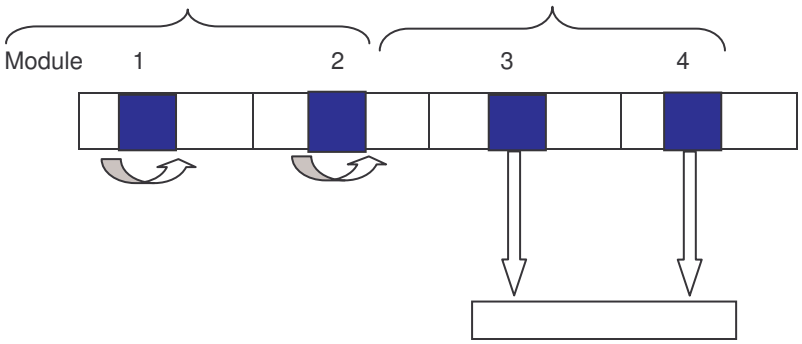


Figure 19: Types of assignments in the modules

The self-assessment assignments were constructed with text and hyperlinks. In graded assignments, the destination server, where students' answers are sent, is defined in the DVB-HTML code.

Figure 20 illustrates self-assessment assignments.

Figure 20: An example of self-assessment assignments

Graded assignments are constructed with an element that enables interactive forms for students' answers. Figure 21 illustrates graded assignments.

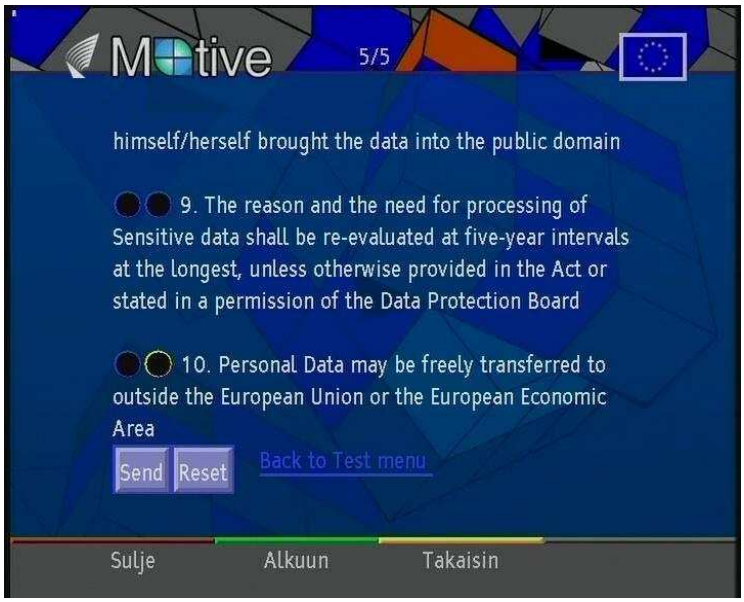


Figure 21: Graded assignment

The non-linear course structure was used in the learning material and assignments to allow flexible navigation for students; it was constructed for the DVB-HTML based environment, even though the literature review brought up no prior implementations in iTV. Moving to/from/between entities and sub-entities was possible using hypertext links. Pages are navigated using the colour button on the STB remote control or the links on the pages. The final structure of the course is presented in Figure 22.

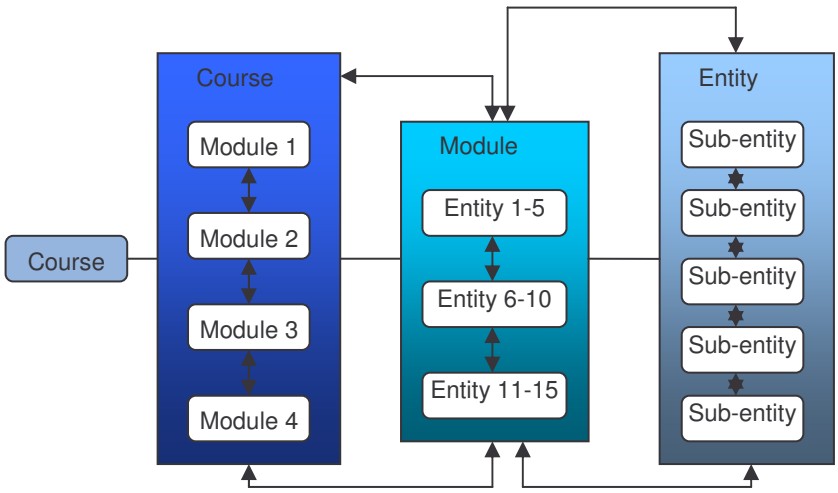


Figure 22: Non-linear structure of the course

5.3.3 Communication system

In the requirement phase, it was decided that the course should include one-way interaction, two-way interaction, interaction with several participants, and 'student-learning environment' interaction. In addition, it was planned to use multiple technologies in communication. For the interaction performed between students and between a student and a teacher, the *Multichannel communication system (MCCS)* was developed.

Figure 23 illustrates the use of MCCS. It provides functionalities through the use of many platforms: computers, DTV, mobile phones, and communicators.

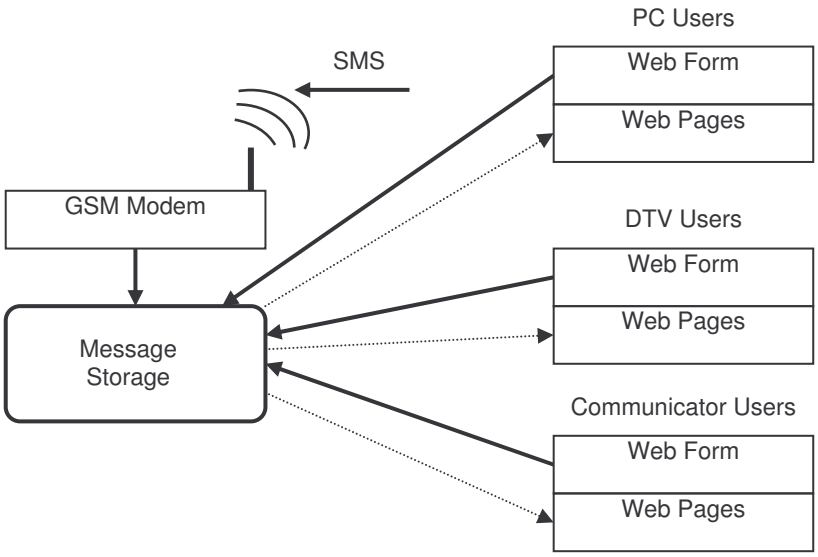


Figure 23: Structure of the MCCS

The communication server generates three types of JSP pages, each optimized for browsing a particular platform. The DVB-HTML browser was also used in viewing messages in DTV. In DTV, 5 messages are seen on a television screen. On a PC screen, 50 messages can be displayed, and on the screen of the Nokia Communicator, 3 messages. Writing new messages and sending them to the server is accomplished using

the Web forms. All the messages are received by the server and are saved in the specific Message Storage.

Figure 24 illustrates the structure of the communication rooms. Every course has a communications room, but the room may include sub-rooms for small group work, as shown in Figure 24.

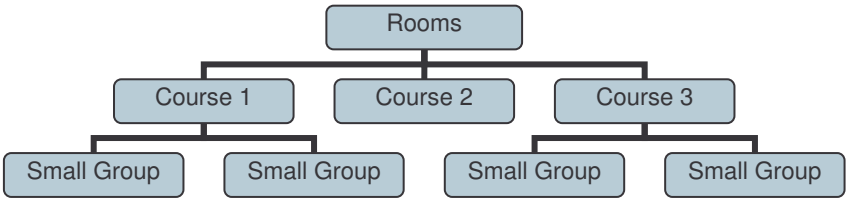


Figure 24: Structure of the communication rooms

In DTV, the messages are written using a virtual keyboard, such as that shown in Figure 25.

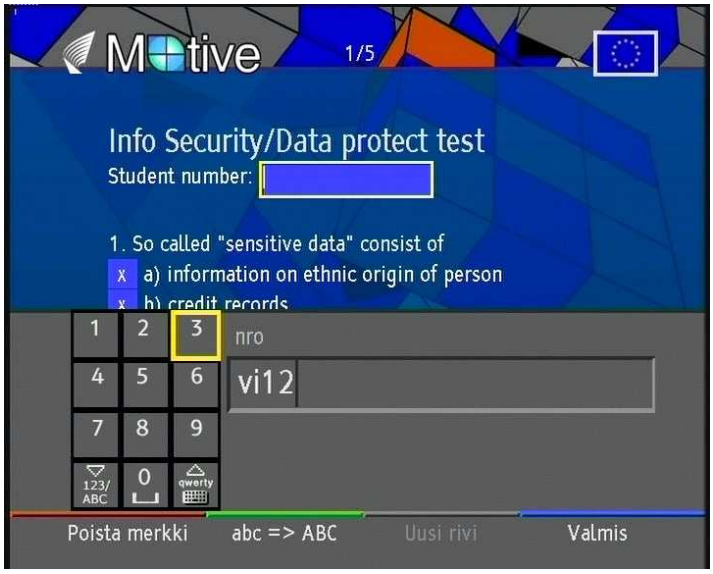


Figure 25: The virtual keyboard

The keyboard is controlled with the arrow and selection buttons of the STB remote control. Students solve real-life cases in small groups and tutors guide the process in the MCCS. The theoretical foundation of the course is inquiry learning.

5.4 Summary

The chapter described the learning environment used for implementing the Motive 1 and 2 field studies (see Sub-chapter 6.1 and 6.2). The ORTIKON ACE® Browser (Ortikon, 2005) was chosen as the base for the learning environment. The DVB-HTML Browser could be used for learning purposes with extensions, but it was recognized that the following parts and applications needed to be developed:

- database for learning material
- content production tool
- communication system.

A Motive software tool was developed to enable a Word document-based learning material to be converted to the DVB-HTML form. The tool includes a DB for the storage of the learning material. For the interaction performed between students and between a student and a teacher, the *Multichannel communication system (MCCS)* was developed.

6 T-learning field studies

Available field study opportunities have been very limited and the author has not been able to select them systematically and had to take every opportunity to test T-learning in practice. However, the field studies include participants from different age groups: children, young people, and adults. There are students who are studying in addition to their work, and also students who are participating in elementary school education. One of the participant groups consists of the deaf people, who have special requirements for T-learning. In addition, the field studies include both informal and formal T-learning. The field studies were performed between the years 2002 and 2005.

The four field studies are:

- T-learning field study in the test environment
- T-learning field study in a digital television cable network
- Sign language learning in the MHP and IPTV environments
- Online community with the help of instant messaging via iTV.

6.1 T-learning field study in test environment

6.1.1 Introduction of field study in 2002

The Local Demands in Global Enterprising course was partly studied via DTV during the first field study. The objective of the course was to provide basic information on the regulations governing the provision of Knowledge Society services and on the legal framework for e-commerce, especially from the viewpoint of a company in industrial IT. It was an optional course for students taking their Master's Degree in Computer Science and majoring in Industrial IT. The course consisted of four modules: Introduction: Provisions of Information Society Services, E-Commerce Directive, Electronic Signature and Information Security and Data Protection. Information Security and Data Protection was the module studied via DTV.

Two field study groups of HUT (Helsinki University of Technology) studied a module of the course in a test environment because MHP STBs for cable networking were not commercially available. The test environment was located in the HUT building in Lahti and operated between 9 and 22 September 2002. The other parts of the course were studied via the EduLink learning environment (Edusolutions, 2006). The DVB-HTML learning material and individual assignments were stored on the hard disk of a Philips Trimedia STB; a return channel was not available.

6.1.2 Students' background

The field study groups consisted of students from the computer science and industrial engineering and management departments. All students were adults and their ages varied between 26 and 59. Twenty-five per cent of the students were female. Over one half of the students said that they were either experienced or very experienced in using computers. However, two students had very little experience in using computers, and one student stated that she had not use the Internet at all. However, all students said that they had used teletext services on the television either daily or occasionally.

6.1.3 Material and methods

The research information was gathered from a survey form which consisted of multiple-choice questions and open questions. The questions covered the students' background information and questions concerning learning in the Motive environment. The multiple-choice questions were analysed with a quantitative method and the text questions with a thematic method (Eskola et al., 2005).

During the experiment students were alone, but the learning process of a few students' was recorded with a video camera with the students' permission. The object of the recording was to check whether there were problems in a particular part of the learning material or in navigation with the remote control of the STB.

6.1.4 Field study experiments performed

The research question was: Can DVB-HTML be used for learning purposes? If yes, what needs to be considered in delivering a learning service via iTV?

The research consisted of two parts:

- DVB-HTML-based learning material
- individual assignments.

The purpose of the first field study was to research the following:

- the DVB-HTML-based learning material
- the structure of the course
- navigation in the learning material
- self-assessment assignments
- the structure of the self-assessment assignments.

Students were shown how to use the learning environment before using it. Furthermore, they received brief instructions in paper format on the use of the Motive Browser and a remote control for the TV set. The Motive Browser (Ortikon, 2005) was used to browse through the learning material and for individual assignments.

Figure 26 illustrates the structure of self-assessment assignments. The structure was based on the structure of the self-assessment artefact (see Figure 89). Students studied a module and after that performed assignments based on self-assessment.

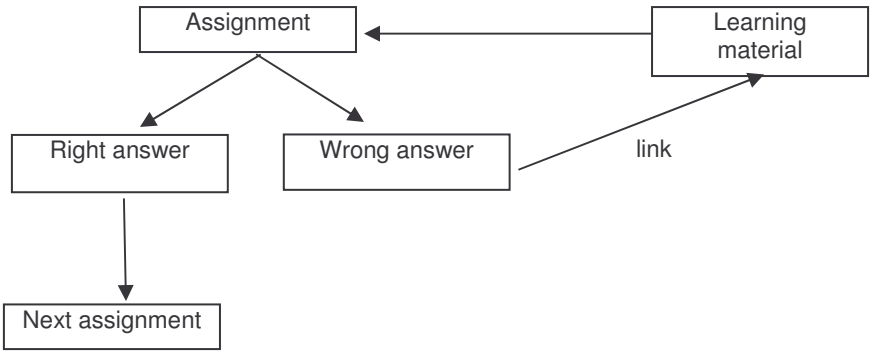


Figure 26: Structure of self-assessment assignment

Figure 27 illustrates the structure used in the learning material. The structure was based on the use of links to connect entities and sub-entities. The learning material consisted of DVB-HTML-based learning material that included text and still images. Only local interaction with the material was possible.

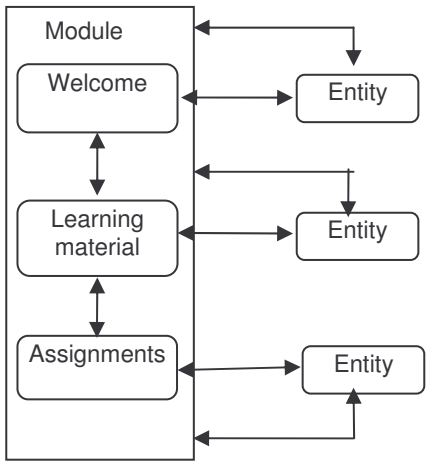


Figure 27: Non-linear structure of the module

The field study implements the information system part of the iTV learning system artefact (see Figure 28).

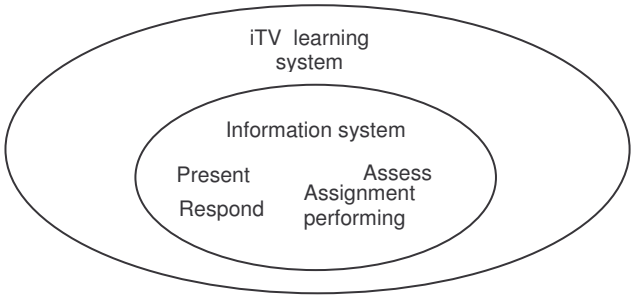


Figure 28: Implementation of the information system

An STB remote control was used to browse through the learning material. The use of arrows, colour, and selection buttons was allowed. The red button of the remote control was used to get instructions on how to study in the environment. The green button was used to move to the front page of the content. The yellow and blue buttons did not incorporate any functions. The current position in the material and the amount (number of screens) remaining are indicated in the bottom right-hand corner of the page. The colour of the text was white and selected text was yellow.

Figure 29: Appearance of the content in the field study

6.1.5 Results

The themes extracted from the survey form are: the appearance of the text; readability; navigation; TV view mode; self-assessment assignments, and DTV as a learning environment.

Three types of problems were noted in the survey forms concerning the DVB-HTML-based learning material:

- appearance of the text
- navigation methods
- TV view mode used.

6.1.6 Appearance and readability of the text

Text is the most important format for the presentation of information in iTV news applications, because the speed of perception is regulated by the user and reading a text is faster than watching a video (Brecht et al., 2005). According to the same guidelines, still images should be used as a supplement to the text. The learning material in the field study followed the guidelines.

For most of the students the volume of learning material was suitable. The font size was also suitable. Students mentioned the following problems with the appearance of the text:

- too few pictures
- word division was not liked
- preference for the text to be presented in columns.

Because images played a supplementary role, not every page included an image. One of the challenges of television is the limited size of a television screen. It is necessary to consider carefully what is presented on the television screen and what is not. The idea of the use of images was to bring added value to the learning material. It was difficult to find suitable images for all the themes covered by the learning material. Another issue

considered was copyright issues. Therefore, the learning material included only images that had been photographed by our laboratory.

Word division was not liked. A student wrote: “Word division is disturbing. If there is not enough room for a whole word in a line, the whole word should be moved to the next line.” The reason for the use of word division was the possibility of including a few more words on a page. According to the results, word division affects readability negatively and should therefore be avoided.

From the content producer’s point of view, subject division was also a problem, even though the students did not mention it. When producing content for the first field study, it was not possible to preview the content on a TV screen while producing it. Every time content needed to be implemented for further development, a trip to the company’s premises in another city was required. The result was that the learning material included pages that had only one word, the last word on a topic which had not fitted into a previous page. The possibility of previewing the content on a TV screen solved this problem later.

A few students would have preferred the text to be presented in columns. This function was not available in the first field study, but is currently one of the options for presenting text. Furthermore, depending on the subject, a glossary or definitions of words could bring added value to learning. A student wrote: “Depending on the subject, a dictionary could be added to the content; it could clarify words and the main terms.”

6.1.7 Navigation

Students used the arrow buttons of a STB remote control for navigating through the learning material. All students except one felt that they could easily move in the learning material. All felt it was easy to learn to use the arrow and selection buttons. Furthermore, the links in the learning material were recognized well. However, problems concerning navigation with help of the remote control were recorded. Three students wished that the number buttons could be available when moving between sub topics. Few (3) suggested that the colour buttons could be used when moving back from and forward to a page. One student asked for a sitemap.

A link was also desired, to connect the assignments and the learning material so that students could have a chance to look for additional information while performing assignments. In the field study, a student needed to go back to the main page after studying the learning content to move to the assignments. In the future, more flexible movement between learning material and assignments is required.

6.1.8 Other results

According to the guidelines for the presentation of iTV news applications, full-screen mode is suitable (Brecht et al., 2005). In the field study students did not have the opportunity to choose the screen mode. The learning material page did not cover the whole TV screen and normal broadcasting was partly visible on the television screen. A few (3) students felt that it disturbed their concentration. The results indicate that full-screen mode should also be available for learning content. Other screen modes can also be required if students want to watch a video while reading text.

The multiple-choice questions were especially liked because of the easy and fast feedback on wrong answers (Aarreniemi-Jokipelto et al., 2005C). The basic structure of assignments seems to be correct, but more feedback is required. A student wrote: “Feedback on wrong answers is needed.” Another student would have liked an additional comment on a correct answer. It was also suggested that the system could deliver information about how many assignments were correct.

All interaction in the field study was local. According to the results, the feedback from the system is important. Thus, an additional comment in the case of a correct answer and feedback in the case of a wrong answer should be provided. It means that the number of pages will increase, because the same “correct answer” or “wrong answer” page cannot be used for all correct and wrong answers. From the learning point of view, these changes are necessary.

All students responded that the subject was suitable for DTV and that they would most probably want to use this kind of learning service in the future. There were no negative comments relating to the use of the remote control for browsing through the learning material. The students were used to teletext services, and thus the same kind of way of presenting learning material did not cause any problems.

6.1.9 Conclusions

According to the research, two factors affected the utility of T-learning. They are the characteristics of TV as a medium and the combination of technology and pedagogy. Content production forms the final and special combination of the technology and pedagogy used.

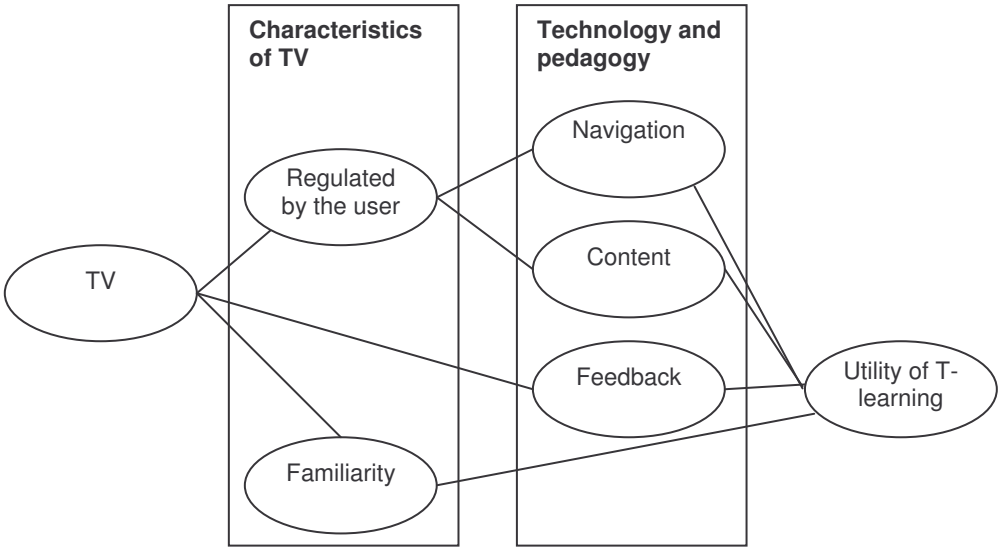


Figure 30: T-learning utility in the field study

The characteristics of TV which affected the utility of T-learning are the familiarity of TV as a medium and the opportunity for users to regulate the system. Students were used to teletext services. No problems relating to the use of TV for learning purposes were recorded. It seems that it is important that students are allowed to make choices and decide how to move around the content.

The combination of technology and pedagogy appeared in content, navigation, and feedback. Students felt that it is important that they have an opportunity to move around the content in the order they desire. The DVB-HTML content should have enough links to allow free navigation. It seems that a linear content structure would not satisfy these requirements, since more flexible opportunities are required. The use of a non-linear structure is a solution, but the nature of TV as a medium needs to be recognised in content production. Compared to WBEs, TV demands more links between levels and a tighter form in terms of the presentation of the content.

The readability of the content affects the utility of a T-learning service. According to the research, issues that affect readability are: the amount of text per page; word division, and the division of sentences between pages. A sentence cannot be divided between two pages. Word division affects readability negatively.

Most of the pages included only text and only a few pages included still images. Only a few students requested more still images. It seems that the readability of the text was more important than visualisation in the form of still images. This is supported by the literature. Text is the most important way to present information and still images should be used as a supplement to the text (Brecht et al., 2005).

Feedback from the system is important. It was the only way to get some kind of response to one's selections and actions. A student wrote: "There should be some kind of feedback on a wrong answer." Now, students got the message: correct/wrong answer. Students also requested an additional comment on a correct answer and a link to additional material. It seems that it is important that students can regulate the navigation and decide if they want more information or not.

Figure 31 illustrates how the learning system works.

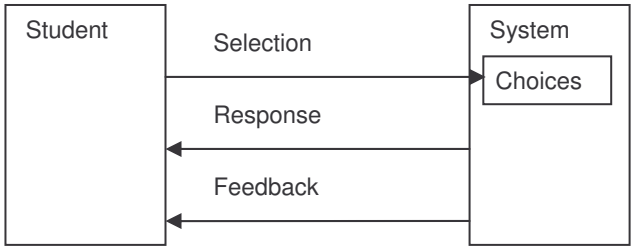


Figure 31: How the learning system works

The **learning system** refers to the combination of a browser used to present learning content and to the learning content. The learning content includes choices to be selected by a student. Choices included opportunities to select the desired part of the content in the desired order and selection opportunities in assignments. The **feedback** refers to comments sent to a student from the system after the student has answered a self-assessment assignment. **Response** refers to the opening of a page that is selected by a student.

6.1.10 Future actions after the field study in the test environment

The main problems were in navigation. A suitable method for navigating long lists in learning material was needed. The use of colour or number buttons should be examined as a solution. Another option was to change the structure of the learning material so that long lists did not exist any more. In addition, the mode of the television screen was a problem. It could be solved easily by allowing students to choose the TV mode. The learning path between assignments and learning material needed to be redesigned.

6.2 T-learning field study in a digital television cable network

6.2.1 Introduction of the field study

On January 12, 2004 a field study group started studying a course via the cable network of DTV. The course was the same as in the first field study, but now the whole 'Local Demands in Global Enterprising' course was studied via the Päijät-Visio (Päijät-Visio, 2006) digital television cable network (Aarreniemi-Jokipelto et al., 2004 B).

The research question is: What needs to be considered in the production of the content of a T-learning course and facilitating the learning process via iTV when the learning process is totally conducted via iTV?

Figure 32 illustrates the learning environment used in the field study. It is based on the T-learning system artefact (see Figure 82).

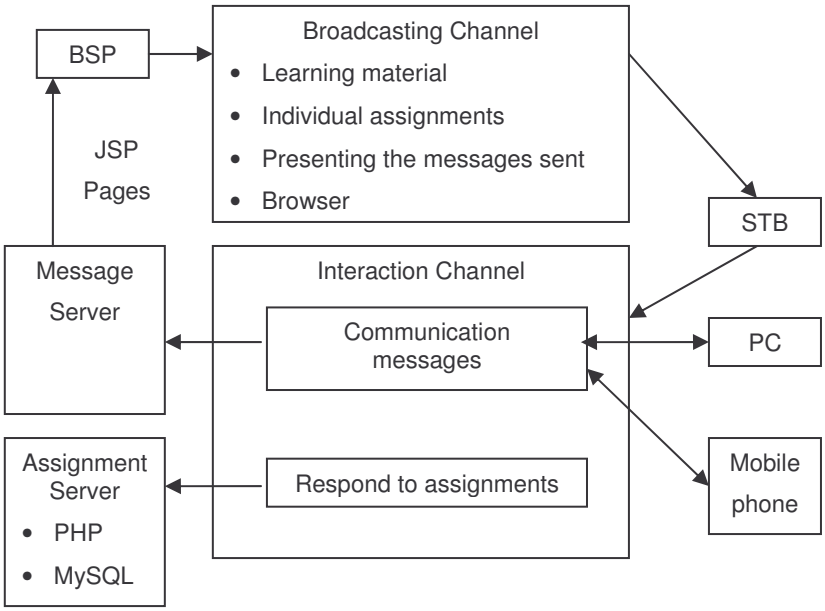


Figure 32: Structure of the learning environment in the field study

The learning environment included a multi-channel communication system providing functionalities through the use of many platforms; PCs; digital TV; mobile phones, and communicators. The idea of multi-channel use was to support the accessibility requirement of T-learning and ensure user satisfaction with usability. The messages are delivered as *Java Server Pages (JSP)* through the message server to be broadcast by the *Broadcast Service Provider (BSP)* and to be presented with the Browser. In addition to a television, students had to have an MHP-based *set-top box (STB)*.

DVB-HTML was selected for use as the presentation format for

- learning material
- assignments
- communication messages.

The ORTIKON ACE® Browser (Ortikon Interactive, 2005) was used in the field study. It was planned to use the DVB-HTML browser as an engine in the following T-learning situations:

- presentation

    - learning material
    - self-assessment assignments
    - group assignments
    - sent messages
- navigation.

The navigation was based on the use of a remote control with colour, arrow, and selection buttons. With the help of the arrow buttons, students could move in the direction of the arrow. The functions of the colour buttons were changed after the first field study. The yellow button was used in navigation. It made it possible to move to the previous page. The red button closed the application and the green button opened the first page of the content. The blue button opened the screen mode function and the instructions for the browser. The selection button was used to make choices.

In graded assignments, the students responded via the return channel, which was either a cable modem or an ADSL connection, and the answers were stored in a server for assessment.

Participation in problem solving of real life cases and multiple-choice questions acted as the criteria of assessment. The participation in group assignments in a multi-channel conversation system shows the ability of students to understand the subject as a whole. It also makes it possible to estimate how well students have figured out the problems in the subject and the cases used, as well as their ability to see the subject and problems analytically. With multiple-choice questions it is possible to check how well the terminology and concepts are understood, as well as how well the most important details covering the whole course are known.

6.2.2 Students' background

The field study course was limited to eight students because MHP enabled STB for the cable network of DTV was not commercially available. It was possible to loan the MHP enabled I-Can STBs for the cable network of Digital TV. The STBs allowed the use of both a telephone modem line and an ADSL connection as a return channel.

The students' ages varied between thirty-eight and fifty-five and all the students were men. All students were experienced with computers and used teletext services either daily or occasionally.

All students had earlier studied in WBEs and all except one liked learning in WBEs. None of them had an STB at home and only one had earlier tested a DTV application. Most of them had no plans to buy an STB during the coming year. Twenty-five per cent said that they did not believe that DTV was suitable for learning purposes. One student had written: "It might take years before these kinds of systems work. I doubt the navigation."

6.2.3 Material and methods

The research objectives of the field study were:

- Is multi technology use in DTV important?
- Is the DVB-HTML learning material suitable for learning purposes?
- Has the navigation problems in the first field study been solved?
- Does the new structure between assignments and learning material work better than in the first field study?
- Does interaction support learning via iTV?
- Is the Motive learning environment suitable for learning purposes?
- Are students satisfied with the remote control as a control device?

The research information was gathered by means of a survey form, which consisted of multiple-choice questions and questions in text format. The questions consisted of the students' background information and questions concerning the learning environment and the platform. The questions concerning the platform and the learning environment were grouped into the following themes:

- devices
  - use of STB and return channel
  - use of remote control
- applications
  - use of multi-channel communication system
  - use of Motive browser
- appearance of learning material
- assignments
  - self-Assessment assignments
  - graded assignments
- usability of the learning environment
- interaction
- digital TV as the learning environment.

The multiple-choice questions were analysed with a quantitative method. In addition, learning via DTV was observed. The text format answers and observation data were analysed with a thematic method (Eskola et al., 2005).

6.2.4 Field study experiments performed

The course was divided into two sections: an individual and a group section. In the individual section students studied the learning material in the peace and order they wanted. The section included two types of assignments: self-assessment and graded. In the beginning of the group section, students were able to discuss with the tutor about questions that had arisen during the individual section. After that, they worked as a group discussing and solving the problems. During group assignments, the teacher's role was seen as a guider of the learning process, not as a supplier of knowledge.

6.2.5 Results concerning the platform

Figure 13 illustrates the parts of the Motive learning environment and connections between it and the T-learning model. **Platform** refers to an application intended to facilitate learning and education. It includes different kind of technical functionalities, to deliver learning material and to allow communication.

According to the students' feedback, MHP enabled DTV is a suitable learning environment, where students would like to study more. The system was easy to use and it did not take long to learn to use it.

In the beginning, students had problems with the return channel communications. One problem was that the ADSL outlet was on the other side of the home, because a modem or an ADSL has never before been needed near a television. The field study clearly indicates the need for developing new features in a regular TV set, since it has gained a new function and purpose as it now serves as a channel to an interactive learning environment.

Figure 33 illustrates the use of learning material in the DVB-HTML format and the use of the DVB-HTML browser. In addition to serving as a presentation and navigation engine, the browser had a supportive role in collaboration, knowledge creation, communication, guidance, and feedback, because it allowed the sent messages to be presented to students.

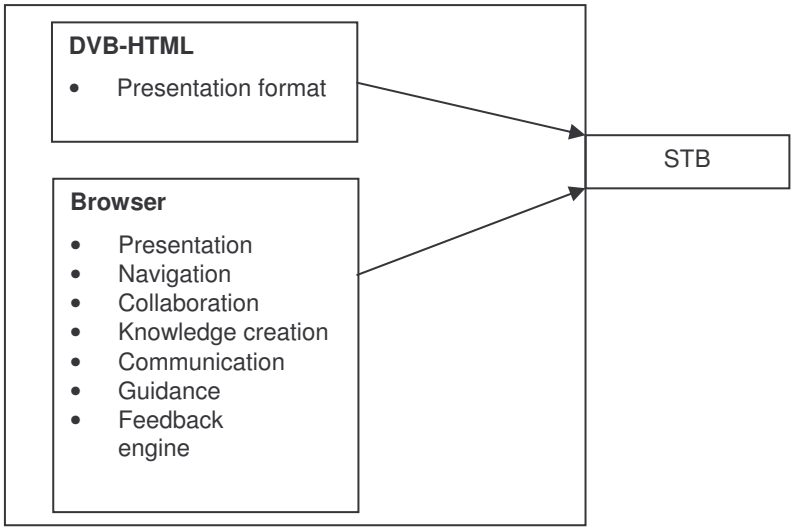


Figure 33: Use of DVB-HTML format material and DVB-HTML browser (Aarreniemi-Jokipelto et al., 2005F)

To conclude, the use of the DVB-HTML browser was a positive surprise given students' and HUT's expectations, even though the control device is slower than a mouse or a keyboard. A student wrote: "It is a little bit slower to browse through the learning material compared to the use of a mouse and a keyboard, but it was a positive surprise compared to my expectations in advance."

The browser was seen as working well for reading and browsing through the learning material. The problem is with the writing; the virtual keyboard was seen as too slow to use and other devices were requested for writing.

The DVB-HTML browser fulfils the special requirements of T-learning, when combined with other applications. It makes possible formal learning, as well as the presentation of the learning material, response to the course assignments, and the presentation of sent messages. It supports knowledge creation, guidance, feedback, and collaboration. It is easy to produce DVB-HTML-based learning material.

The multi-channel conversation system is based on the T-learning communication artefact (see Figure 93). It was reported to be good because students were independent of time and place thanks to being able to use different devices for discussions. The use of the multi-channel option in writing and reading in iTV was seen as very important because reading and writing are independent of time and place, and the virtual keyboard is too slow to use for writing. A student wrote: "In that case, reading and writing are not dependent on time and place." Another student wrote: "As long as you cannot use a traditional keyboard with digital TV, there have to be other solutions available. Writing with the help of a remote control and a virtual keyboard takes too much time."

One problem came up concerning the STBs; the time to load pages was too long. Such technical problems tend to disappear over time, but now it complicates studying and too much time was spent on technical issues instead of learning.

Navigation in the course was based on the non-linear course structure artefact (see Figure 88). In 2002, there were requests for a hot-key to make it possible to get back to the previous page. In the 2004 field study, which was provided with a colour button, the

feedback was positive. When asked if the use of colour buttons was useful in navigation, students stated:

- “The colour buttons were the best part of the system.”
- “The colour buttons make it easier to navigate around the learning material.”

One student argued that a side map would make navigation faster. Another student suggested that “the structure of the links in paper format would make the navigation easier”.

MHP technology has suited the kinds of learning objectives and the budget of the *Local Demands for Global* Enterprising course. Although, it has not been economically viable to produce videos and multimedia, learning based on interaction with learning material as well as between other students and the tutor has been possible.

The self-assessment assignments were based on the structure of the self-assessment artefact. When asked if the structure of the self–assessment assignments artefact (see Figure 89) supported learning and facilitated easy access to learning material to study more, students answered “yes”. A student commented: “It made searching for correct information faster, which is important in this kind of environment.” Another student wrote: “The links were useful.” Another student stated that “it is important to get feedback immediately. Otherwise it is impossible to know if you have learned everything correctly”.

The graded assignments were based on the structure of the graded assignments artefact (see Figure 91). It provided a way to use assignments for assessment. Students need to get immediate response from the server after they have sent their answers to the assignment server. The current system did not provide the feedback of the status of a submission, leaving the students uncertain of their response.

The learnability of the learning environment was good. When asked how fast they learned to use the browser and were able to move smoothly around the learning material, almost 60 per cent of students responded that they had learned it in less than 15 minutes. A student commented: “I got used to it in 10 minutes.” Another one said: “After a few trials.”

Finally, the problems concerning the appearance of the learning material in the first field study have been mainly solved.

6.2.6 Results concerning the Motive learning environment

The purpose of a learning environment is to facilitate learning. While a platform includes technical features, a learning environment includes features to support learning.

Like in all online learning, the biggest barrier in the beginning may be overcoming a fear of communicating via new media. Results of the field study showed similar results. Some students became familiar with the new media very quickly, and for others it took more time.

Also, the attitude to learning and to the use of DTV affected learning. Those who in advance told that they like to study in learning environments have been more satisfied in studying in DTV than those who do not like to study in learning environments.

When asked if digital TV is suitable for use as a learning environment, almost 90 per cent of students answered “yes”. A student stated: “In my opinion, digital TV is a medium for everyone, whereas a computer is still not.” People are used to television and school TV programmes; therefore it is easy also to start using TV for new kinds of solutions. Older people are more used to television than computers, and it can be easier for them to use TV for learning. Additionally, as described in the first chapter, computers have not been able to solve all E-learning problems.

Another student argued that “T-learning can be an option in particular situations”. These situations are, for example, geographical availability, visualised media, the familiarity of TV as a medium, and the fact that TV is an easy-to-use medium.

Another student stated that “DTV is suitable for use as a learning environment, but DTV still requires further development”. That is correct. DTV requires further development if it is to be used for learning. This field study has been an attempt to develop the use of iTV in learning. Not everything is perfect yet, but the first steps have already been taken. If the maturing of technology generally takes from 10 to 15 years, it means that there is still work to do.

Another student noted that “technology is developing. If people have got used to mobile phones, they will get used to the opportunities provided by digital TV.” Currently, 35 per cent of households have an STB and they have had a chance to become familiar with the opportunities offered by DTV. September 2007 is coming closer. Then people will be forced to start using DTV if they want to watch TV. Of course it takes time to become familiar with old media with new functions.

Collaboration occurs when more than just one person works on a single problem-solving task (Marttunen et al., 2004). The results of the pilot course indicate that interactive digital TV suits collaborative learning. Furthermore, interactive digital TV makes possible multi-channel interaction, which supports the requirements of lifelong learning.

With the multi-channel communication system, the student had the opportunity to use different devices for reading and writing messages. Communication enabled community building. The sense of community motivated students and made problem-solving easier.

The interaction channel was seen as important in T-learning, because interaction enables learning from others. Problem solving is also easier when interacting with others. The motivation increases if you are not studying alone and have the possibility to exchange ideas with other students. 87 per cent answered that the use of a communication channel in learning via digital TV is either very important or important. The reasons for this importance are:

- the possibility of learning from others
- easier problem-solving
- motivation
- exchange of opinions.

Students had a chance to discuss the case with each other. It made possible learning from others, which was valued by students. Problem-solving in a group was liked compared to working alone. The possibility of communication with each other had a motivating character. Students were not studying alone, but instead they created a virtual community via television. It was possible to get help from the other members of the community and from the tutor.

In addition, students said that the multiple-choice questions based on self-assessment were good because they provided an immediate response from the environment. Almost 90 per cent felt that they supported learning. Their comments are:

- feedback came immediately!
- made it easy to check how well the subject studied had been learned
- people learn from mistakes
- increased motivation to learn

- guided learning process
- quiz-like character
- chance to practice without a teacher.

Twenty-five per cent of students felt that the fact that the teacher did not have access to the results of the self-assessment assignments affected the amount of time they used for the self-assessment assignments. Another student continued that “it provided freedom to test one’s knowledge in a more relaxed fashion. The assignments were not too easy, because they required us to go through the material a few times so as to be able to answer them”. Also, the multiple choice self-assessment questions were liked because of the immediate response from the environment. A student stated that “self-assessment assignments added motivation, because the feedback came immediately”. He felt that in this way he could organise his learning of the content. Links to the content in the event of an incorrect answer made it easier to find information. A student stated that “links from assignments to the content were very important”.

Students also felt that they would like to study more via DTV. Compared with WebCT and other Internet-based learning environments, the MHP-enabled learning environment is more flexible for adult students because it:

- allows the use of different devices for discussion
- supports the principles of lifelong learning
- makes studies possible in addition to working.

A student stated that “DTV is suitable for everyone, but a computer is not yet”. Another student stated that the “content of assignments was suitable for the course”. Another continued that “the assignments improved learning outcomes, because they were many-sided”. Another student argued that “performing self-assessment assignments was a good way to study via iTV”.

In an MHP-based learning environment, a great deal can be accomplished with fairly simple and economical solutions. The MHP-based learning environment can be a good solution when the studied subject matter changes continuously and learning material has to be updated frequently. A student stated that “DTV is one media possibility for distance learning, but TV imposes new requirements on the content: it demands tight, clear, and concise material”.

Table 6 summarises the main results concerning the research objectives.

Table 6: Results of using MHP as a technology

Research objective	**Results**
Is multi technology use in DTV important?	It is important for working adults because students are independent of time and place while studying.
Is the DVB-HTML learning material suitable for learning purposes?	Yes. It was suitable for this content and target group. Self-assessment assignments were especially liked. DVB-HTML should be tested with different contents and target groups.
Have the navigation problems in the first field study been solved?	Yes. Colour buttons had solved the majority of the problems so same navigation problems no longer existed
Does the new structure between assignments and learning material work better than in the first field study?	Self-assessment assignments received good feedback from students as described in Section 6.2.6
Does interaction support learning via iTV?	Yes. Interaction is important. According to the students, it enabled learning from each other, made problem solving easier, and increased motivation.
Is the Motive learning environment suitable for learning purposes?	Students were mostly satisfied. The biggest problems are message writing and slowness of STB in opening pages. Fixing the imitations of STB are crucial. The new generation STBs need to be able open pages faster to enable learning. A virtual keyboard can be used in learning if long messages are not required. If the service requires long messages other media for writing need to be used if no other keyboards are launched for MHP.
Are students satisfied with the remote control as a control device?	Not totally. It is slower than a mouse and a keyboard. It works for browsing and reading, but is too slow for writing messages.

6.2.7 Conclusions

Three issues can be found that affected the utility of T-learning in the field study. They are:

- person
- technology
- content.

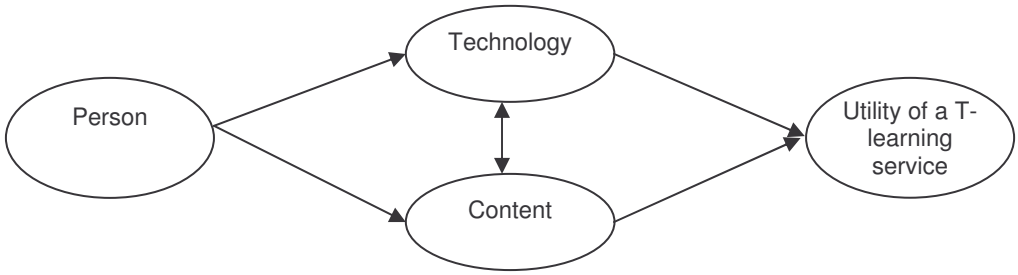


Figure 34: Utility of T-learning in a digital television cable network

The students were affected by the technological solutions and the pedagogic solutions in the content. They were adults who were studying in addition to work and family duties. They valued flexible learning opportunities, which were notified in the content production.

From the technological viewpoint asynchronous communication, the use of multiple channels for communication, the chance to choose the learning place, 24/7 availability, and DVB-HTML affected the utility of T-learning. Asynchronous interaction was important because of students' life situations. It was possible to communicate with the tutor and other students when they had time. The use of multiple channels for communication made possible flexible communication independently of the place. 24/7 availability meant flexibility in practice, because students could choose the day and time of the day when they studied. DVB-HTML made possible the use of a text-TV-like form. To conclude, in a student's words: "Browsing through the content was a positive surprise compared to my expectations in advance." The familiarity of TV and text TV explain the positive feedback.

The pedagogic solutions during the content production phase influenced the final form of the content. The content can roughly be divided into two parts: the existing learning material and the learning process. The important issues in the learning material are:

- appearance of content
- structure of content
- types of content.

According to the results, self-assessment assignments are suitable for DVB-HTML content. According to students, the assignments motivated them, increased learning outcomes, and guided learning. The non-linear structure was liked and it made possible flexible movement through the content. The students felt that the appearance of the content was good. There were no requests for videos. A few videos were produced for the course, but in the field study, this would have required another channel, which was not available. Compared to the first field study, the appearance problems in the content were solved. Word division, which had caused readability problems in the first field study, was not used.

The learning process includes the following issues: community; guidance; knowledge creation, and feedback. Most of the students felt that interaction is important in learning via DTV. Interaction facilitated community-building. Students were not alone, but they had a common purpose, following the course. The virtual presence of the others provided motivation and made problem-solving easier. The feedback and response from the other members of the community was important.

Guidance also affects the utility of T-learning. Guidance seems to be more important when the context of the media is new. At the beginning of the course, students requested a meeting at the school when they had technical problems with the return channel communication. In the same situation they requested additional information about the

course, e.g. how it should be studied. Throughout the course guidance was needed. In the problem-solving cases students demanded more information about the subjects. In individual assignments more information was needed for students to succeed in delivering their answers correctly. This is supported by the literature. In self-assessment assignments the system was able to guide the process more in the cases of both correct and incorrect answers.

Knowledge creation is important in this kind of learning service. The course needs to include challenges for students. The supplier of knowledge is not a teacher, but, instead, the students as a community need to create knowledge. The browser served as an engine for collaboration and working in a community. Students had a goal. They looked for information, used their experience and previous information, and generated new knowledge on the way towards their goal. During the process, what was needed was a teacher, other students, and learning material, which supported the process. However, the main issue was active participation and responsibility for one's own learning process.

Feedback also affects the utility of T-learning. Feedback can come from a teacher, other students, or the learning environment. From the point of view of the learning process it is most important to have feedback available as requested. The value of the correct timing of feedback needs to be recognised in the production of the content of a course.

6.3 Sign language learning in the MHP and IPTV environments in the year 2005

The research objectives of the field study were to discover:

- what is important in videos including sign language
- how to present text in combination with sign language videos.

6.3.1 Introduction of the field study in sign language learning

DEAFVOC is a Leonardo da Vinci language-competent project, funded through the EU (Deafvoc, 2006). The aim of the project is to develop language teaching in vocational education in four EU countries. During the project, standard model curricula, "Sign language as a Mother Tongue" and "Written Language as a Second Language for the Deaf" have been created, as well as a virtual demo learning material for the Internet. The field study of the sign language in T-learning is based on the Deafvoc project.

Currently, deaf people study alone or in small groups with the help of an interpreter in regular schools all over Finland. Usually, schools do not have sign language-competent teachers; due to this, language teaching is centrally organized with the help of a medium suitable for learning via sign language. The purpose of the field study is to find out the suitability of DTV as a medium of learning through sign language

In the field study, a DTV platform is used for broadcasting the demo learning material to sign language teachers and students in schools in Finland. The learning material consists of videos and text. The content was produced for both the MHP and IPTV environments because it was unsure whether the MHP STBs for cable networks would be available in time.

6.3.2 Literature review

No information about the use of MHP or IPTV in sign language was found. No research concerning the educational use of DTV for deaf people was found, either.

“To date there would appear to be little advisory information about sign language interpretation for television.” The following guidelines are based on discussions with organisations for the deaf in the UK and experts in the field of signing (Cenelec, 2003). They are for general use, not specifically for educational purposes. Requirements relating to sign language interpretation are (ITC, 1997):

- quality of screen
- size and shape of overlaid inserts
- choice of dress and background colours.

First, gestures that convey meaning through sign language must be easily and accurately recognisable. Second, the interpreter needs to occupy at least one sixth of the screen. Third, appropriate clothing should ensure a good contrast. To ensure that the person signing is clearly distinguishable, contrasting plain colours and suitable lighting, for example, can also be used.

The United Nations “Standard Rules on the Equalisation of Opportunities for Persons with Disabilities” (United Nations, 1994) call in Rule 5 on governments to encourage the media – television, radio, and newspapers – to make their services easily available to everyone. In most European countries little has been done in practice and organisations and people seldom have guidelines on how to produce texts which are easy to read and understand (ILSMH, 1998). Therefore, the ILSMH European Association has produced European guidelines for the production of easy-to-read information for people with learning disabilities. The guidelines do not name television as a use area. Because no other more appropriate

guidelines were found, these are partly used in this context. According to the guidelines, easy-to-read material is generally characterised by:

- the use of simple, straightforward language
- only one main idea per sentence
- the avoidance of technical language, abbreviations, and initials
- a clear and logical structure.

The 2003 Switchover communication desired DTV to do more than just offer more channels. It mentioned that “access to digital broadcasting should include citizens with special needs, notably people with disabilities and older people” (Commission, 2003). In the European Parliament’s 2003 resolution on Television without Frontiers, the Parliament called on the commission “to address the problem of improving access to the broadcast media for those suffering from sensory impairment” (EU Parliament, 2003). In Finland the law on Yleisradio Oy provides that YLE will also produce services for sign language users among its programmes. “In practice, a daily news broadcast of five minutes is the only regular service in sign language offered by the TV” (Kl-deaf, 2006).

It is estimated that there are 740,000 hearing-impaired people in Finland, 8,000 of whom are deaf. Finnish Sign Language is the mother tongue of 4,000–5,000 deaf people. 10,000 hearing people use it as their mother tongue, second language, or foreign language (Kotus, 2006). In the whole world there are 70 million deaf people (Kl-deaf, 2006B).

There are two types of help services for deaf people for use with TV: subtitling and signing. Hearing-impaired persons may benefit from the use of a subtitling service or the use of sign language in the service. A subtitling service adds subtitles to the programme so that the audio track of the programme can be read from the subtitles. In Finland the subtitles have been tested in an MHP subtitling project (ArviD, 2005B). Subtitling services can also be used in language learning.

6.3.3 Participants’ background

A total of 17 people participated in the field study. 50 per cent of the participants had sign language, 39 per cent of the participants had Finnish, and 11 per cent of the participants had another language as their mother tongue. 59 per cent of the participants were deaf and 41 per cent were hearing.

Figure 35 illustrates participants’ status. 59 per cent of them were male and 41 per cent were female.

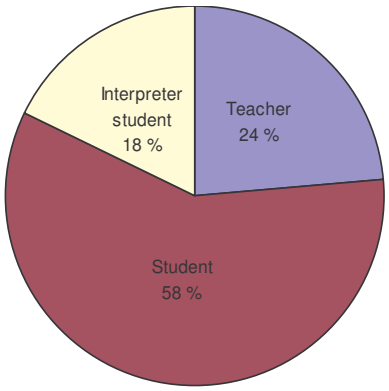


Figure 35: Participants’ status

Figure 36 illustrates participants' ages.

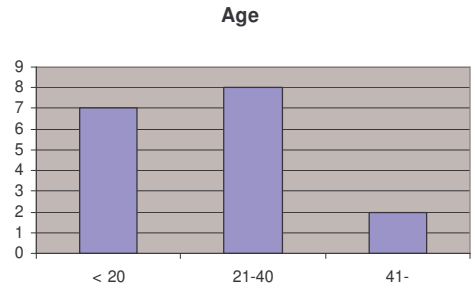


Figure 36: Participants' ages

6.3.4 Material and methods

The information was gathered with a survey form. The survey form consisted of multiple-choice questions and text-format questions. The questions were also signed for the students. The answers were analysed with a quantitative method. In addition, two teachers were interviewed, one in each school. The interviews were analysed with a thematic analysis method (Eskola et al., 2005). The questions in the survey form and in the interviews were divided into the following themes: background information; previous use of web-based learning environments, text TV, and computers; parts of the learning material; the text part of the material; videos in the material; learning assignments and interaction, and digital TV in sign language learning.

6.3.5 Performed experiments in the field study of sign language

The learning content included both text-based material and signed material. The content was produced both for the MHP and the IPTV environments, because it was uncertain whether the MHP STBs for cable networks would be available in time. Because the required MHP STBs and IPTV infrastructure were not available in time, the field study was performed using an IPTV STB and a PC emulator. The used browser was the HTML browser of Kreatel IP-STB 1510.

The field study was performed in two schools: Turku Christian Institute and the Aura Institute.

6.3.6 Text-based learning material

Figure 37 illustrates an example of textual form of content. The graphic appearance of the content was good according the research. Hyperlinks had been recognized in the content. The task of the colour buttons in the bottom of the page had been understood.

The contrast between text and the background was good enough. A great deal of text was located on a page. On some pages, it would have been better to write the text on several pages. On some of the text pages the background had included two colours, which had disturbed the reading. In the future, the background will be one-coloured. On the whole, the amount of text had not disturbed the users. Also, it is suggested to check whether there is enough contrast with a person who has poor sight.

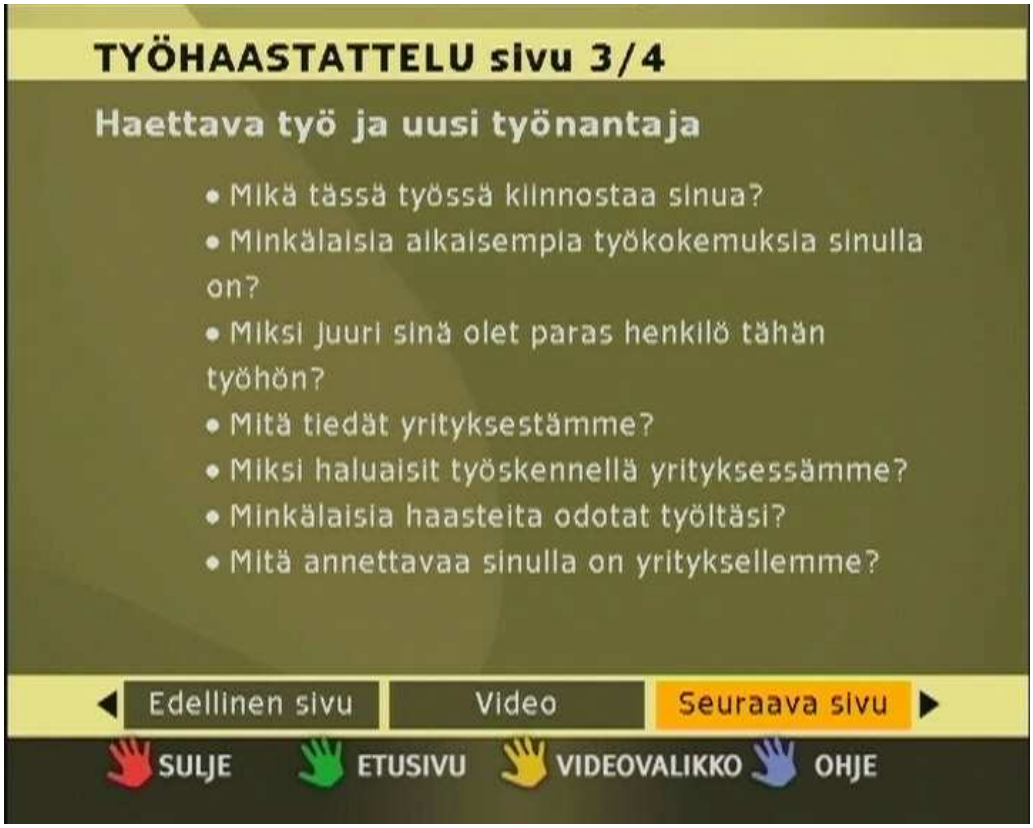


Figure 37: An example of the text-based learning content

6.3.7 Sign language use in learning content

Figure 38 illustrates the use of sign language in the content. According to the ITC requirements relating to sign language interpretation (see Section 6.3.2), signs must be easily and accurately recognisable. According to the research, the quality of the videos was good enough for the signs to be understood. According to the European Easy-to-Read Guidelines, the most important aspects of a video are that it has a clear script and that the text and pictures do not change too rapidly. The reason for using videos was to make it possible to understand the signs in the field study. Because of this, the videos also satisfy the easy-to-read guidelines relating to videos.

According to the ITC requirements relating to sign language interpretation (see Section 6.3.2), appropriate clothing for a signer should ensure good contrast. According to the research, the signer was clear and the clothing was suitable. A participant wrote: “Dark clothing made it easier to recognise signs and the signer signed in a clear and lively way.” According to the results, the signer should use dark clothing of one colour, and the background needs to be sufficiently light to ensure sufficient contrast.

There were a few comments concerning the red line around the signer in one video. The red blended and disturbed the watching of the video. The problem with the colour red is generally recognised (Roibás et al., 2005). Horizontal lines should be avoided because they tend to flicker if they are only one pixel high.

Figure 38: An example of sign language use in the content

The length of the videos was suitable. They were from one to four minutes long. The option of pausing the video was requested because it would make it easier to perform assignments. A participant wrote: “The videos need a run/pause function.” An alternative solution would be to divide the videos into smaller segments.

According to the ITC requirements relating to sign language interpretation (see Section 6.3.2), the interpreter needs to occupy at least one sixth of the screen. That was the case with all the videos and the content satisfies the ITC requirement (see Figure 39).

The content included an animation that did not occupy one sixth of the screen. A participant wrote: “The size of the animation was too small. It was too difficult to understand the signs.” Thus, both animations and videos should follow the rule of occupying one sixth of the screen.

The ITC requirements relating to sign language interpretation suggest contrasting plain colours and the use of suitable lighting to distinguish the person signing. A participant in the field study wrote: “The signer could be easily distinguished from the background.” The blue background colour was liked. The results indicate that the content satisfies the ITC requirement.

In the future, a one-coloured background which does not include bright figures should be used. According to the research results regarding sign language, the background of the upper part of the body in particular should be clear and of a calm colour. In Figure 39, the logo on the upper left-hand side disturbed some of the participants. A participant wrote: “The logos were too big, especially the logo which was on the signer’s upper left-hand side.”

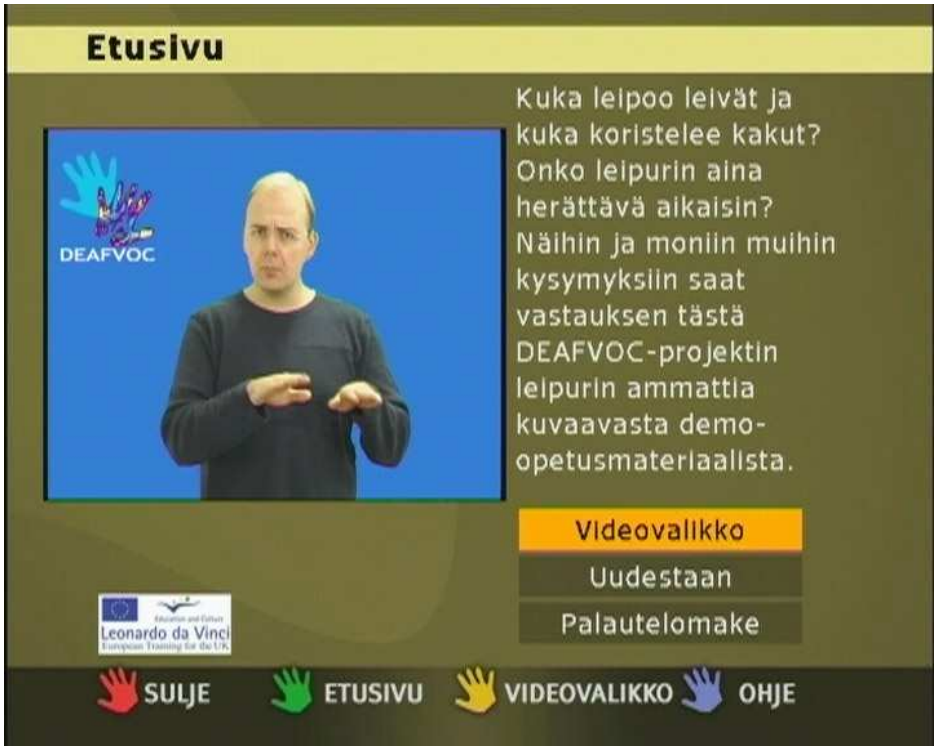


Figure 39: An example of content including both a video and text

Figure 40: An example of the use of animation in the content

6.3.8 Learning content structure, glossary, and plain text

According to the easy-to-read guidelines (see Section 6.3.2), the way a document is structured is very important. The contents should follow a clear and logical sequence. The structure of the learning content in the field study was based on the non-linear structure of the educational service artefact (see Figure 88). The non-linear content structure was liked because it allowed users to go through the content in the order they desired. According to the material, no problems relating to the structure were recorded. It indicates that the non-linear structure of the educational service artefact fulfils the clear and logical structure requirement.

A new development area is a glossary. It should include the words in text and signed formats so as to facilitate understanding of the content. According to the interviews, the need for a glossary is important, because many deaf people have sign language as their mother tongue and Finnish as a second language. Their ability in the Finnish language is not necessarily very great. It was also hoped to use an easy-to-read text format in the content, for the same reason. An advantage of plain language is that other groups than the deaf could also use the content. Plain language benefits the following people (Sillanpää, 1999):

- people with a disability (deafness at birth, deaf-blind, mentally handicapped, CP handicapped, MBD symptoms, aphatic people, seriously multiply-handicapped people)
- people with reading and writing disabilities
- older people
- people whose mother tongue differs from the official language of their community.

Figure 41: An example of the content

According to the European Easy-to-read guidelines the layout of a page can play a big part in how easy it is to read.

6.3.9 Informal vs. formal learning

According to the interviews, in addition to the current informal use, this type of content can be used for formal learning. Based on the research, DTV is suitable for learning via sign language because the instructions to the assignments can be given with sign language and because DTV enables visualized presentation forms.

Table 7 summarises the results relating to the research objectives.

Table 7: Results of sign language use

Research objectives	**Results**
What is it important to note in videos including sign language?	The most important is that the background of the signer's upper body be a single colour and quiet. Figures in the background should be avoided. The signer should use dark clothing of a single colour. The contrast between the signer and the background needs to be high enough.
How can text be presented in combination with sign language videos?	The text can be independent of the videos or as a substitute. Non-linear structure serves learners. It is recommended that the background be a single colour and not include figures. It is recommended to have a glossary for difficult words included in the text. The glossary should include definition in a textual and in sign language form.

6.3.10 Conclusions

Table 8 summarises deaf people's special requirements relating to T-learning.

Table 8: Deaf people's special requirements for T-learning

	Sign language
Form of content	Possibility to choose either text or video
Structure of content	Non-linear Logical, clear
Layout of pages	Not too much information per page Keep sentences together on one page A large font size
Glossary	Both in textual and signed form
Text	Plain language Small enough pieces
Background of text	One-coloured, e.g. blue
Signed videos	Need to include fast-forward and rewind functions or videos need to be divided into smaller segments Need to occupy at least one sixth of the screen Length from one to four minutes Possibility of watching again
Quality of signed video	Good enough to recognise signs easily and accurately
Clothing of signer	Dark clothing and of one colour
Background of signer	Sufficiently light to ensure a large enough contrast between the signer and the background One-coloured background, e.g. blue The upper part of the signer's body need to be clear and quietly coloured No logos

The use of iTV in deaf people's learning is examined from the viewpoint of visualised culture. Figure 42 illustrates the reference frame used to analyse T-learning from the visualised culture point of view. Visualised culture affects content structure, navigation, and types of content, which, in turn, affect the usability of the content for deaf people.

Visualised culture refers to deaf people's culture, in which visual elements play an important role. In iTV it means the greater-than-usual use of figures, images, and videos.

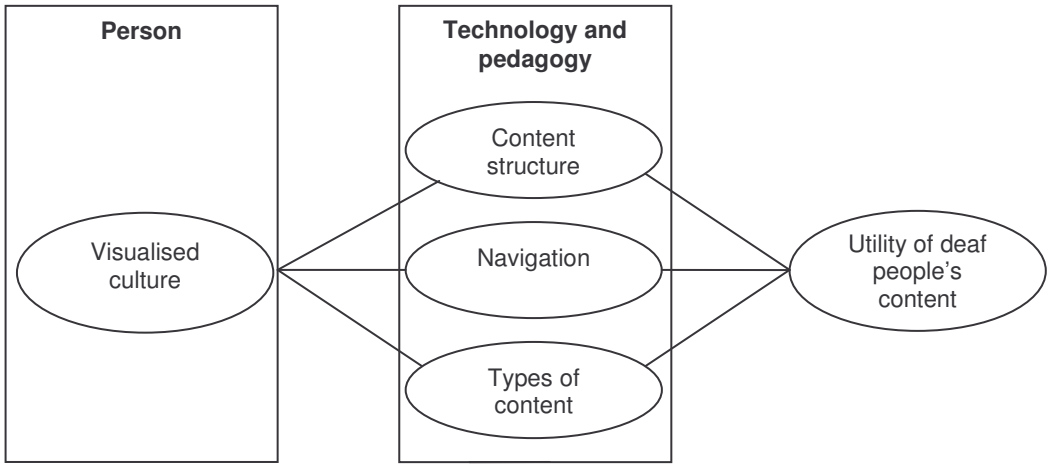


Figure 42: Utility of deaf people's content

The use of several languages is important. In addition to Finnish, sign language also needs to be provided as an option, because there are students who have sign language as their mother tongue and they might have problems with Finnish. In content this means the use of two languages. According to the results, the amount of text per page needs to be smaller than in the field study. Those who have Finnish as their mother tongue had no problems with the amount of text per page. Half of the participants with sign language as their mother tongue felt that the amount of text was too large.

The three main benefits of TV for deaf people are:

- visual medium
- familiarity of the medium
- good accessibility.

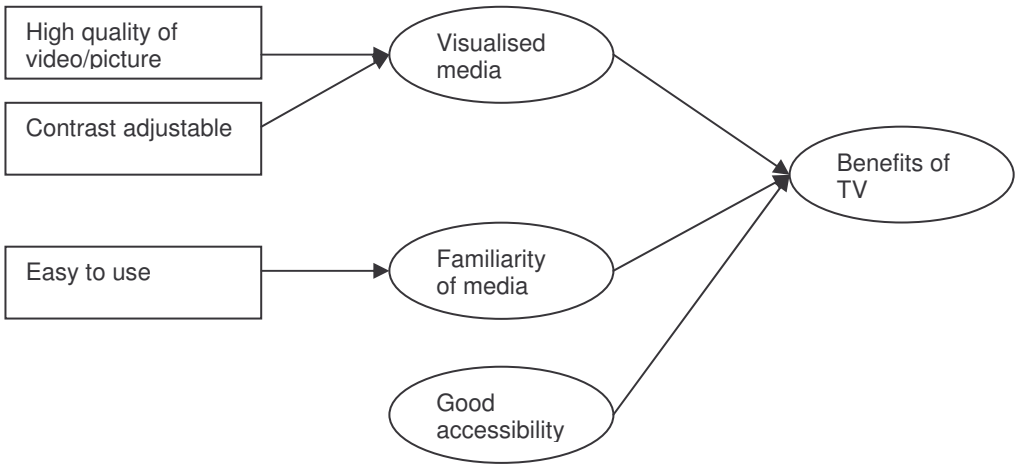


Figure 43: Benefits of TV

The high quality of pictures and videos and adjustable contrast are the advantages of TV which benefit deaf people. The familiarity of TV and ease of use make it easy to start using TV for learning. In Finland sign language is not used much on TV, but many have seen the news in sign language. Compared to computers, another advantage of TV is good accessibility.

Figure 44 illustrates how the learning system works. The **learning system** refers to the combination of the browser used to present learning content and to the learning content. The learning content includes choices to be selected by a student. Choices include opportunities to select the desired part of the content in the desired order. **Response** refers to the opening of a page that is selected by a student.

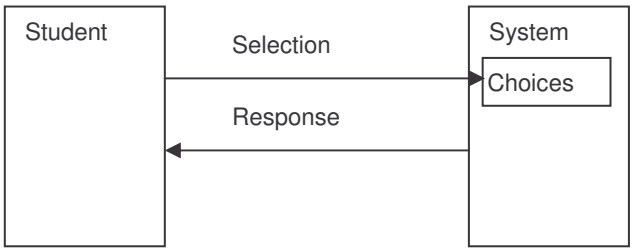


Figure 44: How the learning system works

6.4 Online community with the help of instant messaging via iTV

The research question was: what is characteristic of children's use of instant messaging via iTV?

6.4.1 Introduction of the field study

Starting in January 2005 The YLE Education of the Finnish Broadcasting Company has offered a new afternoon club service for schoolchildren from the age of 9 to 11 years. The name of the programme is Tuu juttuun (Get along) (Yle, 2006). It gives to the children a safe option for lonely afternoons at a time when their parents are still at work but the children are already at home. Another major target group for the programme is the afternoon child care programs and the children spending the afternoon hours there.

A central goal of the service has been to form a reciprocal community of users and to support this community, as well as to utilize the interaction of the community. The aim of the field study was to examine the students' interaction and communalism in a DTV environment. Another objective was to understand and identify the attributes of children's use of instant messaging. In addition, the communication system artefact was field-tested.

An MHP-based Instant Messenger application (Axel, 2005) customised for YLE was used in the field study. The application works with an analogue modem or broadband connections. The text input mechanism is similar to the input style of text messages with mobile phones. The application includes a virtual keyboard for message writing. The Instant Messenger makes it possible to chat while watching the programme. In this research it is used to create a programme-specific community, but it also includes other functionalities. Axel Technology's message room moderator tool is used to ensure that only suitable messages are broadcast to the viewers in the field study.

6.4.2 Instant messaging – literature review

Instant messaging (IM) refers to a text-based system for lightweight messages that support Internet-based synchronous text chat between users on the same system. It has become popular during the last years first among teenagers and increasingly among business users. It has been popularized in the form of America Online's Instant Messenger (AOL, 2005), and Microsoft's Messenger (Microsoft, 2005). The services provide client software to log into proprietary networks and an interface to write messages to other users (Frees et al., 2004). Some IM systems have offered versions that run on wireless devices. In some systems, pictures and URLs can be included in the messaging.

Internet Relay Chat (IRC) systems tend to be used for communication between strangers around topics or activities of common interest. IM is used for messaging with known people.

Users can use nicknames and add their friends to their so-called buddy lists. New names can be added to the buddy list by obtaining the nicknames through personal contact. Because messages cannot be sent to those who are offline, the applications indicate who is online. As many people stay logged in for days or weeks at a time, seeing that someone is on line does not necessarily mean availability (Isaacs et al., 2002).

IM has become a substantial part of the young people's culture (Frees et al., 2004). There is little empirical information about how and why teenagers use IM. One reason why IM and SMS became so popular among teenagers is that the applications are trivial to install and set up, and they are light to use. The popularity of IM indicates that teenagers appreciate its synchronous or near-synchronous character and presence awareness, despite the fact that there exist many competing media (Schiano et al., 2002, Grinter et al., 2002).

The next results are based on a study of 16 IM users in the United Kingdom and the United States. The primary reasons for using IM among teenagers were (Grinter et al., 2002):

- socializing
- event planning
- schoolwork collaboration.

Multitasking seems to be characteristic for teenagers' IM use. All the participants of a study had performed other computer-based activities, such as completing schoolwork, web surfing, and emailing, simultaneously. Most of the participants interact via IM with their real space relationships. The major obstacle to the adoption was a lack of system interoperability, but peer pressure was even higher and is the major reason for IM adoption among teenagers. The participants had expectations about when their friends would be online. They also invited friends to join in a chat or made arrangements at school to meet on line later.

The IM ShowMe applications promotes a "Learn by Doing" approach and allows an instructor to view a student's desktop and use annotations and text messages to guide student towards solutions. In addition, the application includes the functions (Frees et al., 2004):

- to text message any student or instructor on the course
- to search previous text conversations in a database.

The IM application was tested during the years 2002 and 2003. In the last usage, half of the students (11/22) took part in a chat conversation. The conversations ranged from 10 minutes to over 2, 5 hours with a steady stream of text messages. Totally 975 messages were sent in the eight conversations. When asked whether the tools were useful, less than 50 per cent of the students agreed. There was no significant relationship between usage and grades on assignments (Frees et al., 2004).

In Sweden, a study was done on how the awareness of presence affects instant messaging in a large university computer laboratory. WebWho application was used in the study. It allows the possibility to virtually locate another student, and among other functions, to communicate via an IM system. Students used IM mainly to keep in touch socially and to organize and coordinate their group assignments, as well as to coordinate coffee breaks. Seventy per cent of the total number of messages were sent between different laboratory rooms within the building. Eight per cent were sent between different computers within the same laboratory room where students have actually seen each other. Twenty-two per cent of the messages were sent outside the building (Ljungstrand et al., 2000).

A mobile IM called Hubbub was used in a 5,5 month study. It is an IM that runs on a wireless Palm or a PC. The interviews indicate that most people developed a sense of connection with their remote colleagues, and some came to rely on it (Isaacs et al., 2002).

Studies of IM in the working place indicate signs of IM's ability to improve productivity (Handel et al., 2002, Isaacs et al., 2002, Nardi et al., 2000, Frees et al., 2004). The informal communicative nature of IM supports workplace activity and reinforces the social "glue" to tie people together (Grinter et al., 2002).

No research results on children's IM use were found. As described in Section 3.4.2, an attempt to provide interactivity via TV was made on the Winky-Dink and You children's programme between the years 1953 and 1957. There was also a "Barra Panda" edutainment programme in Portugal that included interaction with the tutor. According to the results, interaction with the tutor received negative comments from children.

6.4.3 Children's background

A total of 33 children - 18 girls and 15 boys - participated in the field study. Their ages varied from 10 to 13. The previous table illustrates the number of participants in each age group.

Table 9: Participants' age

10	11	12	13
3	25	4	1

91 per cent of children said they watch TV daily. Only one child said they did not watch TV at all. 46 per cent of children used a computer daily and 33 per cent of children used a game console daily.

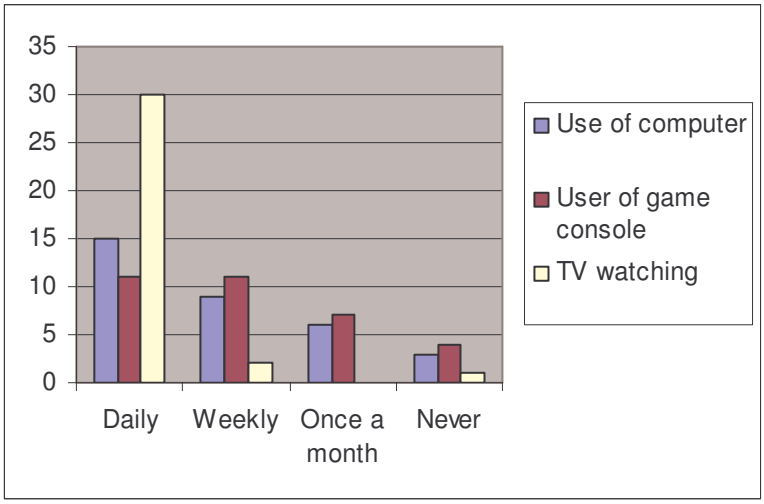


Figure 45: Use of computers, game consoles, and watching TV

Figure 46 illustrates why the children use computers. 33 per cent said that they use computers for IM.

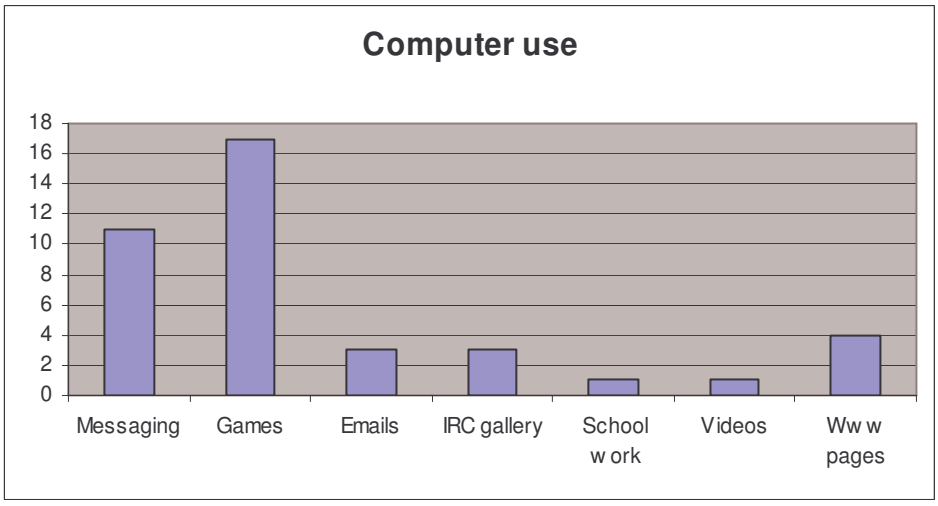


Figure 46: Purposes of computer use

6.4.4 Material and methods

The data-gathering techniques were: observation; interviews; questionnaires, and log files. The children's background information was gathered with a questionnaire. The children's work while using the communication programme was observed. Afterwards the log files of the communication were analysed. Children were interviewed in the same small groups in which they had used the application. The moderator was also interviewed. The interviews were based on the following themes: possible subjects to be discussed via IM; guidance on IM use; communication as a part of a TV programme; education with the help of TV; community via IM; the usability of a TV screen, and the IM application used.

A quantitative method was used to analyse the children's background information. To analyse the interviews and log files, the thematic analysis technique (Eskola et al., 2005) was used. The analysis focused on identifiable themes and patterns in the use of IM in the field study. The log files were analysed with the help of a quantitative method and a thematic analysis. The research questions based on the themes extracted from the interview data are:

- What is the purpose of IM use via DTV?
- What is the moderator's role?
- What are the policies regarding IM use?
- How can message writing be supported in instant messaging?
- What are the main usability problems with the application?
- Does the use of instant messaging via iTV promote an online community?

6.4.5 Performed research in the field study

Figure 47: Example of the MHP massager program on television screen

Because the required MHP STBs were not available in time, the field studies were performed at YLE and instead of using a television and a MHP STB the PC emulator was used in communication. On three Mondays from 9 to 13 children participated in the field

study, 33 children in total. They watched 'Tuu juttuun' programme on television in small groups of two or three. They discussed the themes in the programme simultaneously with the help of the PC emulator. The themes of the programme were: helping other people; fears, and the use of money.

Figure 48 illustrates the IM system used. When a child had written a message, the message was delivered to the Jabber server via an interaction channel. Next, the sent messages were checked by the moderator. She had the chance to accept or reject a message with the help of the message room moderator tool. In addition, she could write her own messages. The accepted messages were broadcast to the other children via a broadcasting channel.

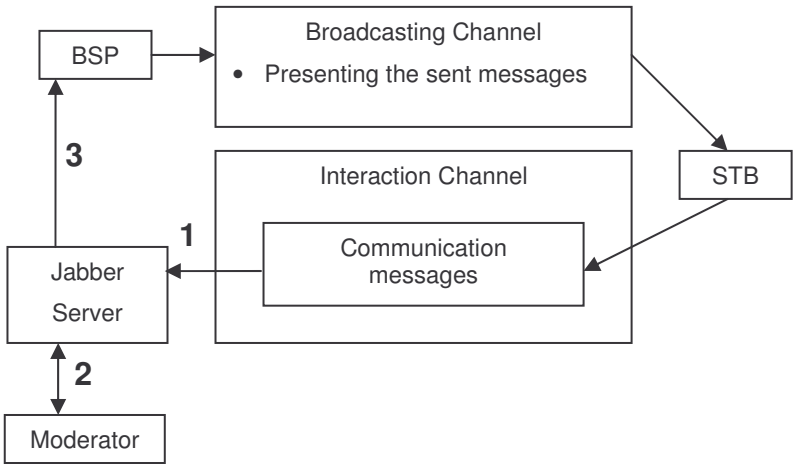


Figure 48: Communication system

6.4.6 Purpose of IM use via DTV

Table 10 compares IM use via the Internet and DTV.

Table 10: Comparison of IM use via the Internet and DTV (Aarreniemi-Jokipelto, 2006)

	Internet	**DTV**
Reason to use	Socialising, peer pressure	Participation, community
Communication with	Friends	Strangers, community members
Participation	Passive	Active
Tasking	Multitasking	Single-tasking
Reasons to use	Simple to install, easy to use	Available without extra cost
Policies	Tacit assumptions	Rules
Availability	24/7/52	During the programme
Functions	Communication Image delivery	Communication

The goal of IM use in the field study is characterised by children's active participation in the programme. The concept of the Tuu juttuun programme includes children's participation as an important feature of the programme, according to the interview. The broadcasting company created the frame for the programme, but the children as a community created the final programme with each other. They discussed the topic of the day and participated in quizzes. When comparing the reasons for using IM via the Internet, there are differences. The reasons for use via the Internet are characterised by socialising and event planning. Some use IM because of pressure from friends. The use is more passive than and not as goal-directed as it is via DTV.

With the Internet IM is used with friends, but with DTV the participants can be strangers or community members. They share the common purpose of exchanging ideas about the subjects of a programme. IM use via DTV has similarities to IRC use, because in IRC communication is between strangers.

Multitasking is characteristic of teenagers' IM use via the Internet. According to the interviews, the situation will not be the same with DTV. Active participation demands concentration on participation via DTV. There will not be extra time to perform other activities.

The reasons why IM became popular among users is that the applications were easy to install and use. According to the interviews with the children, the reasons for using IM via DTV are different. The most important is that there is no extra cost.

There are no strict rules for the use of IM via the Internet. According to the children, IM via DTV requires rules, because the purpose of IM is different. Without rules the subject of the communication will not be what it is supposed to be.

The service via DTV is planned to be available during a programme, but IM use via the Internet is available 24/7/52.

To conclude, because the reasons for using IM in T-learning differ from IM use via the Internet, the characteristics of IM in T-learning are also different.

6.4.7 Role of the moderator

Table 11 illustrates the types of IM use via DTV.

Table 11: Types of IM use via DTV

	Educational	**General**
Purpose	Educational	General conversation
Connection to a programme	Added value to the programme	Socialising
Moderator	Yes	No
Subject of messaging	Desired subject	No topic subject Fluent stream
Example of programmes	Tuu juttuun programme	Sport programme

IM via the Internet does not have a moderator. The need and role of a moderator via DTV depends on the purpose of IM use. It seems that a moderator is needed if IM is strictly connected to a programme and IM use is expected to bring added value to a programme.

Students felt that a moderator was needed if the communication was expected to stick to the desired subjects. The moderator reviewed all the messages before they appeared on the PC screen. In addition, the moderator's role was to ask the children questions and activate their work. The literature (Maloney-Krichmar et al., 2002) supports a moderator's active participation in IM.

A moderator's questions to children need to be formed so that answers are more than just "yes" or "no". However, questions cannot demand answers that are too long if writing time is limited. The idea was to avoid patronising questions, according to the interview.

6.4.8 Policies for IM use and message writing

According to children's views interviews, messages including swearing or abusing should be rejected. Half of them also wanted messages concerning off-topic subjects to be rejected. Totally almost twenty per cent of the messages were rejected. Part of online communities is policies, for example, in the form of rules to guide people's interactions. According to the children, some guide of rules in advance would have limited the number of rejected messages. The importance of rules is greater if the goal is added value to the programme instead of general conversation.

Figure 49 illustrates the messages sent. The number of messages sent varied during the three Mondays. The first group sent 180 messages, the second 207, and the third 252 messages. A total of almost 20 per cent of the messages was rejected.

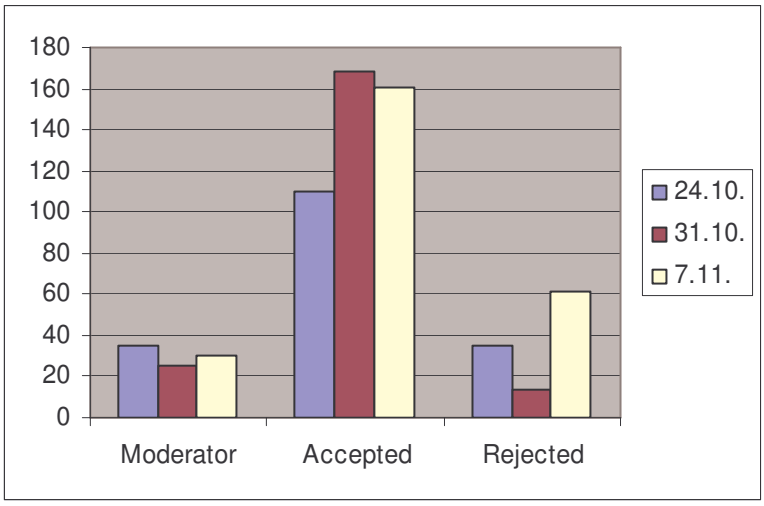


Figure 49: Number of moderator, accepted, and rejected messages

The average length of the messages sent varied from three to six words during the field study. Children mostly answered a question from the moderator or commented briefly on a theme in the programme. The moderator was usually the one who started a new theme.

Students did not want the discussion time to be limited to a particular time during the programme, but instead be available during the whole programme. The students would have liked to continue the communication afterwards in the Internet.

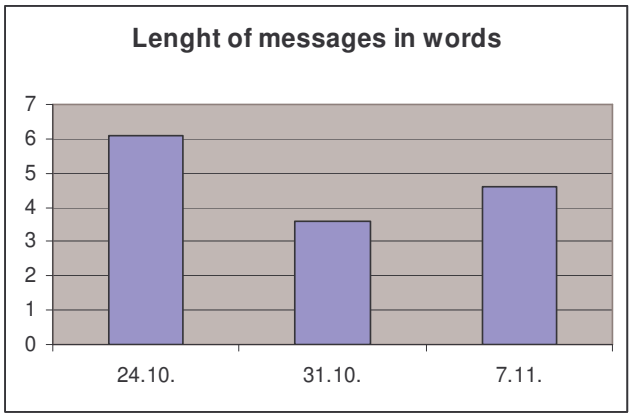


Figure 50: Length of messages in words

A favourite part of the programme was a drawing competition. Two children via telephone aimed to guess the picture that was being drawn on television. Children via the communication application competed with each other to see who could guess the picture first. According to interviews, in addition to commenting on subjects with the application, it can be used in this type of competitions.

Table 12: Types of IM use via DTV (Aarreniemi-Jokipelto, 2006)

	One communication room	Several communication rooms
Characteristics of communication	Commenting on a subject Answering questions	Deeper communication
Communication based on	Question	Theme
Time	Few minutes	Hour(s)
Subject	Frequently changing	Stays the same

In the field study, only one communication room was available. The application includes an option for the use of several communication rooms. According to the interviews, one communication room did not allow deeper communication about a subject, because the topics in the programme changed so fast. Commenting and short answers to the questions were characteristic of the communication. The use of several communication rooms would have allowed communication based on a theme to continue for much longer than was the case in the field study. Here the time for one question was limited to a few minutes. Several communication rooms would have allowed the discussion to take much longer, even hours. Here the subjects changed frequently, but with the use of several communication rooms, the subjects in a communication room could stay the same.

6.4.9 Usability

One of the usability requirements of a T-learning system is learnability, as described in Section 7.2.1.6. The students' ability to learn how to use the application was good. After a little guidance, students were able to write messages and to use the application. According to an interview: "I was surprised that the children started to work immediately." If the application did not work as the children had expected, it was not a problem. They were happy when they found a new function or a feature in the application. During the observation, it was possible to hear them scream for joy: "This works in this way." Despite a few technical problems, children felt that the application was easy to use. According to the

children, the application does not limit the discussed subjects. The main importance of the application was the active participation it allowed to the children.

Some children mentioned that Scandinavian letters were difficult to write because you need to use a virtual keyboard or press a button on a PC keyboard several times to get them. One child said: “It was difficult to write “ä”.” Another said: “It was irritatingly slow to write “ä” and “ö”.” The functionality is based on the same function used in mobile phones. Children had experience in using a PC and these functions did not work in the same way as they had experienced, because these functions were developed for DTV. The results could have been different if the environment of the field study would have been the MHP as it had been designed for.

Some children had difficulties in navigation. They were not able to move from the “message writing” field to check the participants’ messages. In addition, everyone had not noticed the possibility to see the archived messages. These types of problems would also have appeared if the environment of the field study had been DTV.

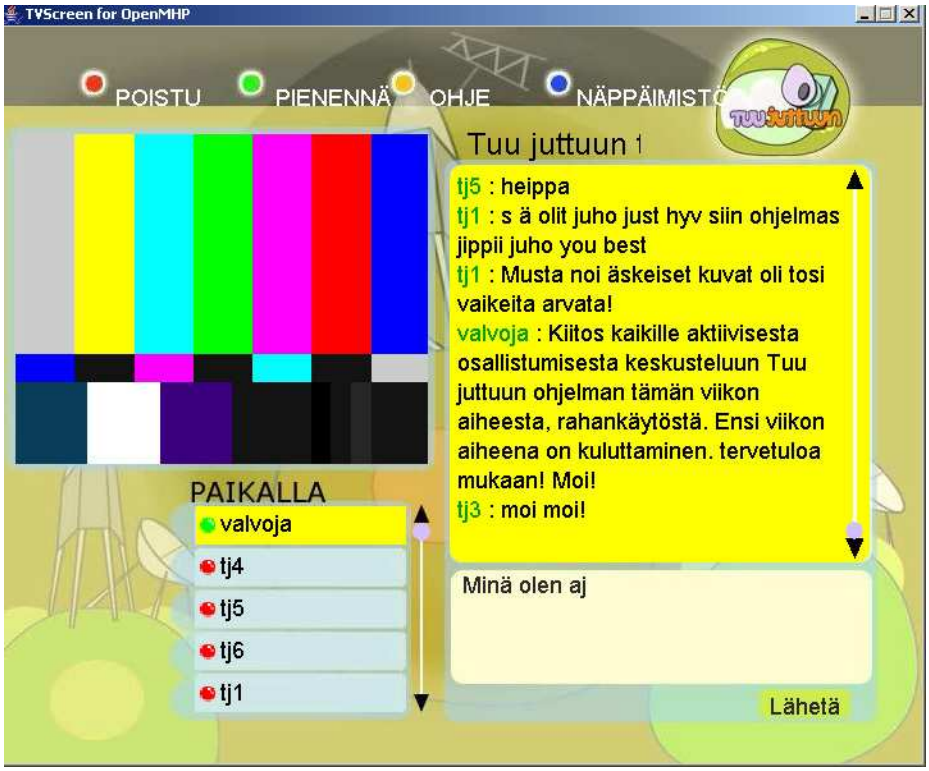


Figure 51: Another example of the communication application

The children felt that they were able to watch the incoming messages simultaneously while watching the programme. In practice, in many small groups, one child was writing and one or two children were watching the programme. According to children it would be easier to follow the programme and the messages sent simultaneously when both could be seen on the same television screen. According to the interview, it is at least as easy to read text on the television screen as it is on PC screen.

6.4.10 Online community

An online community includes four parts (described in Sub-chapter 3.1): people; purpose; rules, and technology. The field study fulfils the requirements. Children had the common goal of participating in the programme by communicating about the topic of the programme

in real time. The rules were not given by the broadcasting company, but children started to create them by themselves. The MHP application made possible real-time interaction between the children and a sense of community. However, the results are based on the use of instant messaging constructed for MHP, but used with a PC emulator. Thus, more results are required in order to confirm the results and to make it possible to say more about the character of the community created via iTV.

6.4.11 Conclusions

There are three main issues that affect IM utility. The issues are:

- purpose
- community
- programme.

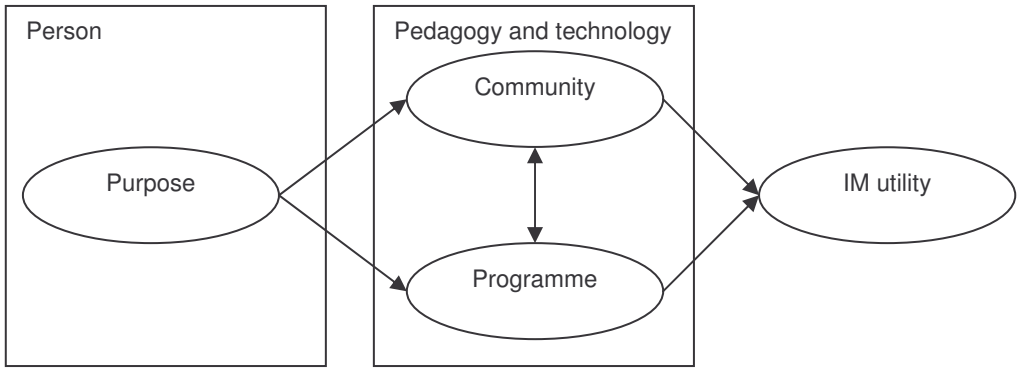


Figure 52: IM utility

The purpose of a user or a user group affects IM utility, but also the community and the programme. If the purpose is educational and goal-directed, it affects the participation, working with the use of IM, and policies. Additionally, a moderator may be needed. The participation is active, there is no time to do anything else simultaneously with IM use, and rules are required. A student stated that “if there are no rules, the messaging will be general communication and communication will be off-topic.”

The community and programme in T-learning are a combination of pedagogy and technology. The final form of the programme and the goal of the community are created in content production. In this type of service, both the programme and the IM community are needed for IM utility. If it is desired that the use of IM is to add value to a programme, the IM community has to have the characteristics defined by Preece, but it includes a fifth and new element: connection to a programme. The design of the programme defines the type of connection. It can be answering questions, participating in quizzes, or discussion about a subject.

The programme affects IM utility. It decides what kind of IM use is requested from a community. If the tempo is fast, only short comments or answers are expected. If the tempo is slow, deeper communication about a subject is requested.

Figure 53 illustrates how the learning system works. The **learning system** refers to the IM application and the server used for storing the messages. Students sent messages to the system. The moderator also sent messages and the accepted messages to be viewed by students.

Figure 53: How the learning system works

According to the children, the main benefits of the use of IM via iTV were:

- Does not cost any extra
- Easy to use
- Familiarity

6.5 Conclusions

iTV facilitates both formal and informal learning. The use of Instant Messaging in the connection of the “Tuu juttun” programme is a concept of informal learning which was liked by students, because it made participation in the programme possible. Additionally, the sign language study proves that iTV is suitable for informal learning. Both Motive studies are examples of formal learning via iTV.

On the basis of the empirical studies, iTV makes possible both asynchronous and synchronous communication. Asynchronous communication was used in the Motive 2 study. It provided flexible learning opportunities to adults to study while working full-time. In the Instant Messaging study, children participated in a TV programme using synchronous communication.

The students in the Motive 1 study stated that they would most probably also want to use the same kind of DVB-HTML-based learning service in the future. Most of the pages were plain text and only a few pages included still images. The textual format was liked. The browser was seen as working well for reading and browsing through the learning material. A student wrote: “It is a little bit slower to browse through the learning material compared to the use of a mouse and a keyboard, but it was a positive surprise compared to my expectations in advance.” The problem is the generation of text; the virtual keyboard was seen as too slow to use, and hence other devices were requested for writing.

In the Motive 1 study no problems relating to the use of TV for learning purposes were recorded. It seemed that it is important that students are allowed to make choices and decide how to move around the content. The use of a non-linear structure is a possible solution in TV, but TV as a medium needs to be recognised in content production. When asked in the Motive 2 study if digital TV is suitable for use as a learning environment, almost ninety per cent of students answered yes. A student stated: “In my opinion, digital TV is a medium for everyone, whereas a computer is still not.” Another student argued that “T-learning can be an option in particular situations”. These situations are, for example, geographical availability, visualised media, the familiarity of TV as a medium, and TV as an easy-to-use medium.

The multi-channel communication in the Motive 2 study was reported to be good because students were independent of time and place thanks to being able to use different devices for discussions. 24/7 availability meant flexibility in practice, because students could choose

the day and time of the day when they studied. A student wrote: “As long as you cannot use a traditional keyboard with the digital TV, there have to be other solutions available.”

In the Motive 2 study the students had a chance to discuss the case with each other. It made learning from others possible, and this was valued by students. Problem-solving in a group was favoured over working alone. The chance to communicate motivated students. Students were not studying alone, but instead they created a virtual community via television. It was possible to get help from the other members of the community and from the tutor.

In an MHP-based learning environment, a great deal can be accomplished with fairly simple and economical solutions. The MHP-based learning environment can be a good solution when the subject being studied changes continuously and the learning material has to be updated frequently. A student in the Motive 2 study stated that “DTV is one media possibility for distance learning, but TV imposes new requirements on the content: it demands tight, clear, and concise material.”

On the basis of the sign language study, DTV is suitable for learning in sign language, because the instructions for the assignments can be given with sign language and because DTV promotes visualised presentation forms. According to the study, the three main benefits of TV for the deaf are: visualised media, the familiarity of the medium, and good accessibility. The high quality of pictures and videos and adjustable contrast are advantages of TV which benefit the deaf. The familiarity of TV and its ease of use make it easy to start using TV for learning.

7 T-learning modelling

This chapter develops a T-learning model to inform the design and production of T-learning materials and services, drawn from the conclusions of the field studies.

Järvinen (2004) states that theory can be derived in an inductive way by generalising from the observations made by a researcher and from the results of empirical studies. As Figure 54 illustrates, the empirical studies, the realization of the Motive learning environment, and literature are used to construct the theory, model, and framework for T-learning. March et al. (1995) state that the theories must explain how and why IT systems work within their operating environments. IT research builds and evaluates constructs, models, methods, and instantiations, but it also theorises about these artefacts and attempts to justify these theories. The empirical studies aimed to understand and describe how and why T-learning services have worked or have not worked.

Niiniluoto (1980) states that theory collects, integrates, and systematises separate previous results. Figure 54 illustrates the ways in which the results from different sources were collected and integrated in this research. Empirical studies, which include four field studies and a survey, are the main sources. The realisation of the Motive learning environment (see Chapter 5) is also used as a source.

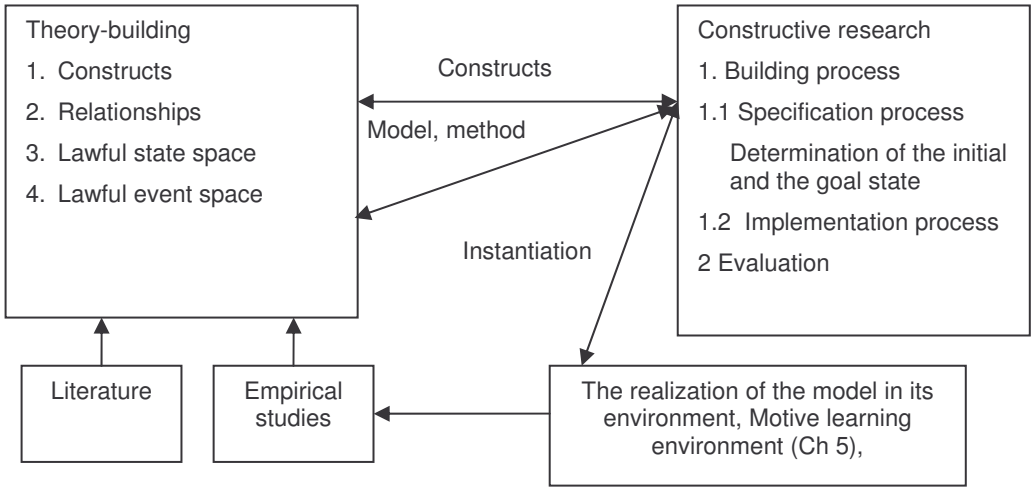


Figure 54: Methodologies and phases performed during the construction of the T-learning artefact

The results of constructive research are constructs, models, methods, and instantiations. The main research object of this thesis is the creation of a T-learning model to fulfil the requirements defined in Sub-chapter 1.3.

The motivation behind the building of a new artefact is either the lack of the artefact or the low quality of the outcome achieved by the old artefact (Järvinen, 2004). In this research the motivation was the lack of a T-learning artefact. Järvinen goes on to state that someone can also have an idea or a concept to apply or to use some resources in a new way. In this research the new resource was iTV technology, which was designed to be applied to learning.

7.1 The initial state

Building is a process of constructing a model for a specific purpose. The first phase is the initial state (see Sub-chapter 1.4.2).

The purpose of the construction process in this research is to create a T-learning artefact. In the year 2001, no T-learning artefact was found in the literature. Nor was any evidence of the use of the MHP standard for learning purposes found.

Figure 55 illustrates the initial state of the T-learning artefact in the year 2001. Television had been a popular and widely used form of media for distance learning via analogue broadcasting for over 50 years. Digital broadcasting in Finland started on 27 August 2001. The aim of the Transport Ministry in Finland was to cease analogue broadcasting in the year 2006. On 4 March 2004 the Finnish government decided that Finland will cease analogue broadcasting on 1 September 2007 and all broadcasting will be in a digital form. As described in Chapter 3, several digital television standards exist.

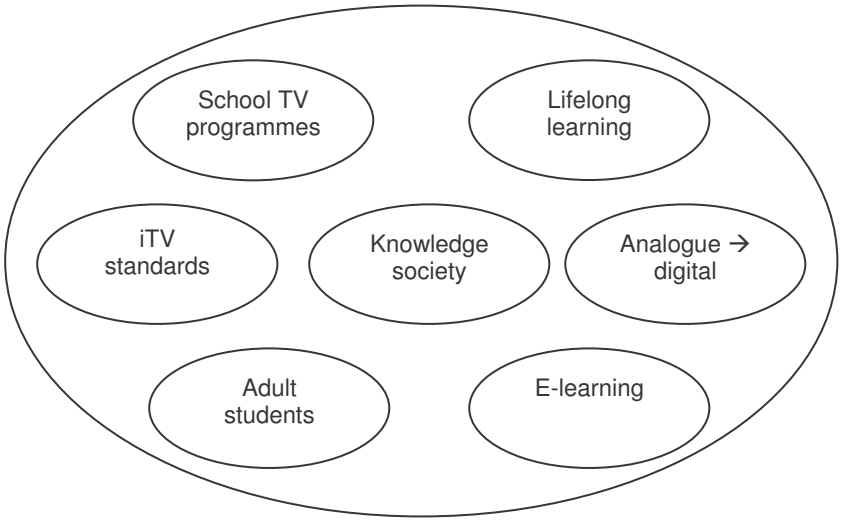


Figure 55: The model of the initial state

In the knowledge society education is no longer a once-in-a-lifetime experience that happens during childhood or early adulthood, but rather a continuous lifelong process. Adults need education to advance their career position. Older persons are a new interest group for education. E-learning has not been able to fulfil the new requirements of the knowledge society, as described in Section 1.2.2.

7.1.1 The specification process

The purpose of the specification process is to determine the goal state of phenomena (Järvinen, 2004). In this research the purpose is to determine the goal state of the T-learning model under construction. The general requirements for the goal state were:

- Interaction and communication need to be made possible in the T-learning model.
- Graded assessment needs to be made possible.
- Learning material and assignments need to be presented.
- Possibility to use the same model in the context of different subjects.
- Possibility to use the model in the context of subjects which need to be updated often.
- Opportunity to support the learning of adults and older persons.

Weber (2003) states that a theory is an account that is intended to explain or predict some phenomena perceived in the world. To describe anything perceived in the world, two fundamental constructs are needed: things and the properties of things. Phenomena are the states of things or events that occur to things.

The objective of the research was to build a theory or a model to make it possible to understand and describe the main functions and characteristics needed in learning via iTV. The phenomenon consists of five things: content producer; student; teacher; content, and iTV learning system. The events in the five things are content production and the learning process, as illustrated in Figure 56.

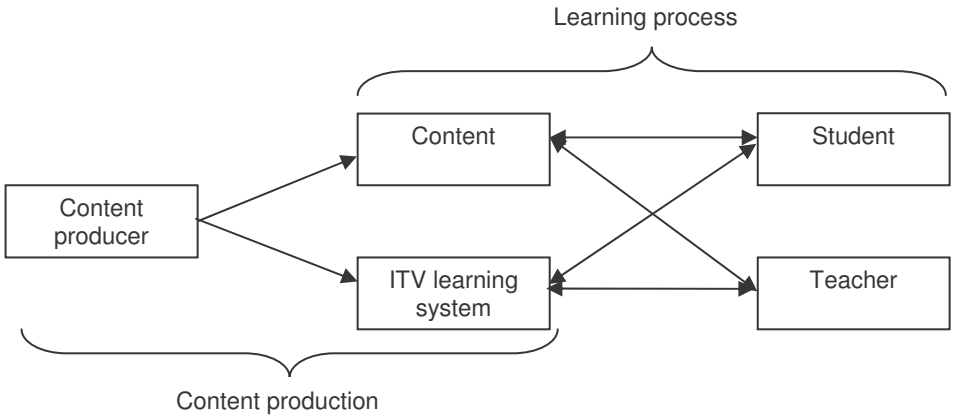


Figure 56: Things and events of things in the T-learning phenomenon

A **construct** is a property of a thing. Weber (2003) states that theory seeks to explain or predict the values of or changes in the values of these properties. The properties of the iTV learning system and content were defined as follows:

- interactive
- able to transfer the content to students
- able to assess learning
- supports the learning process.

Interactive refers to the interaction between students, between a student and a teacher, and between a student and an iTV learning system/content. **Transferring of content** refers to the transferring of learning material, assignments, and sent messages to the students. **Able to assess learning** refers to the possibility of assessing learning somehow. **Supports learning process** refers to the features and functions that aim to support learning. The T-learning theory seeks to predict the values of these properties.

Weber (2003) states that often some subset of properties is likely to have a special status in theory-building. These properties are called **dependent variables**. The other properties are of interest because they are associated in some way with changes in the value of the dependent variables. In this research the properties of the iTV learning system and content are dependent variables and changes in the other properties are seen to affect the value of dependent variables. Weber goes on to state that once the constructs have been chosen, it is necessary to explain how they are related to one another; in other words, how the values of constructs change in concert according to some sort of law. Specifying laws of interaction can be difficult. In this phase of the research, it can be said that the values of the constructs are associated with one other, but quite how cannot be specified more precisely.

Järvinen (2004) connects Weber's (Weber, 2003) lawful state and even spaces of theory-building to the initial and goal states of a building process. The **lawful state space** refers to the set of combinations of construct values for which the model is expected to hold good. The choice of constructs dictates the things to which the model applies (Weber, 2003, Järvinen, 2004). The **lawful event space** refers to a set of changes in the state of the constructs for which the model is expected to hold good. In this research the theory will not

account for the phenomena that are not included in the given T-learning definition. This is also the boundary of the domain of interest. The values those constructs can take on are defined later in this chapter.

The main problem relating to T-learning was defined in Sub-chapter 1.3 as “Which kinds of T-learning models ought to be developed to understand and describe the conclusions and observation results from the field studies”? Figure 57 illustrates the things and features needed in the goal model as a picture.

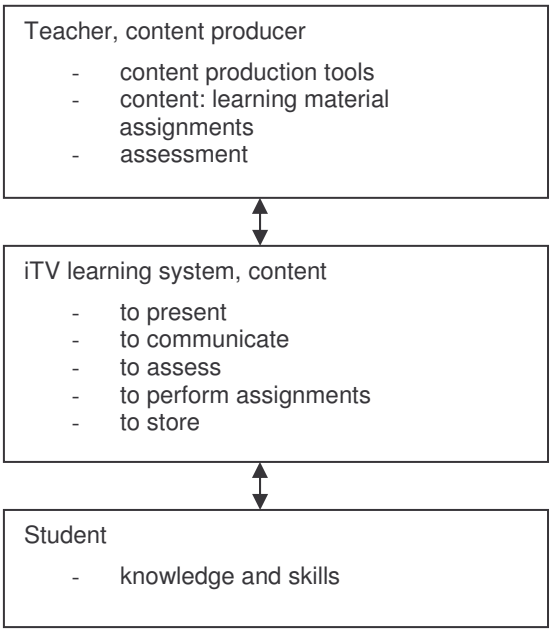


Figure 57: Things and features needed in the goal model

Teachers and content producers need to have a way of producing content. The system needs to present content, provide a way of communicating, to perform assignments, and to store the content. The output from the system is the provision of knowledge and skills to students. Teachers need a way to assess the output of the iTV learning system. The output is the result of learning through the iTV. The output can be used for formal and informal learning.

The following list of problems extracted from the picture illustrates the required functions of an iTV learning system.

- How to produce learning material?
- How to store learning material?
- What is technology?
- How to assess learners?
- How to present learning material and assignments?
- How to communicate?
- How to perform assignments?
- How to create knowledge and skills?

As described earlier, the T-learning phenomenon was defined as consisting of two events: the learning process and content production. Figure 58 illustrates the subsystems of the iTV learning system.

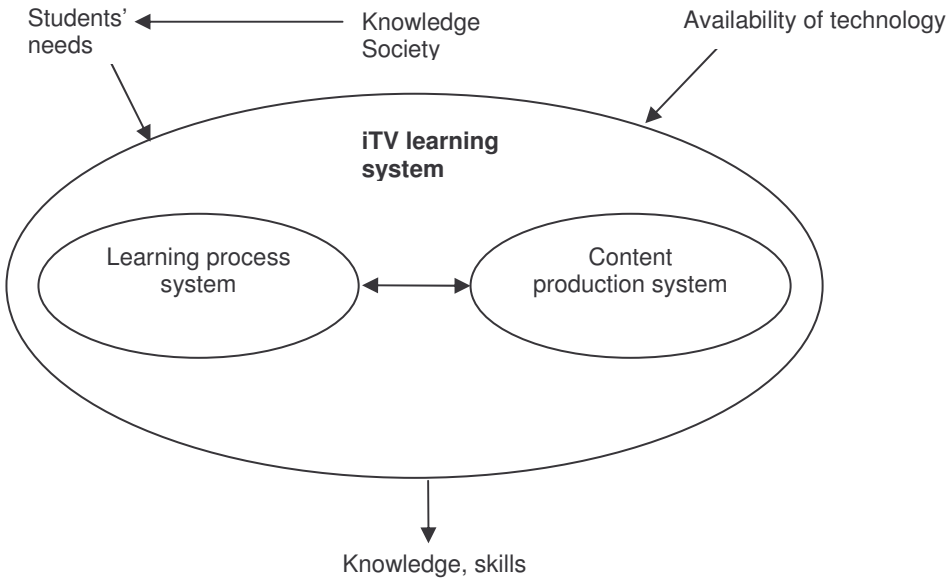


Figure 58: Inter-relation of systems

The system is affected by students' needs, the Knowledge Society, and availability of technology. It should produce knowledge and skills. The earlier defined functions are used to identify what the learning system needs to accomplish. The following definitions are defined for every event.

Learning process system

- The system should enable communication between students and between a student and a teacher.
- The use of communication media should allow multichannel use.
- The system should enable presentation of learning material and assignments.
- The system should enable responding to assignments.
- The system should enable assessment.

Content production system

- The content producer should be able to store the learning material.
- The content producer should be able to transform the content into required form.
- The content producer should be able to update the content.
- The content producer should be able to use the content in different courses.

Figure 59 illustrates the goal model of the iTV learning system.

The learning process needs to allow different forms of communication using message writing and reading and the use of several media. It also needs to allow the presentation of content, performance of assignments, assessment and response to support a student's active role. The content production needs to include features to produce content and transform it to a particular form, and to store learning material. In addition, the material is updatable and reusable in different courses and media.

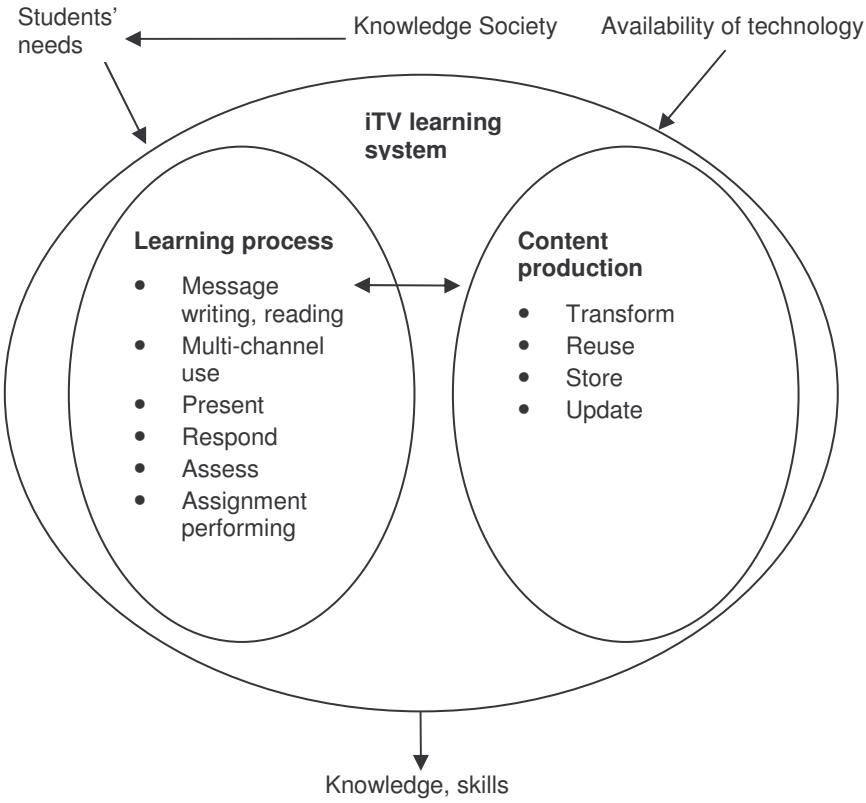


Figure 59: The goal model of an iTV learning system

7.2 The implementation process

Järvinen (2004) states that in the implementation process the research question can be formulated as follows: Given certain initial and goal states and particular resources, how can an artefact be built specifying the given specification? Theoretical and/or empirical concepts and ideas are needed. This research uses the conclusions of the empirical studies, the literature of iTV technology (Ch 3), and televised learning (Ch 2) in the implementation process.

Järvinen (2004) goes on to say that in order to solve the problem, a researcher can apply at least two different heuristics: problem reduction and state transition. In this research, **problem reduction** is used, in Järvinen's words, to divide a problem into sub-problems, and then later again into sub-sub-problems etc. until a solvable sub… problem is found. There are two principles used to perform the reduction: breadth-first and depth-first. In the **breadth-first** principle a problem is divided into sub-problems and a researcher tries to solve all the sub-problems at the highest level first. Attempts are then made to solve unsolvable problems at the next level down, and so on. Chapter 5, Motive learning environment presents the way in which the T-learning environment was constructed in this research.

The T-learning model aims to provide the general requirements specification for an iTV learning system. It also aims to form the language of the T-learning discipline. Conceptualisations are extremely important in design science because they define the terms used when describing tasks (March et al., 1995). It is not necessary to create totally new constructs for a discipline, but instead the existing constructs can be used (Järvinen, 2004, Järvinen et al., 2004). In this thesis the constructs of E-learning are used whenever possible.

The developed T-learning model defines the functions, usability requirements, and quality attributes of an iTV learning system. On the basis of the empirical studies, three types of features were found which affect the iTV learning system and content. The three types of features are technical, pedagogic, and personal features.

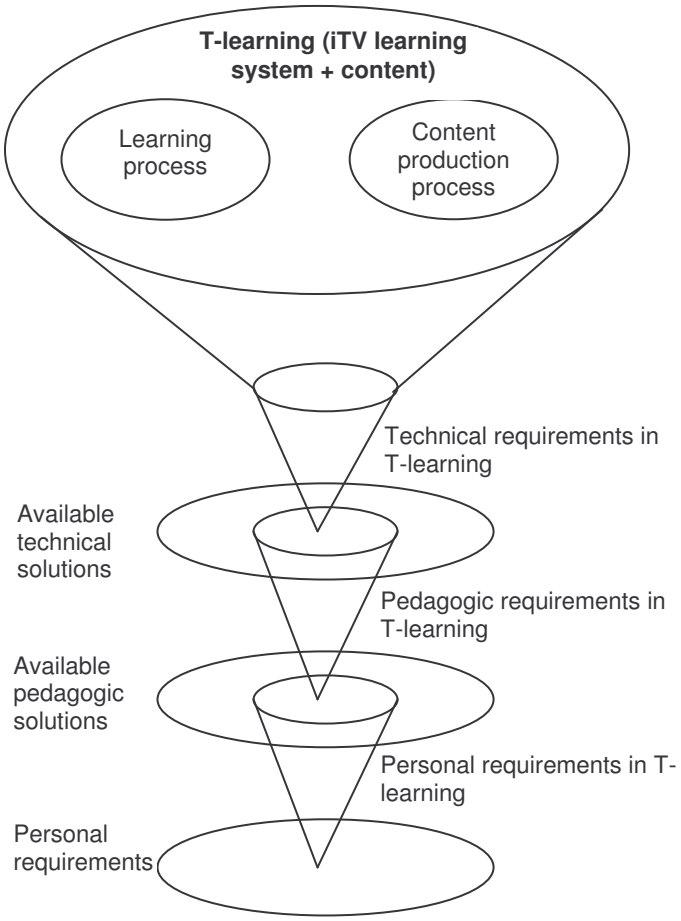


Figure 60: T-learning model

According to the field studies, personal requirements are crucial for T-learning services. In the sign language study (see Sub-chapter 6.3) it was recognised that deaf people's visualised culture affected the content structure, navigation, and types of contents to be used. In iTV visual elements means the use of figures, images, and videos in the content. In the Motive 2 study (see Sub-chapter 6.2), adult students studying in addition to work and family duties valued flexible learning opportunities, such as the use of multitechnology. In the IM study (see Sub-chapter 6.4) the purpose of a user or a user group affected the IM utility.

There exist several different kinds of personal requirements. The T-learning model defines the personal requirements that need to be recognised in the learning process and content production in T-learning.

According to the results from the empirical studies, pedagogical solutions are important for the final service. According to the students, solving the cases together in the Motive 2 study had influenced their learning. The virtual presence of the others had provided motivation and made problem-solving easier.

Technical solutions are affected by students' requirements and pedagogic solutions. They aim to fulfil the requirements. In the Motive 2 study asynchronous communication, multi-channel use in communication, the chance to choose the learning place, 24/7 availability, and DVB-HTML affected the utility of T-learning. In the sign language study good accessibility and usability were the benefits of TV in sign language use. According to the IM study, the goal of the service and the pedagogical solutions affect which kinds of technical solutions need to be constructed.

The personal (students') requirements affect the system from outside, while the other two affect it internally. The model allows the use of different technologies in T-learning and allows different types of learning to be performed in the system. It is possible to use only a particular subsystem of the learning system to implement certain functions.

As described in Chapter 1, lifelong learning is typical in an Knowledge Society, which means that new student groups participate in the learning services and affect the iTV learning system by its requirements. The availability of technology affects these technical requirements. Principles of learning affect the whole learning system.

The next table illustrates the key constructs of T-learning from a technical point of view. During the empirical studies (see Chapter 6), it was found than the content and the iTV learning system had more properties that were found during the specification process. Properties concerning technology are described in the next table. The table also defines the construct values for which the model holds good.

The technical requirements serve also as a reference model for platforms used in T-learning. This model describes the technical requirements, but not the technical level of the requirements.

7.2.1 Taxonomy of technology

Table 7: Taxonomy of technology

Dimension	Description of values
Transmission • the role of iTV technology in transmission	• iTV as the only available technology • Students using separate technologies • Students using multitechnologies
• service availability	• push services • on-demand, pull services
• time shifting.	• personal video recorder (PVR) • on-demand.
Interaction/Communication	• student – learning material • student – student(s) • student(s) – teacher / tutor • student – learning environment
Security	• data integrity • authentication • data privacy
Accessibility	• accessibility to suitable technology • accessibility to reliable technology • accessibility of applications • accessibility of content production tools • accessibility of open standards • accessibility of widely accepted/used standards • accessibility of the infrastructure
Controlling of system	
Usability • inside the learning environment	• relevant information presented • supportive images • videos to support text • clearly marked exits
• during 'student – learning environment' interaction	• feedback from system • instruction from system • devices working smoothly together
• student experience	• support learning • learnability • usable • valuable

7.2.1.1 Design options for T-learning applications

Transmission refers to the transmission of learning material, assignments, and sent messages. Transmission is a basic requirement in all T-learning services, as the empirical studies and literature show. The T-learning model allows the use of different technologies to assist in creating new learning possibilities following the definition of T-learning. Additionally, the student learning scenario (Hulsen et al., 2004) uses television to broadcast course material (see Figure 7).

There are three themes concerning transmission.

- the role of iTV technology in transmission
- service availability
- time shifting.

Time shifting is not valid for sent messages.

The technology of iTV is the primary technology in T-learning, but IP and mobile technologies are allowed to be used as secondary technologies. **The role of iTV technology in transmission** can have three forms in T-learning. First, iTV technology might be the only technology provided, as illustrated in Figure 61. That was the concept in the two empirical studies, sign language (see Sub-chapter 6.3) and IM (see Sub-chapter 6.4). Another example from the literature (see Sub-chapter 3.2) is school TV programmes broadcast for students via a broadcasting channel.

Figure 61: iTV as the only available technology

Second, students are using iTV technology in learning, but in addition to the iTV technology, some of the students can use other separate technologies - mobile, IP, or other - when they experience accessibility problems. The part of the content to which the other technologies should be made available, and for whom, is decided in advance. The concept of students using separate technologies is illustrated in Figure 62.

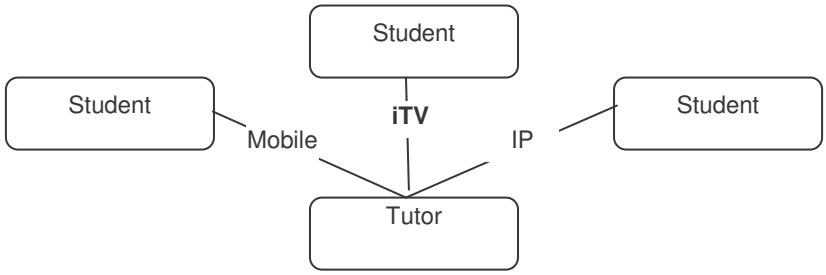


Figure 62: Students using separate technologies

Kjus (2005) has the same idea of a different combination of cross-media. He states that a basic cross-media structure is when each medium carries out self-contained communication with different audiences.

Third, students have total freedom to choose the technology they want to use. The choice can be limited to certain parts of the content, but students have the chance to use the technology that satisfies best their need in different circumstances. The same content can be seen in connection with any of the technologies. This supports the idea of lifelong

learning, because students can fit their studies in more flexibly with their other work and family duties. The idea of students using multitechnologies is illustrated in Figure 63. The T-learning field study in a digital television cable network (see Sub-chapter 6.2) is an example of this. In the study separate technologies were allowed to be used for communication. According to the results, multitechnology use is important for working adults, because students are independent of time and place while studying.

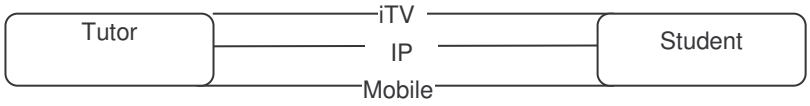


Figure 63: Students using multitechnologies

In the context of cross-media Kjus (2005) has defined the same kind of structure. He states that the other basic structure of cross-media is a structure in which all media function inter-dependently in communication with the same audiences.

The second theme in transmission is **service availability**. Technologies give the student more choices. The way the learning material is delivered in T-learning services can be divided into:

- push services
- on-demand, pull services.

The **push services** are scheduled by broadcasters. Educational programmes (see Sub-chapter 3.2) and connecting with classrooms (see Sub-chapter 3.3.3) are typical examples of the push type of services. The educational services are not available for the student at the time desired by her, but, instead, at the time decided by the broadcaster. The IM field study is an example of push services. The IM service was available only during the TV programme. The IM field study is an example of the push services. The IM service was available only during the TV programme. If recorded lectures (see Sub-chapter 3.3.2) are mailed to the student, she has more freedom to choose the time of learning; if they are watched together in the classroom they are a form of push service. The State University of California (Mara, 1964) and Michigan State University (Sawyer et al., 1986) have used recorded lectures mailed to students. Pennsylvania State University (Robinson et al., 1989) has used recorded lectures to be watched in classrooms.

On-demand learning services are learning services which can be downloaded via the interaction channel at the desired time. In the case of on-demand services, the student has control of delivery, but in that of push services, the service provider has control. López-Nores et al. (2005A) argue that “in the T-learning environment, it does not seem adequate to leave the discovery of services in a pull model”. In this research totally opposite results have been gained. On-demand learning services were requested in the survey illustrated in Chapter 2, because with on-demand learning services students can study whenever they want.

On-demand T-learning services can be divided in three groups:

- on-demand services available 24/7/52
- on-demand services available 24/7 during restricted time periods
- on-demand services available restricted time.

Services available 24/7/52 are really available whenever a student wants, 24 hours a day, seven days a week, and 52 weeks a year. A 24/7-type of service is available 24 hours a day and 7 days a week, but only during restricted time periods. The results of the focus group define permanent availability (24 hours a day) as a content user requirement for news services (Brecht et al., 2005). The Motive 2 study has similar results. A 24/7-type service

was used in the Motive 2 field study (see Sub-chapter 6.2). Adult students valued the fact that they were able to choose the time when they studied. 24/7/52 can be used in informal learning services, but it is not suitable for formal learning, because formal learning traditionally requires involvement by administration, teachers, and other students. Thus, learning has some kind of schedule even though it does not require synchronous learning. On-demand services can be available also for a restricted time, for example during the programme the on-demand services are part of.

The third theme in transmission is **time-shifting**. From the time-shifting point of view, there are two T-learning solutions:

- personal video recorder (PVR)
- on-demand.

Looms (2005) defines **PVR** as a device that allows its user to watch television when and how he wants. He continues that in particular "young viewers are part of an "a la carte" society used to consuming what they want, when they want, and where they want".

Broadcasting of educational services is a push type of delivering. The service is broadcast via the broadcasting channel at the time decided by the broadcaster. PVR allows time shifting to the desired time by a recording of the educational programme. The student is responsible for the recording, and recording is possible only while broadcasting. Figure 64 illustrates the roles of students and broadcasters roles in time-shifting with PVR.

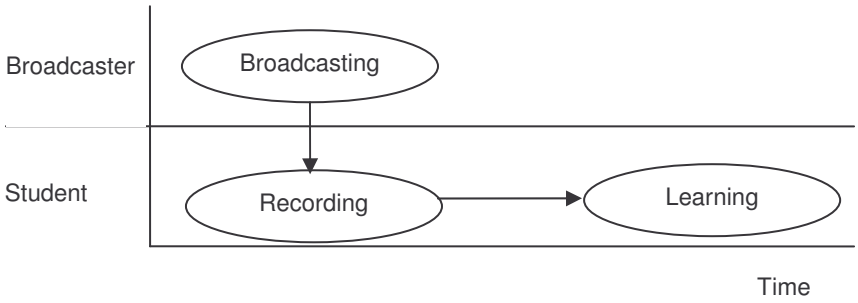


Figure 64: Roles of students and broadcasters in time-shifting with PVR

Figure 65 illustrates an on-demand educational service. On-demand educational services require an interaction channel. A student now has an active role and decides the delivering time of the educational service. A broadcaster or a service provider has made the services available, but a student decides the exact time of downloading and learning.

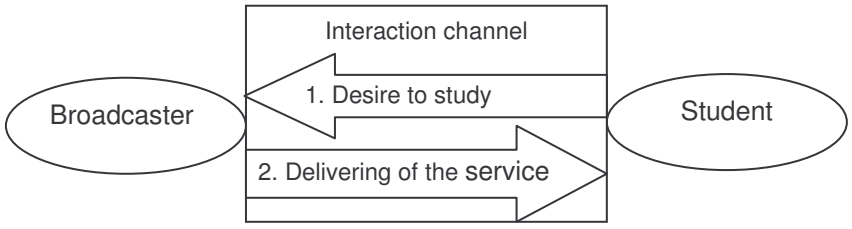


Figure 65: On-demand educational service

Technology allows time-shifting by means of the PVR. With time-shifting technologies, and television on-demand, the individual student has more choices and a more active role than in the push type of services of traditional broadcasting. An interviewee in the survey study emphasised that DTV with the help of on-demand services supports the idea that the

student is the most important part of the learning process better than analogue broadcasting.

7.2.1.2 Interaction/Communication

Jensen et al. (1999) state that watching television is always an active and interactive process, because viewers choose what they watch and interpret and make sense of what they see. iTV provides different kinds of interaction forms compared to analogue broadcasting. “The wish for interactive services is generally ranked low by users” (Rasmussen, 2003). However, there is a difference between adults’ and children’s notions. Children accept and master interactive functions more enthusiastically than adults (Rasmussen, 2003). According to the Motive 2 study adults also value interactive services. Different kinds of interaction forms were valued highly in T-learning. 87 per cent answered that the use of a communication channel in T-learning is either very important or important. The character of T-learning differs from the interactive services connected to a TV programme, which might explain why adults value interactive services.

iTV is needed to enable learning process via iTV. According to the field studies (see Chapter 6), there are four types of interaction in T-learning:

- student – learning material
- student – student(s)
- student(s) – teacher / tutor
- student – learning environment.

Figure 66 illustrates ‘Student – Learning material’ interaction as a one-way interaction. The interaction is performed inside of the learning process system in the T-learning model. The conclusions from the Motive 2 study (see Sub-chapter 6.2) prove that ‘student-learning material’ interaction is important. It made it possible to check in the self-assessment assignments how well the subject under study had been studied.

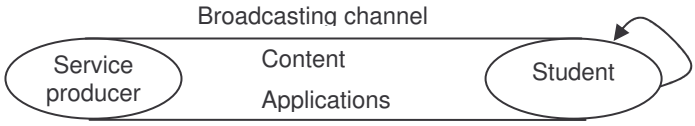


Figure 66: Student – learning material interaction as a one-way interaction

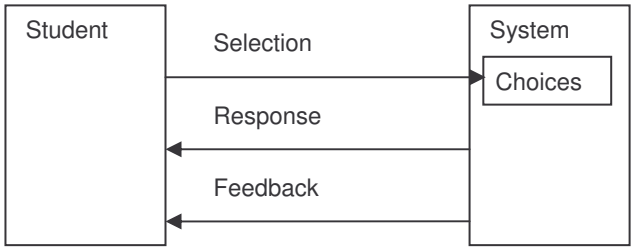


Figure 67: Student-learning material interaction

The learning material includes choices to be selected by a student. Choices include opportunities to select the desired part of the content in the desired order and selection opportunities in assignments. After students have responded e.g. to assignments, the system sends feedback. The system also responds to a student after a selection by opening a page.

Figure 68 illustrates ‘Student – Student’ interaction as a two-way interaction. The interaction requires an interaction channel for sending messages and a broadcasting channel for presenting sent messages. The interaction takes advantage of the learning process system in the T-learning model.

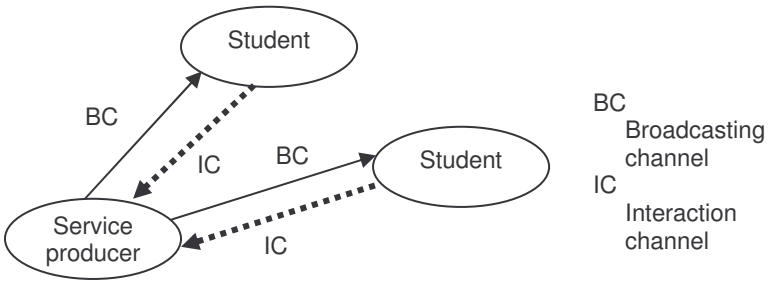


Figure 68: Student – student interaction as a two-way interaction

According to students in the Motive 2 field study, ‘student-student’ interaction was important, because interaction made learning from others possible. Problem-solving was also easier when interacting with others. A student stated that “motivation increases if you are not studying alone and have the chance to exchange ideas with other students”. In the IM study (see Sub-chapter 6.3) the whole TV programme concept was based on student-student interaction. The broadcasting company created the frame for the programme, but children as a community created the final programme by communicating about the topics of the TV programme.

Figure 69 illustrates ‘Student – teacher’ interaction. The implementation of interaction is similar to ‘Student – student’ interaction.

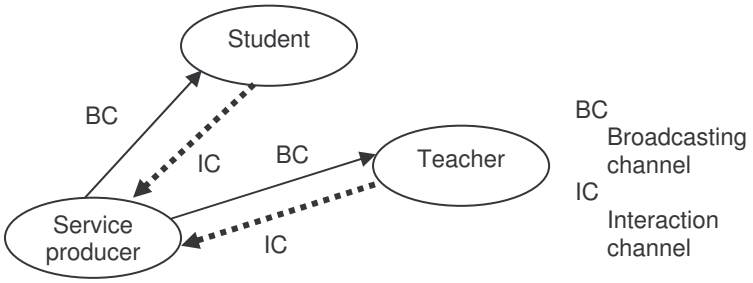


Figure 69: Student – Teacher interaction as a two-way interaction

‘Student-teacher’ interaction has different purposes. In the Motive 2 field study, the teacher had a role as an instructor of learning, not the supplier of knowledge. In the IM study students stated that a moderator is needed if the communication was expected to stick to the desired subjects. The moderator’s role was to ask children questions and activate their work.

Figure 70 illustrates the interaction between several students and a teacher. This is the concept used in the Motive 2 and the IM field studies. 87 per cent of the students in the Motive 2 field study felt that the use of a communication channel in learning in digital TV is either very important or important. The whole concept of a T-learning service can be based on this type of interaction, as in Sub-chapter 6.4.

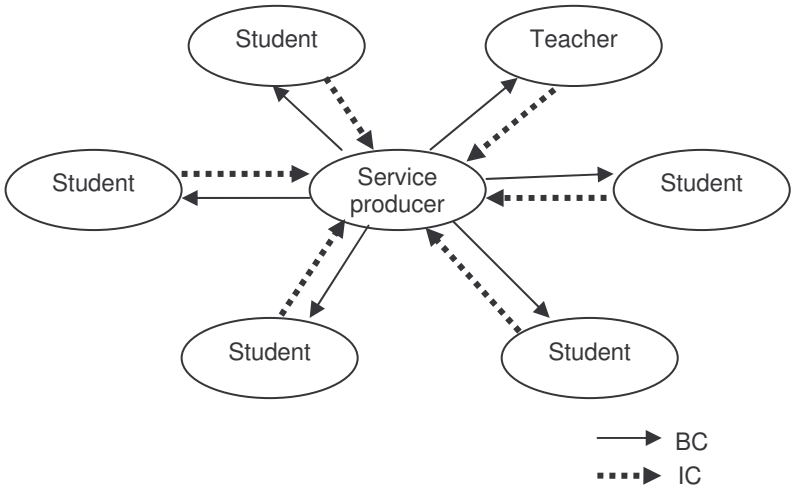


Figure 70: Interaction between several students and a teacher

Figure 71 illustrates the 'Student – Learning environment' interaction. The student interacts with the whole learning environment. The learning environment consists of two subsystems, the learning process and the content production, which are parts of the iTV learning system in the T-learning model. A student interacts with the learning process via a broadcasting channel and with the same system via an interaction channel. The student is not directly connected to a content production system, but the content sent to the learning process system comes from the content production system.

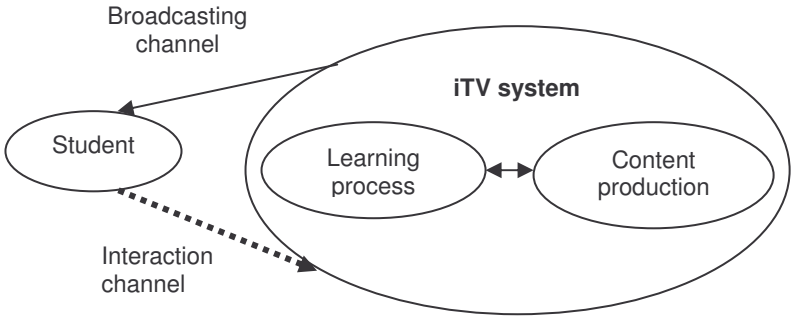


Figure 71: Student – learning environment interaction

In the iTV usability study, the importance of feedback after sending an email was recognised (Shrimpton-Smith et al., 2005). They stated that because of a lack of feedback 50 per cent of the test users did not know if their email had been sent successfully and they tried to send it again, but there was still no feedback and the test users felt frustrated.

7.2.1.3 Security

In the goal model, the security affects the learning system both internally and externally. First, it is outside of the iTV system in the 'student – learning environment' interaction. Second, it is inside the iTV system in the subsystems. The learning process, and content production subsystems need to be secured. In T-learning, security includes the following features:

- data integrity
- authentication
- data privacy.

Data integrity ensures that the data has not been modified and the content can be trusted to be exactly what it is supposed to be. Data integrity is important in, for example, the assessment of learning. Only authorized people may have access to student information, students' responses, and scores. In addition, it should be possible to check who has changed the information and when.

Authentication includes the students' identification and authorization. Reliable identification of students is required for providing access to learning services only to securely authenticated students. Unauthorized persons must not be able to read student messages in a learning environment. Secure access affects the students' desire to participate in a communication forum. Authentication can be ensured with username-password combinations, which have been generally used in E-learning also. If required, even more secure solutions exist for authentification in iTV. In the Motive 2 and IM field studies a username-password combination was used.

Data privacy refers to the protection and proper use of student's personal information. Personal information includes the student's social security number and scores. They must be stored so that only authorized people can reach them.

7.2.1.4 Accessibility

Like in all learning, accessibility is also important in T-learning. In the context of this thesis, accessibility has several levels in technology:

- accessibility to suitable technology
- accessibility to reliable technology
- accessibility of applications
- accessibility of content production tools
- accessibility of open standards
- accessibility of widely accepted/used standards
- accessibility of the infrastructure.

When compared with computers, one of the main advantages of TV is easy accessibility, because of the wide coverage area of DTV.

The United Nations "Standard Rules on Equalisation of Opportunities for Persons with Disabilities" (United Nations, 1994) call in rule 5 on governments to encourage the media to make their services easily available to everyone. In practice, it means that the technology needs to be suitable and reliable for the target group. Roibas et al. (2005) have suggested sound feedback accessible by means of each button to help people with minor vision problems.

Furthermore, applications, standards, and infrastructure are required. The target group affects accessibility, with different requirements for the T-learning service. The sign language study (see Sub-chapter 6.3) specifies the requirements for sign language use in learning. Motive learning environment (see Chapter 5) describes the demands for content production tools and applications. The whole research was affected by the iTV standards and devices based on particular standards.

7.2.1.5 Control of the system

Devices vary, depending on the technology, but T-learning sets a requirement for input and output devices. The functions required to control the iTV learning system are presented in Figure 72.

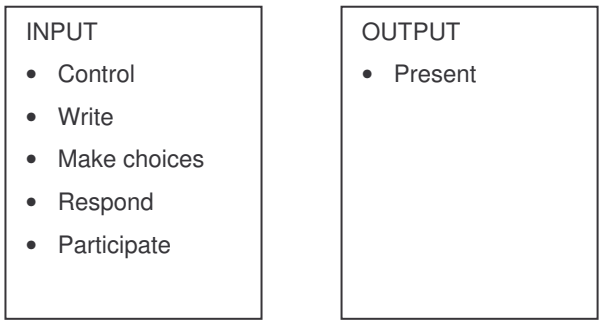


Figure 72: Functions of input and output devices

So far, the control device in MHP and IPTV has been a remote control of a STB. Because of the limitations of a remote control, it has been suggested that mobile phones could be used in the future as a control device. Roibas et al. (2005) state that an advantage of mobile devices is that they are personal. With the possibility of content providers tracking user's click streams, it might be possible to provide personalised services. A proper device for writing has not yet been developed. The use of virtual keyboards as the only writing tool limits any T-learning service; this needs to be recognized in content production. In addition, input devices are needed to make sure the student has an active role in making choices, responding, and participating. So far, these have been performed with a remote control.

The input devices allow students a new active role in iTV, but the output devices operate in a more passive mode. The main function of the output device is to present content. The devices needed by students to study in an iTV learning system have so far been a TV set and a STB, which are used for input and output.

The functions of input and output devices described are available currently, but in the future it might be possible to use voice and gesture to input and avatar to output.

7.2.1.6 Usability

T-learning usability requirements are affected by the students; the age of learning extends from childhood to old age and needs change during this period. In addition, students may have special requirements due to disabilities, thus the requirements of the quality of images, for example, or of texts and sounds may vary. Bad usability affects learning: the system becomes the key issue instead of learning.

T-learning usability requirements appear:

- inside the learning environment and content
- during 'student – learning environment' interaction
- student's experience.

The two first ones in the previous list define the functions needed to satisfy the usability requirements, but the last one in the list determines how students experience the learning service. For years, usability has referred e.g. to the testing of applications, interfaces, and navigation, but now "usability is replaced by human experiences" (Jensen, 2006). Instead of measurements of error rates and time per task, likeability, sociability, playability etc. are examined. Jensen (2006) continues that experience designers aim to create experiences that produce the desired perceptions, cognitions, and behaviour among their users.

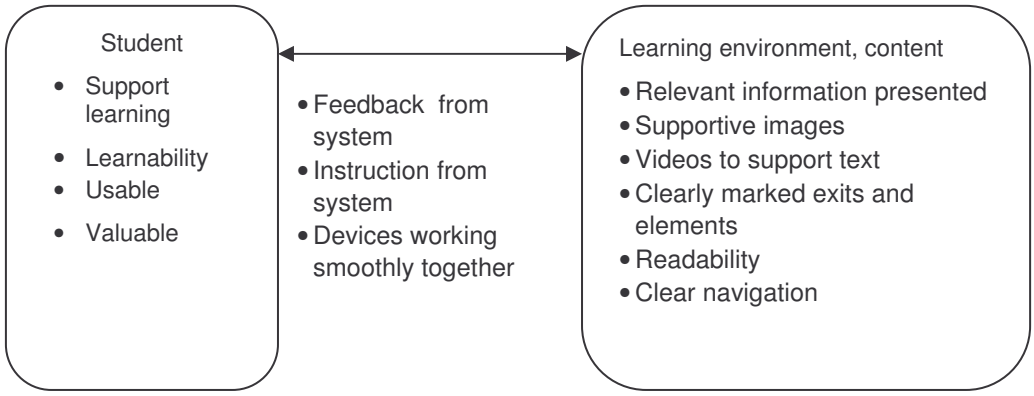


Figure 73: Usability in T-learning

Support learning refers to the support and added value which the service brings to students. **Learnability** refers to the speed with which the use of a system can be learned. **Usable** refers to a student's experience of how easy the service is to use. **Valuable** refers to the value the use of a service brings to students.

The system needs to provide feedback and instruction to a student. The devices and application should work smoothly together. Because of the nature of TV, only relevant information should be presented. In addition, supportive images and videos need to be used. The exit from the system should be clearly marked.

The font size, font style, and font colour/background affect readability (Darnell, 2005). The sign language study (see Sub-chapter 6.3) recommends that the background of text and a signer are monochrome, e.g. blue, to ensure readability and accurate recognition of signs. BBC (2002) suggests using a font of not less than 24 points for the body of the text and 18 in other cases. Bernardini (2005) states that there are problems connected with colour blindness, which need to be researched more. The key factors that affect legibility are: character shapes' relative weight or the thickness of character shapes, inter-character spacing, and aspect ratios (Roibas et al., 2005). They go on to state that Tiresias Screenfont satisfies the named limitations. The font was used in the field studies and no negative feedback relating the font was gained. Brecht et al. (2005) state that clear separation between content and navigational elements is important. The results of both the Motive 1 and sign language studies prove that navigational elements had been dealt with well in the content.

7.2.2 Taxonomy of personal requirements

According to the empirical research (see Chapter 6), personal requirements are crucial for T-learning. The situation is the same both in formal and informal learning. Personal requirements affect what kinds of technical and pedagogic solutions need to be used to satisfy the personal requirements. Personal requirements include type and goal of learning, accessibility, motivation and expectations, and special needs.

Table 13:Taxonomy of personal requirements

Dimension	Description of values

Type of learning
 	
Goal of learning
	• informal
	  ○ “media consumption” model
	  ○ entercation
	• formal
	• specific goals

Accessibility	• geographical • personal • technical
Motivation	
Expectations	
Special needs	Elderly, disabled, and those with visual and hearing impairment may have special requirements

The type of learning can be informal or formal learning, or a student can have some specific goals. The type and goal of learning affect the learning process and also the content production. The sign language study proves that the goal of a user or a user group affects IM utility, but also the community and programme. If the goal is educational and goal-directed, it affects participation, tasking during IM use, and policies. Furthermore, a moderator may be needed. The participation is active, there is no extra time for other tasking, and rules are required. A student stated that if there are no rules, the messaging will be general communication and communication will be off-topic.

Pemberton et al. (2006) define a “media consumption” model of language learning as it “assumes that the learner is primarily concerned with understanding a TV programme but would welcome unobtrusive support for language learning while doing so”. Rey-López et al. (2006) define a new concept for T-learning: entercation. Its purpose is using TV programmes as an entrance to education, providing learning contents related to the programmes.

Accessibility to learning services can be restricted due to the following kinds of reasons:

- geographical
- personal
- technical.

Geographical accessibility means that students’ location affects the possibility of their using iTV educational services. Increased accessibility in distance learning provides more learning opportunities to students, independent of location. As illustrated in Section □, one of the problems in E-learning has been limited access to the learning services. According to the survey, one of the advantages of DTV for learning purposes is its wide penetration.

The lessons learned from a T-learning project in the Amazon showed that in developing countries with a huge digital divide, the use of iTV technology can bring some isolated areas into the Knowledge Society (de Oliveira et al., 2006). They go on to state that in Brazil digital terrestrial television can have a greater potential for inclusion when compared to computers, even though the functionality is limited to STB use.

Personal accessibility refers to a student's personal ability to use educational services. There are students with disabilities for whom a distance education course is better suited than traditional learning. Personal accessibility might be restricted because of, for example, visual and hearing disabilities, which should be recognized in content production. According to an interview in the sign language study, old learning experiences affect the desire to study. Those who have had bad experiences from school have a lower threshold to start learning via the familiar medium of TV than participating in an organised learning opportunity.

Technical accessibility refers to the accessibility of technical devices and to the skills to use them for learning purposes. MHP educational services have suffered from technical accessibility problems, because MHP STBs have not been commercially available for cable networks. The first MHP STBs for cable networks were launched in Finland on April 2006. Accessibility was the most important reason for using DTV for learning, according to the survey. In this context **accessibility** refers to geographical accessibility. In the same study problems occurred relating to the lack of devices. Because of problems of this kind, T-learning has so far suffered from a lack of technical accessibility in the form of devices. At the beginning of the Motive 2 study students also had problems with return channel communication. These problems were mainly solved by additional information.

Motivation and expectations regarding the use of iTV for learning affect T-learning. T-learning students' motivation to do their best has a positive impact on learning. Users' expectation of a medium is based on their experiences; this creates a starting point for their expectations. Students' experiences in *Web-based education (WBE)* affect their expectations regarding the use of iTV for learning. Students who did not like to study in WBEs had more negative attitude to study via iTV in the Motive 2 study. The experience in the use of iTV affected positively the students' desire to use iTV for learning; the Motive 2 field study found that this also affected attitudes towards the future use of iTV.

There are several existing solutions, such as audio description and subtitling, that should be considered in T-learning when the target group includes people with special needs. Sign language can also be used. Elderly, disabled, and those with visual and hearing impairment may have special requirements for the functions of a T-learning service. The sign language study (see Sub-chapter 6.3) defined the special requirements for the use of sign language in T-learning.

7.2.3 Taxonomy of pedagogic requirements

Table 14 illustrates the key constructs of T-learning from a pedagogic point of view. During the empirical studies (see Chapter 6), it was found that content and an iTV learning system had more properties, which were found during the specification process. The properties concerning pedagogy are shown in Table 14. The following sections describe them in more detail.

Table 14: Taxonomy of pedagogic requirements in the T-learning model

Dimension	Description of values
Role of T-learning	Supplementary, Partial, Substitute
Content	• study guide • learning material • assignments
Interaction	• 'student-learning material' • 'student-tutor/expert' • 'student-student' • 'student-learning environment'
Assessment	• self-assessment • peer assessment • graded assignments
Construction of knowledge	
Learning process	
Personalized learning	
Connected to a TV programme	Yes/No

7.2.4 Degree of T-learning in the course/learning

T-learning can have following three different roles in formal learning, as illustrated in Table 14.

- supplementary
- partial
- substitute.

First, television can be used to supplement the conventional classroom learning. The **supplementary role of T-learning** refers to the situation when T-learning is used to provide additional, extra learning services or material. The use of T-learning is not mandatory for a student, because other media and face-to-face learning are the primary forms. An example of the supplementary role of T-learning is presented in the student learning scenario (Hulsen et al., 2004) in Sub-chapter 3.4.1.

Second, **partial role of T-learning** refers to the use of iTV as one of the media to enable learning. In this case, T-learning is planned to have a role and is partially needed in learning. The other parts can be mediated or delivered as face-to-face lectures. An example of the partial use of T-learning is at the University of Laval (Boulet, 1995, Boulet, 1997, Boulet et al., 2002) and at Oklahoma State University (Bailey, 1972).

Third, television can replace the conventional lectures altogether. In the **substitute role,** the whole learning process is planned as a T-learning service. An example of T-learning as a substitute for other forms is the Motive 2 study (see Sub-chapter 6.2).

7.2.5 Content

Based on the field studies, the content of a T-learning service consists of:

- study guide
- learning material
- assignments.

A T-learning service does not necessarily include all of them.

The importance of a **study guide** is even greater when using a new medium or an old medium in a new context. The study guide of a T-learning service should include, but is not limited to, the following information.

- How to use the medium?
- How to navigate?
- What the goal of a learning service is?
- How the learning-process implementation is planned?
- The steps a student should follow during the learning process?
- How to get help?

In the Motive 2 study students had a study guide that aimed to answer the previous questions. During the course not many questions arose concerning the previous questions. It seemed that the study guide served its purpose.

The type of **learning material** in educational programmes has for long been videos. However, iTV enables the use of animations, textual material with new features, and games. The purpose of **assignments** is to provide a context for learning and learning-support.

The structure of text-based learning material and assignments can be either linear or non-linear. In linear course structure, the order in which a course has to be studied is predetermined by the teacher; students cannot change it. The use of computers has brought the non-linear structure to educational technologies in a form of hypertext. In iTV, the hypertext format enables non-linear structure, where students can study the material part-by-part in the desired order. The MHP standard implements the text format with DVB-HTML and IPTV with HTML.

The structure of the learning service supporting navigation is critical, because it determines the way the users move around the learning material. The WBE uses pointer-based navigation, but iTV uses bi-directional movements on the television screen controlled by a remote control. The use of mobile devices for local interaction in iTV has been suggested to provide more-personal services.

7.2.6 Interaction

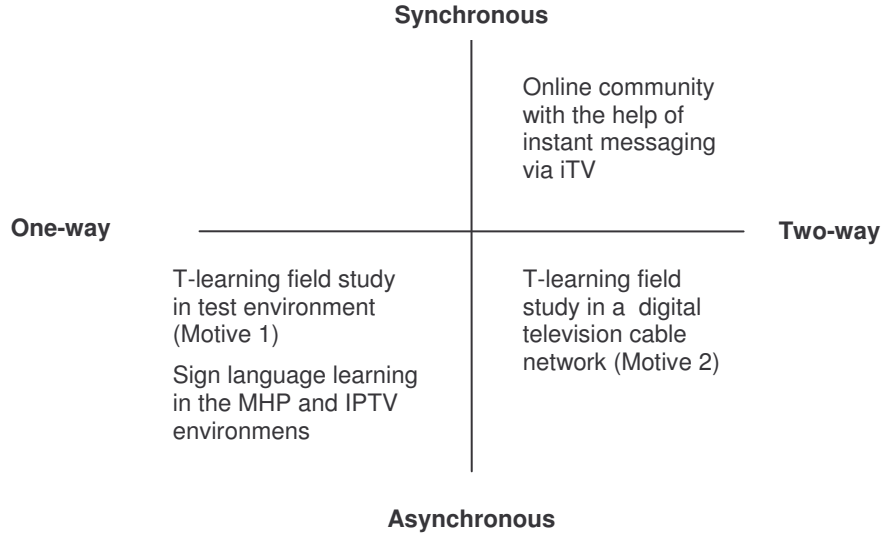


Figure 74: Interaction in the field studies

Traditionally, the use of TV in learning has been placed in the upper-left corner. In analogue broadcasting educational programmes have been synchronous and featured one-way interaction. The field studies prove that T-learning can exist in all four areas. The Motive 1 and sign language studies are examples of one-way services that allow only local interaction. However, the interaction was asynchronous. Both the Instant Messaging and Motive 2 studies included, in addition to the local interaction, other forms of interaction too. The IM study is an example of a synchronous model where students worked at the same time. Motive 2 followed an asynchronous model and allowed the students to interact whenever they wanted.

iTV enables both the synchronous and asynchronous models in communication. Asynchronous learning supports the students' freedom and makes it possible to communicate when it is most appropriate for learners. The synchronous model can also be used, because the sent messages can be updated to the television screen as often as required.

Figure 75 illustrates the following interactions enabled in an iTV environment:

- 'student-learning material'
- 'student-tutor/expert'
- 'student-student'
- 'student-learning environment'.

'Student-learning material' interaction does not require an interaction channel. It can exist in learning material, a study guide, assignments, sent messages, and initial feedback, according to the empirical studies.

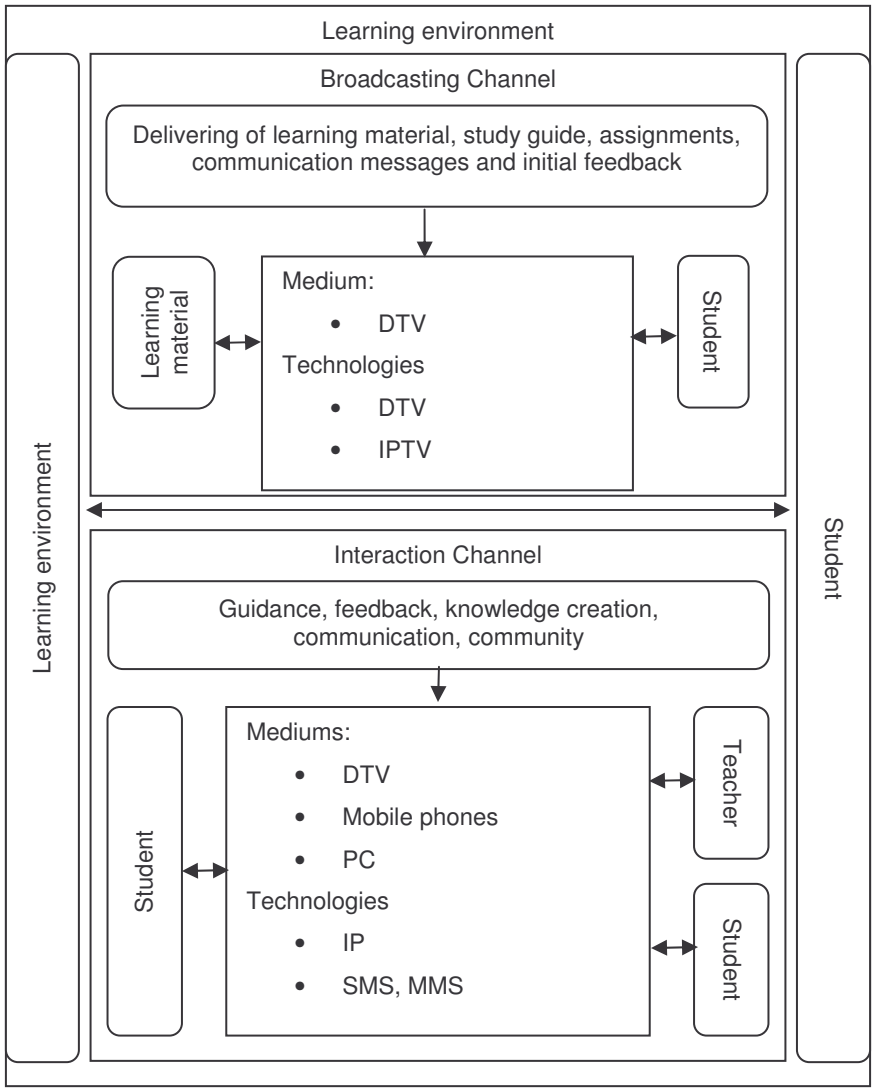


Figure 75: Interactions in iTV learning environment

Figure 76 illustrates how 'student-learning material' interaction worked in the empirical studies in this thesis.

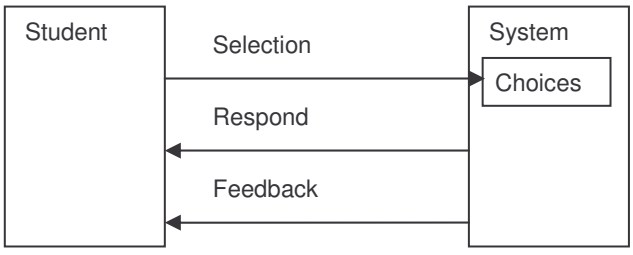


Figure 76: Student-learning material interaction

The **system** refers to the combination of a browser used to present learning content and the learning content. The learning content includes choices to be selected by a student. Choices included opportunities to select the desired part of the content in the desired order and selection opportunities in assignments. The **feedback** refers to comments sent to a

student from the system after a student has answered e.g. a self-assessment assignment. **Respond** refers to the opening of a page that is selected by a student.

Interaction in T-learning has several purposes, such as feedback, guidance, knowledge creation, communication, and community building.

There are four types of feedback in T-learning:

- feedback from learning material
- feedback from teacher
- feedback from peer student
- feedback from learning environment.

The **feedback from learning material** refers to local interaction with the learning material gained with the help of hyperlinks. In iTV it is performed via 'student – learning material' interaction. The **feedback from teacher** is similar to the feedback in traditional face-to-face lectures and is gained via 'student – teacher' interaction. Feedback from peer students can be used for peer assessment, for example. Feedback from fellow-students can facilitate easier problem-solving and increase motivation, as the results of the Motive 2 study show. **Feedback from learning environment** was one of the usability requirements. It is important that the learning environment responses when a student performs an action, sends a message to, for example, confirm that a graded assignment was delivered successfully. In the Motive 2 field study students were waiting for a confirmation message after delivering the graded assignments. In the iTV usability study similar results were found (Shrimpton-Smith et al., 2005). Because of a lack of feedback 50 per cent of the test users did not know if their email had been sent successfully.

The teacher's guidance is very important in iTV in the context of formal learning, as in all distance learning. A student and a teacher are together planning a student's learning process; a student needs to be guided through this process. The teacher can support the process by encouraging problem solving and by guiding the process towards deeper knowledge. The role of guidance may vary depending on the background theory used, but it is important that someone is following the process and helping it if required. According to inquiry theory, in iTV a student is taking an active role of her learning process, but a teacher is available if it looks like guidance and help is needed. The use of a communication channel in learning via DTV is important for most students, according to the results of the Motive 2 study. In most cases, this was because of the advantages gained in 'student-student' interaction.

An online community consists of: people, purpose, policies, and computer systems (Preece, 2000). iTV technology provides the base for communities via iTV. The base consists of different media and technologies that enable the sense of community between participants. There needs to be students to form a community and technology to enable community building via iTV. Generally, members of a community have a common interest in a particular subject. In formal learning, the community can be formed of a small group that is solving a case following the steps of problem-based learning. To develop the sense of community takes time; usually communities have a number of rules as to how they will work to achieve this. Formal learning communities need guidance or some kind of role determined by a moderator, whereas informal communities can exist without a moderator's active participation. According to the empirical studies (see Sub-chapter 6.4), if it is desired that Instant Messaging adds value to a programme, the IM community has to have the parts defined by Pierce, but it should also include a new fifth part: connection to a programme. The design of the TV programme defines the type of connection. It can be answering questions, participating in quizzes, or discussion about a subject. According to empirical

studies (see Sub-chapter 6.2), a virtual community motivated learning and enabled students to get help from the other members of the community.

7.2.7 Assessment

Figure 77 illustrates assessment choices in an iTV learning environment.

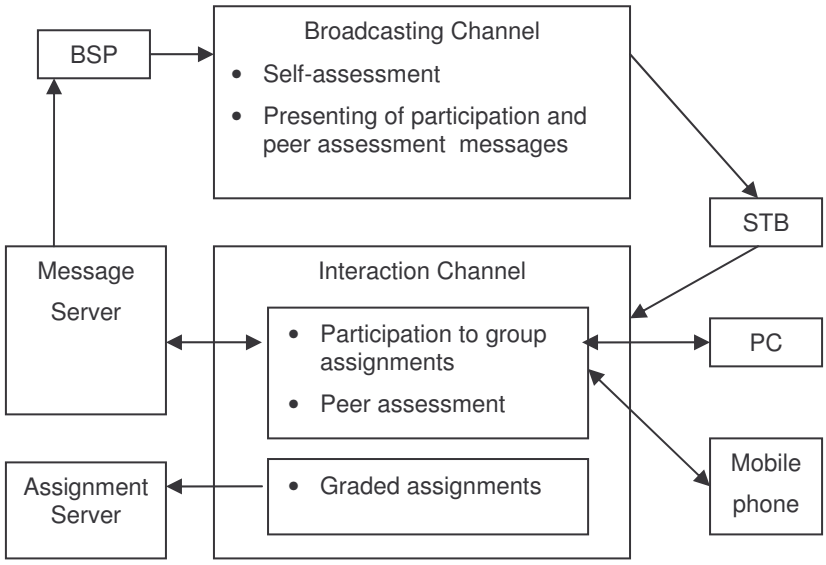


Figure 77: Assessment in an iTV learning environment

The iTV learning environment includes assessment possibilities such as:

- self-assessment
- peer assessment
- graded assignments.

Self-assessment assignments in the MHP-based learning environment provide immediate respond to a student. Self-assessment assignments can be used both in informal and formal learning. According to the empirical study (see Sub-chapter 6.2.5), self-assessment assignments can support learning. They allowed students to check easily how well a subject that had been studied had been learned. A student stated that “they increased motivation to learn”. Another student stated that “people learn from mistakes”.

The other assessment forms in iTV require the use of an interaction channel. Peer assessment and active participation in group assignments require a communication system, while graded assignments require construction of an assignment server.

If T-learning has a partial or a supplementary role in learning, the interaction channel is not absolutely necessary. Then, assessment can be based on assessment in face-to-face situations or the use of other media, as illustrated in Figure 78.

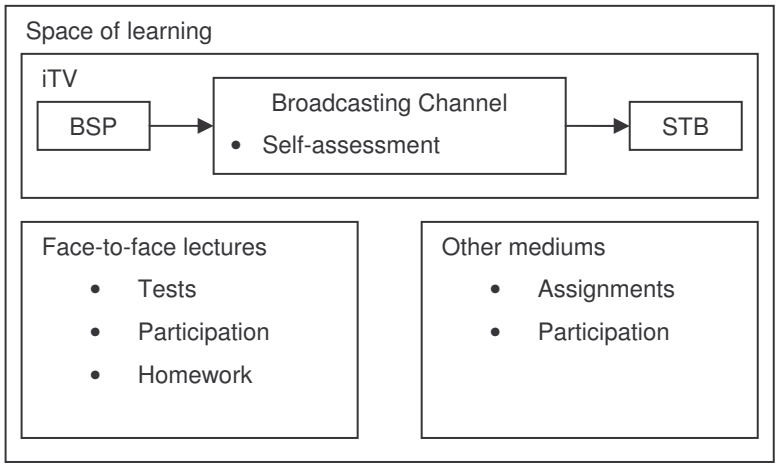


Figure 78: Possibilities of assessing when T-learning has a partial or a supplementary role in learning

7.2.8 Presentation of knowledge

During the Motive 2 study (see Sub-chapter 6.2) it was found that the presentation of knowledge requires collaboration between students. The technical requirement for presenting knowledge in T-learning is an interaction channel. DTV allows users to take an active role by using interactive applications broadcast together with the TV programmes. In the goal model, the existence of a communication system to facilitate interaction between fellow students and a teacher is required. It is based on the fact that a group is able to create new ideas and solve problems on the basis of the thoughts that others have presented.

7.2.9 Learning process

The T-learning service defines the factors required by a learning environment. A T-learning service requires a broadcasting channel. In addition, an interaction channel is required in many T-learning services.

Figure 79 illustrates the learning process in an iTV-based learning environment. In addition to learning material, the whole learning process should be notified in the use of iTV. Figure 79 illustrates learning process in a push-type learning service, where the content is delivered to the students via a broadcast channel at a time decided by the service provider. In the on-demand type of learning service, the interaction channel is used for delivering content. It demands an active role from the student.

The T-learning process consists of learning material, assignments, tutoring, guidance, conversation, and creating and sharing knowledge. The process is planned by a teacher and a student and always has a goal. The learning process takes time and includes several phases during the process. The goal affects the implementation of the iTV learning system. In formal learning, an interaction channel has a bigger role than in informal learning, where an interaction channel can be omitted. In formal learning, the interaction channel can be replaced by face-to-face lectures or the use of other media.

One part of the T-learning process is guidance, which includes evaluation, feedback, and managing the process. Guidance is important in iTV, because the format of learning is new and it has to make sure that students will not get lost in the learning material. In the T-learning process, continuous tutoring and assignments guide and support learning. As a result of the learning process, students will not only have gained new knowledge, but also new skills. By the use of iTV, it is possible to practice skills such as problem solving.

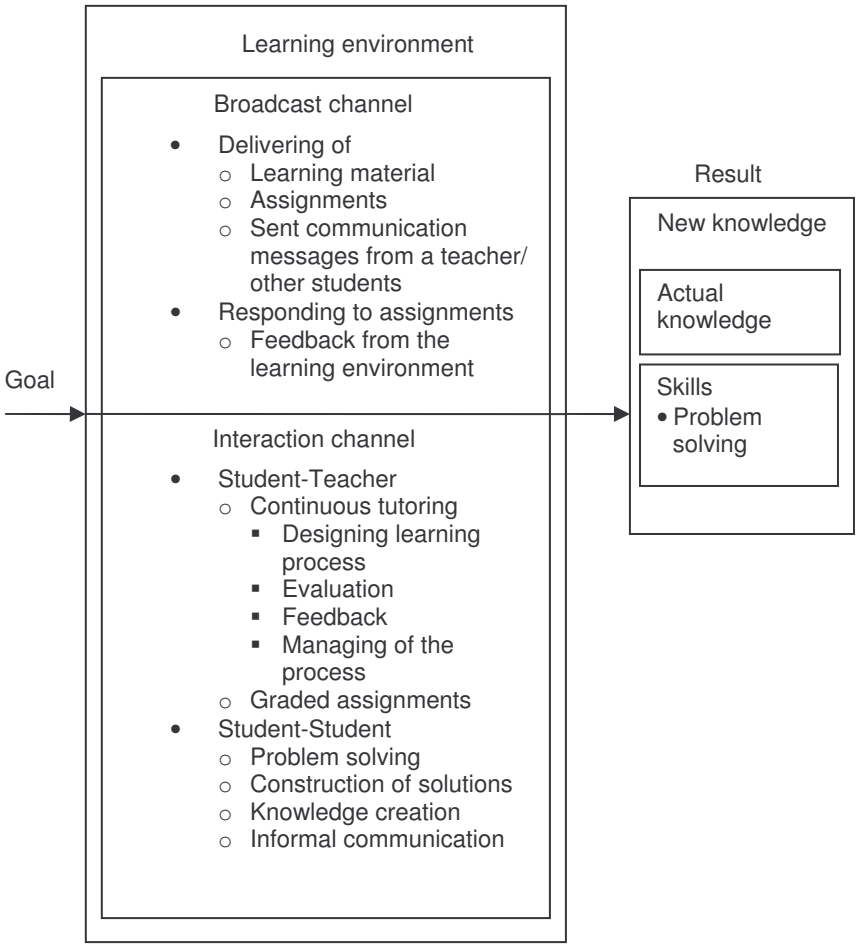


Figure 79: Learning process in an iTV-based learning environment

7.2.10 Personalized learning

Rasmussen (2005) states that “the general individualisation process in Western societies is strong in media and consumption and we will under all circumstances be witnessing a development of personalised media, including television”. One of the major advantages of T-learning is that it is personalized. Personalized learning paths can be gained in DVB-HTML-based material. The importance of personalized learning has grown during the past years because of lifelong learning and new demands from the Knowledge Society. Students have different background, which should be noticed in construction of a learning system and facilitating learning.

During the construction of Motive learning environment it was found that, with the help of the hypertext format, personalized learning paths could be developed in the DVB-HTML material. The path can consist of two parts:

- the part defining a person’s requirements
- the part personalizing the learning material.

However, the personalized learning paths were not implemented in the Motive project.

7.2.11 Connection to a TV programme

A T-learning service can be connected to a TV programme or not. In the IM study (see Sub-chapter 6.4) children participated in a TV programme with the help of an Instant Messaging application. Empirical studies using the Motive learning environment (see Sub-chapters 6.1 and 6.2) were not connected to a TV programme.

7.2.12 Constructs

In addition to the iTV technologies, T-learning includes others, such as mobile technology and *Internet* Protocol (IP). Figure 10 illustrates T-learning as a convergence of technologies and E-learning. The new definition of T-learning, which is valid throughout the T-learning modelling and the rest of the thesis is:

T-learning *refers to learning, enhancing the learning experience, and knowledge construction with the help of several technologies, such as iTV technologies, mobile technology, and IP. Television, or a device suitable for viewing broadcast contents, is the primary medium, while the others are secondary. T-learning may be totally technically mediated or it may include partly traditional face-to-face lectures and printed books. T-learning exists in educational and corporate organizations and supports lifelong learning by allowing access to learning at various ages.*

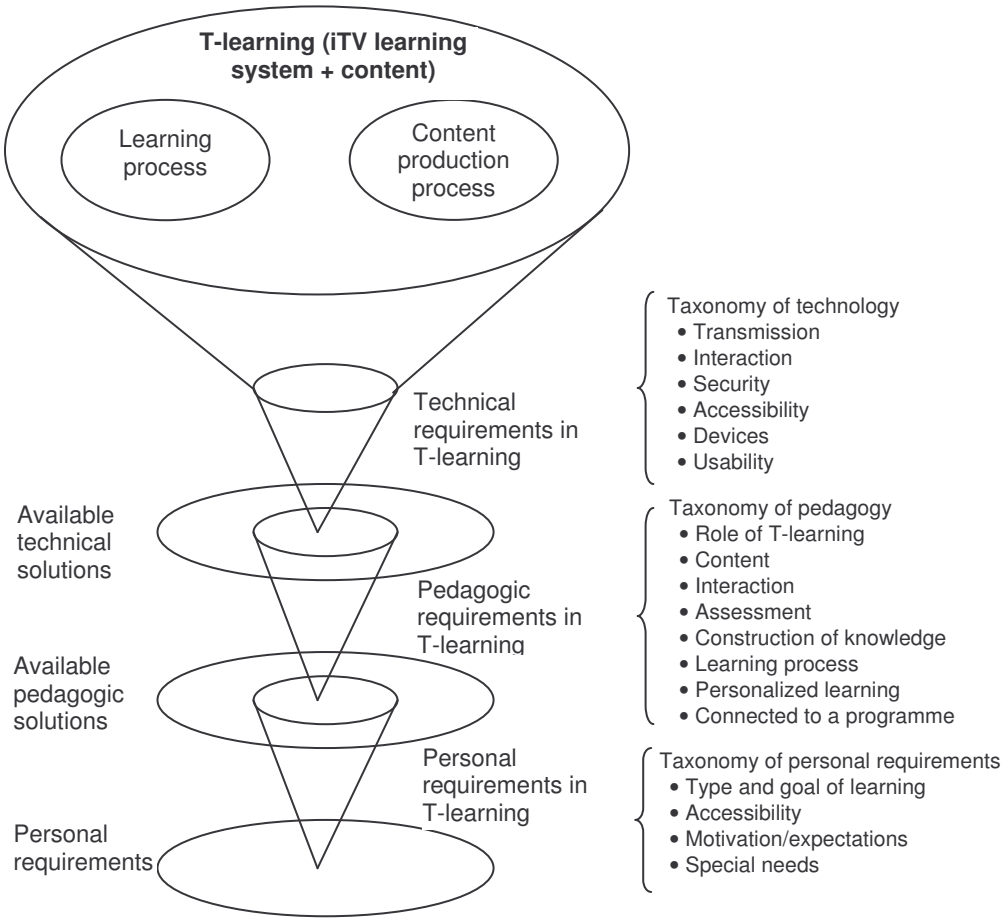


Figure 80: iTV learning model and constructs

Figure 80 illustrates the T-learning model and constructs for which the model holds good. The model describes the requirements for the learning process and content production. The system has to enable pedagogic and technical functions and fulfil students' requirements in an adequate way. This adequacy means security, usability, accessibility and support of learning process from the iTV system.

7.3 Conclusions

The technical requirements of the T-learning model can be used to discover whether the technology implementation of the platform allows the functionalities needed in learning via iTV. The technical requirements include functional and usability requirements and quality attributes. These are: transmission of learning environment, transmission of assignments, interaction/communication, security, accessibility, controlling of system, and usability.

Figure 81 illustrates what is delivered via broadcasting and an interaction channel. As described in Sub-chapter 8.4 an interaction channel has an important role in the learning process. If only a broadcast channel is available, only the following are enabled in T-learning:

- delivery of learning material
- delivery of assignments
- local interaction with learning environment and assignments
- self-assessment
- some form of personalized learning.

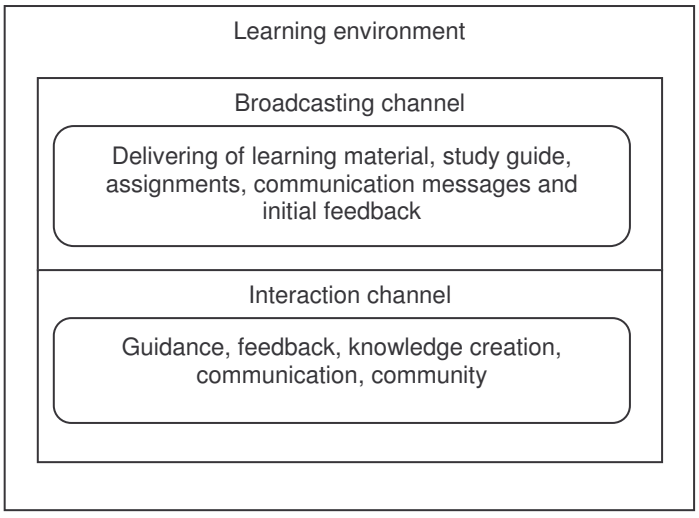


Figure 81: Activities in broadcasting and interaction channels

The use of only a broadcasting channel allows a partial or supplementary role in formal learning, meaning that only a part of the course is implemented via iTV. Thus, a course can include also, for example, face-to-face lectures. Some form of informal learning is also enabled. A combination of broadcasting and interaction channels fulfils the pedagogic requirements defined in the T-learning model.

8 T-learning system model

This chapter introduces the T-learning system model for DVB-HTML and IPTV. The model is a description of the iTV learning system including the technology of particular implementations. The chapter is based on the conclusions of the field studies and literature.

Figure 82 illustrates the T-learning system model including the implementation of repository, information and communication systems. It is a combination of the systems used in empirical studies (see Chapter 6). The learning process system of the T-learning model is divided into two parts: information and the communication system. The repository system includes the functions of the content production system.

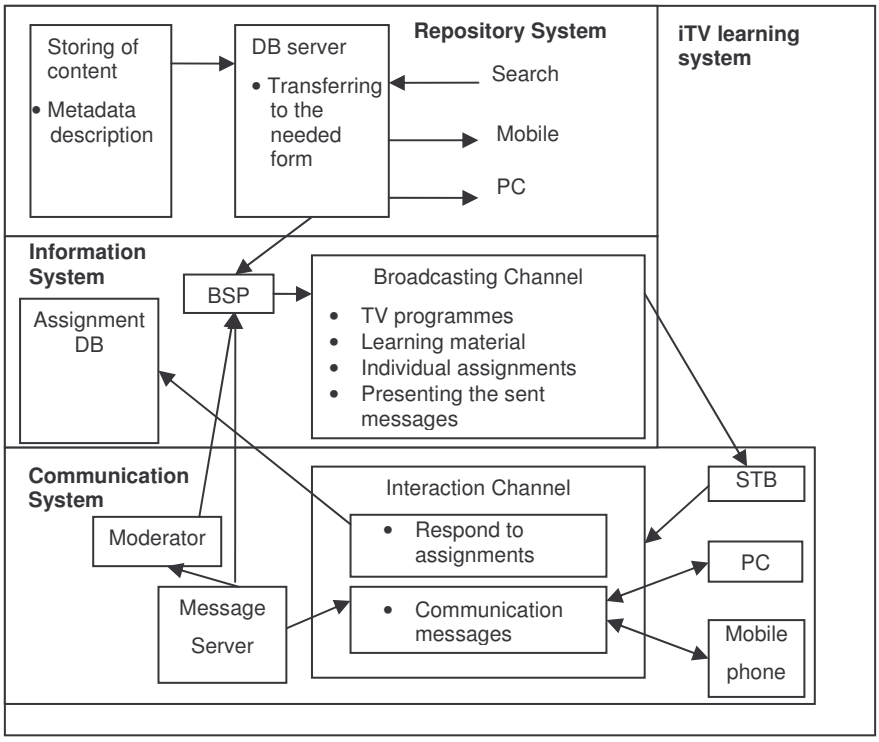


Figure 82: T-learning system model

The model is based on the use of a DVB-HTML browser as a presentation engine and the DVB-HTML standard as a presentation format for students in DVB-HTML. The model can also be used in the IPTV environment, where the browser is inside of the IPTV STB and the presentation format is HTML.

8.1 Repository system

Figure 83 illustrates the database system. The learning material and assignments are stored in the repository system. In addition, the metadata descriptions are defined. The DB server enables the content to be converted into the form suitable for DTV, mobile devices, and PC. In addition, the search of the content from the DB is enabled.

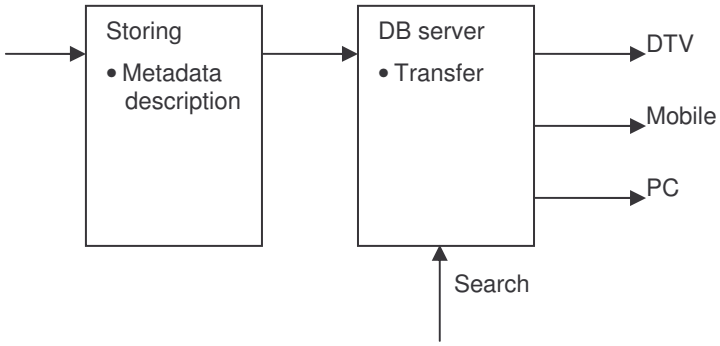


Figure 83: Database system

8.2 Information system

8.2.1 Connection to a TV programme

A T-learning service can be connected to a programme or not. A TV programme can be produced for learning purposes or it can be authentic material. The TV programme in the IM study was produced for learning purposes, but authentic TV programmes have been used in language learning in England (Pemberton et al, 2006). The form of connection can be based on participation, media consumption, entercation etc.

In the IM study the IM service was connected to a programme and permitted participation in a programme. Participation can be commenting on a subject, answering questions, participation in quizzes, communication about a subject etc. The form of the system depends on the form of participation. Because there was one communication room and frequently changing subjects, deep communication about a subject was not possible in the IM study.

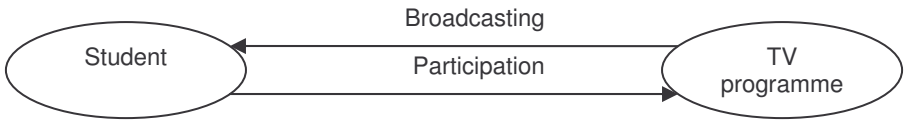


Figure 84: Participation to a programme

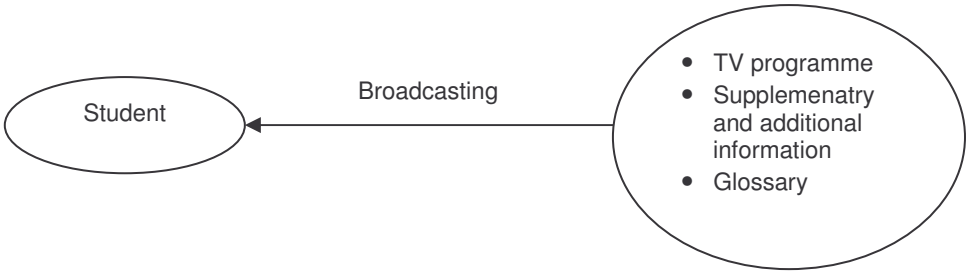


Figure 85: Added value to a TV programme

Added value to a TV programme can include different kinds of services. They can be supplementary or additional information to a programme. An example is a “media consumption” model of language learning in which “just-in-time” explanations and definitions similar to subtitles were available on-screen (Pemberton et al., 2006). In the sign language study students requested a glossary of words to be delivered in sign language and in text form.

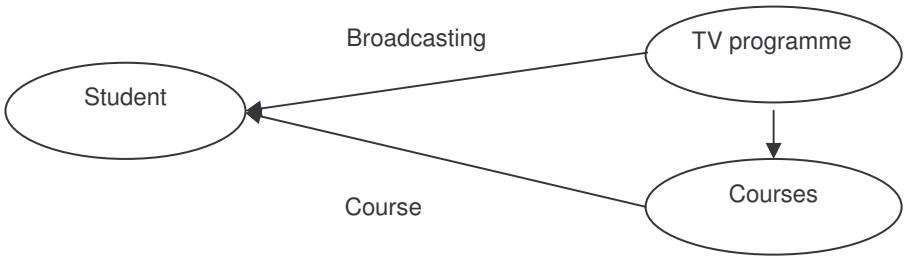


Figure 86: Course relating to a TV programme

An example of a course relating to a TV programme is an “entercation” concept defined by Rey-López et al. (2006). It uses TV programmes as a gateway to education and to provide learning contents related to a programme.

The degree of iTV use in T-learning can vary. In addition to a broadcast TV programme, a learning service can include face-to-face lectures and the use of other media. This was the case in the Motive 1 study. A combination of several media can take advantage of several media and fit better to different learning tasks and situations. Examples of using other mediated parts or face-to-face lectures are from the University of Laval (Boulet, 1995, Boulet, 1997, Boulet et al., 2002) and from Oklahoma State University (Bailey, 1972). Pemberton et al. (2005) have introduced a dual device system for informal language learning, which uses a combination of interactive television and a mobile phone.

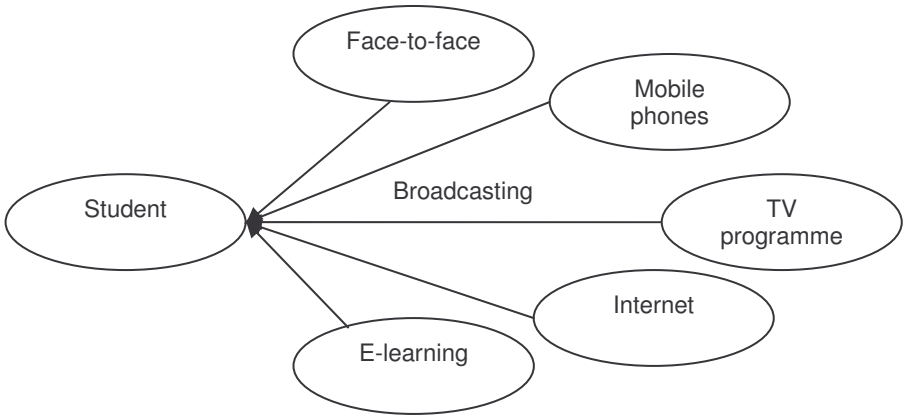


Figure 87: Additional mediums and learning forms to a TV programme

8.2.2 Structure of the educational service

The T-learning system model enables both linear and non-linear course structures. The non-linear educational service consists of modules divided into entities; these can be further divided into sub-entities, as illustrated in Figure 88. The non-linear structure is based on the structure used in the following empirical studies: Motive 1, Motive 2, and Sign language.

Navigation between modules, entities, and sub-entities can be created as requested with links.

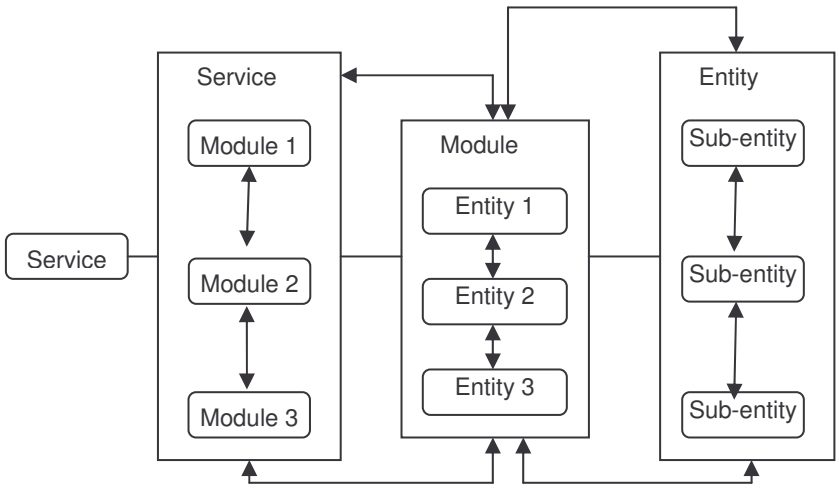


Figure 88: Non-linear structure of the educational service

8.2.3 Assignments

TV allows the use of assignments based on linear and non-linear structures. In the linear structure a student gets immediate feedback after performing an assignment. A student needs to follow the structure decided by the content producer.

The structure of self-assessment assignments used in the Motive 2 study is illustrated in Figure 89. The structure is constructed as a non-linear structure. In the non-linear structure a student has more freedom to choose the order of studying. After entering responses to the system, a student receives an immediate response from the system that, in the case of an incorrect answer, guides him to the source of the correct information in the learning material. After reviewing the material, the student can easily return to the question and try again. With the correct answer, the next question appears.

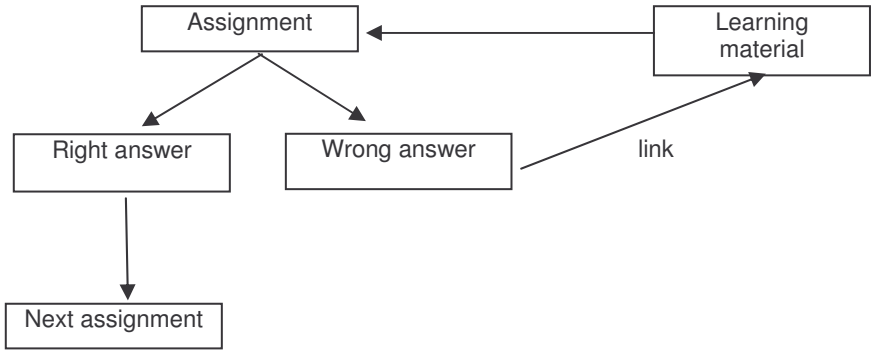


Figure 89: Structure of self-assessment assignments

iTV also makes group assignments possible. Figure 90 illustrates the structure of the group assignments used in the Motive 2 study. The role of a teacher is to instruct about the process, not supply knowledge.

The assignments are cases which students aim to solve in co-operation. A combination of students' previous knowledge and learning material is used in solving the cases and creating knowledge. The learning outcomes are both individual and communal.

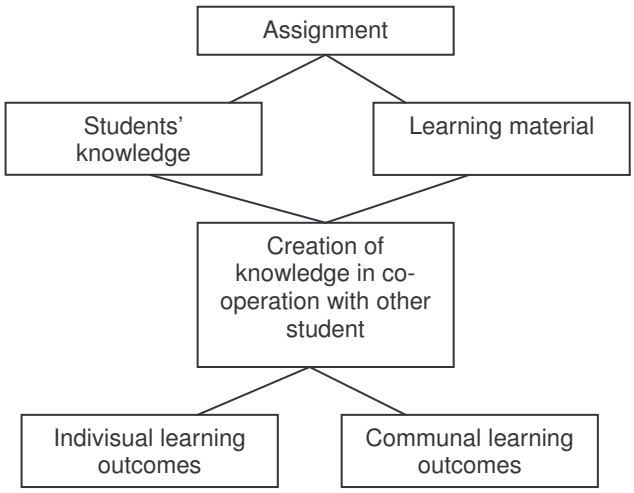


Figure 90: Process of performing group assignments

Figure 91 illustrates the structure of graded assignments used in the Motive 2 study. The assignments are broadcast to students. The students respond to assignments with the remote control of an STB. The responses are delivered to an assignment server. After delivery, a confirmation message is sent to the student.

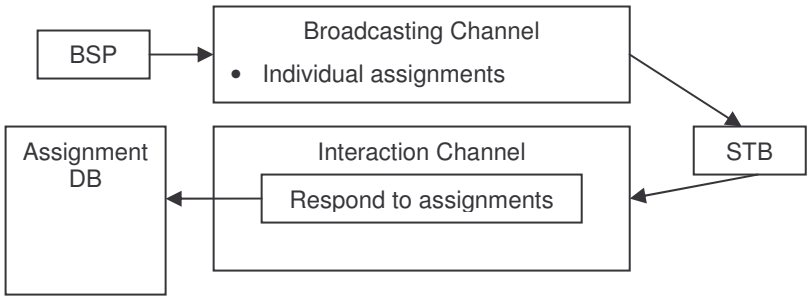


Figure 91: Structure of graded assignments

8.2.4 Personalized learning

Different forms of personalised learning can be found in T-learning. López-Nores et al., 2005A, have illustrated a scenario for personalised T-learning. The "approach is based on a recommender system that automatically makes suggestions about courses that the user may find interesting".

Personalised learning via iTV can have another kind of character when there is DVB-HTML content. The concept was developed, but never field-tested in practice. The idea is that the same course includes several learning paths the students can follow. The learning paths are constructed with the help of links. The beginning of a course includes several questions which are used to define the most suitable learning path for a student. The concept was planned for use on a 'global competencies and interpersonal skills' course, but because of financial problems was never tested in an iTV environment. Students following a certain learning path have different learning material, assignments, and also learning goals. The idea behind the concept was to allow adult students with different kinds of background to study according to their own preferences. Another idea was to deliver learning opportunities which have more value for their work.

8.2.5 Guidance with learning

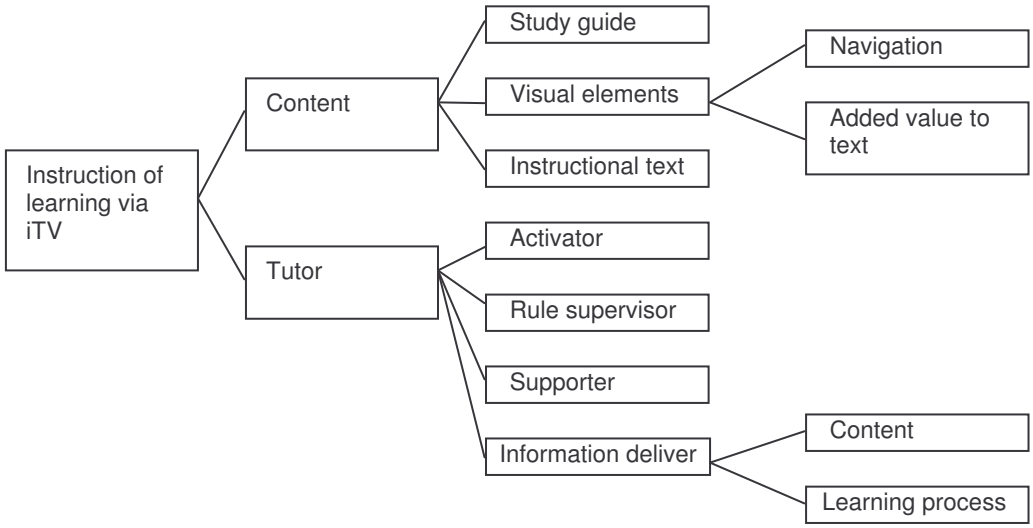


Figure 92: Guidance with learning via iTV

Instruction in learning can be performed with the help of content or a tutor. Content can include features that shape and assist learning, e.g. a study guide, visual features to help navigation, visual features to support content in a text format, or text-format instructions. Instructions in content are general and they aim to deliver the same message to every student. The instructions are based on one-way interaction. The content of a study guide for a T-learning service is illustrated in Section 7.2.5. Visual features and images can have an added value role to support learning. In the content for the deaf people, visual elements were used to support the text written in links. Another solution could be to have an option also to see the information in a link in a signed form. The links can also be named so that they help navigation.

Depending on the T-learning service, a tutor can be required to instruct and support learning via iTV. A tutor's instructions can be either the same for every student or individual. The role of a tutor varies according on the service, as illustrated in the Motive 2 and IM field studies. In the IM study children felt that it was important for the moderator to have an activating role, but she was also expected to ensure that the rules were followed. She did not deliver information relating to content. In the Motive 2 field study the tutor supported the learning process, but he also answered questions relating to the content. The Motive 1 study did not have a tutor. All instruction was based on instructions in the content and on a short set of paper-format instructions to give help in using the application and an STB.

8.3 Communication system

Figure 93 illustrates the communication system of T-learning constructed with the use of several media. It is a combination of the systems used in the Motive 2 and the IM use studies. The communication system is used for:

- information messages
- guidance
- group assignments
- feedback
- assessment
- participation in a TV programme.

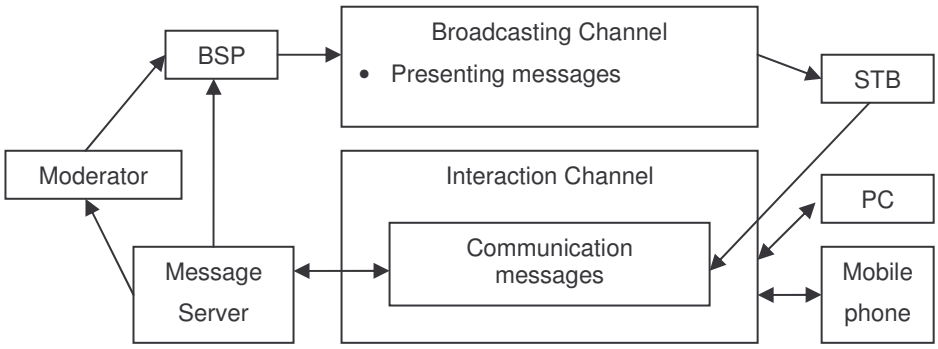


Figure 93: T-learning communication system

The messages are delivered through the message server to be broadcast by the BSP and to be presented via the broadcasting channel.

iTV enables an active student learning role, which is supported by the teacher's guidance. Learning can be based on active participation, conversation, sharing ideas and peer communication.

8.4 Requirements of T-learning for technology

An interaction channel has an important role in the T-learning model. It affects the available choices in the construction of a learning service. Without an interaction channel, no communication between students, or between student and teacher, is possible. It is not possible to gain knowledge with others or to have the whole learning process via iTV.

If only a broadcast channel is available, it can:

- deliver learning material
- deliver assignments
- promote local interaction with learning material and assignments
- promote self-assessment
- deliver some form of personalized learning.

Transmission of learning material and self-assessment type of assignments, which requires only local interaction, can be performed without an interaction channel. Without an interaction channel, T-learning can be used in a partial or supplementary role in formal learning and in other forms to provide learning possibilities as required.

An adequate combination of a broadcasting and interaction channel enables all the pedagogic requirements of the T-learning model to be used in a single learning service. T-learning can supplement other forms of learning in many subjects, but can be limited by personal features presented in the T-learning model. The implementation of learning features can differ from solutions in E-learning because of the special characteristics and restrictions of television as a medium.

It is also possible to implement informal learning without an interaction channel. However, the advantage of iTV compared to analogue broadcasting is that it offers interaction and new visual advantages.

8.4.1 Restrictions of the T-learning model and the greatest design problems

The definition of T-learning defines the domain of interest generally. The model defines constructs, relationships with the constructs, the values of the constructs, and the events for which it holds good in T-learning.

The greatest design problem was to consider all the possible issues that affect learning. The research is supported by the conclusions of the empirical studies performed by the author and literature relating to iTV technology and televised learning.

8.5 Evaluation of the constructed design science products

In computer science literature a key determinant of the value of constructs, models, and methods is the existence of an instantiation. The reason is that constructs, models, and methods that work “on paper” will not necessarily work in the real world. Therefore, instantiations provide the real proof for a design science product (March et al., 1995). Therefore, it could be argued that Chapter 5, Chapter 6, and the field studies in Chapter 7 show that the constructed models work.

In the construction of an artefact the difference between the initial and goal states is evaluated by using a certain utility metrics. The goal state is estimated to be better, more valuable, or more desired with the same metrics. If the research outcome is totally new, “actual performance evaluation is not required at this stage” (March et al., 1995). Järvinen (2004) states that progress is achieved in design science when existing technologies are replaced by more effective ones. The thesis aims to name some of the use areas where T-learning can be facilitated. However, technological rules cannot be presented at this early stage of the T-learning phenomenon.

8.5.1 Use-areas of T-learning

iTV facilitates both formal and informal learning. According to the interviews in the sign language study (see Sub-chapter 6.3), in addition to its current informal use in the study, the same type of content could be used for formal learning. The use of Instant Messaging in the connection of the “Tuu juttuun” programme (see Sub-chapter 6.4) is another concept of informal learning which was liked by children, because it made participation in the programme possible. Both Motive studies are examples of formal learning via iTV.

Self-assessment assignments were especially liked because of the easy and fast feedback on wrong answers in the Motive 1 and 2 studies see Sub-chapters 6.1, 6.2). When asked if the structure of self-assessment assignments supported learning and made possible easy access to learning material so that they could study more, students answered “yes”. A student commented: “It made searching for correct information faster, and that is important in this kind of environment”. Another student wrote: “It is important to get feedback immediately. Otherwise it is important to know if you have learned everything correctly.” In addition, the Motive 2 study used graded assignments for assessment. The types of graded assignments were limited only to multiple-choice questions, because it is difficult to write long texts with the help of a virtual keyboard. According to the results of the Motive 2 study, it seems that assessment based on active participation in group assignments can be used.

On the basis of the empirical studies, iTV makes both asynchronous and synchronous communication possible. Asynchronous communication was used in the Motive 2 study (see Sub-chapter 6.2). It gave flexibility of choice to adults studying in addition to working. In the IM study children participated in a TV programme via synchronous communication.

The students in the Motive 1 study stated that they would most probably also want to use the same kind of DVB-HTML-based learning service in the future. Most of the pages were plain text and only a few pages included still images. The textual format was liked. According to the same research, the issues that affect readability are the amount of text per page, word division, and the division of sentences between pages. Word division affects readability negatively. The students in the Motive 1 study were used to teletext services, and thus the same kind of approach to presenting learning material did not cause any problems and the textual format of the learning material was liked. The browser was seen

as working well for reading and browsing through the learning material. A student wrote: “It is a little bit slower to browse through the learning material, compared to the use of a mouse and a keyboard, but it was a positive surprise compared to my expectations in advance.” The problem is with writing; the virtual keyboard was seen as too slow to use and other devices were requested for writing.

In the Motive 1 study (see Sub-chapter 6.1) no problems relating to the use of TV for learning purposes were recorded. It is important that students are allowed to make choices and decide how to move through the content. The use of a non-linear structure is a possible solution in TV, but TV as a medium needs to be recognised in content production. When asked in the Motive 2 study if digital TV is suitable for use as a learning environment, almost ninety per cent of the students answered “yes”. A student stated: “In my opinion, digital TV is a medium for everyone, whereas a computer is still not.” Another student argued that “T-learning can be an option in particular situations”. These situations are, for example, geographical availability, visualised media, the familiarity of TV as a medium, and TV as an easy-to-use medium.

The multi-channel communication in the Motive 2 study was reported to be good, since students were independent of time and place thanks to being able to use different devices for discussions. 24/7 availability meant flexibility in practice, because students could choose the day and time of the day when they studied. A student wrote: “As long as you cannot use a traditional keyboard with digital TV, there have to be other solutions available.”

In the Motive 2 study the students had a chance to discuss the case with each other. It made learning from others possible, and this was valued by students. Problem-solving in a group was preferred to working alone. The chance to communicate motivated students. Students were not studying alone, but instead they created a virtual community via television. It was possible to get help from the other members of the community and from the tutor.

In an MHP-based learning environment, a great deal can be accomplished with fairly simple and economical solutions. The MHP-based learning environment can be a good solution when the subject being studied changes continuously and the learning material has to be updated frequently. A student in the Motive 2 study stated that “DTV is one media possibility for distance learning, but TV imposes new requirements on the content: it demands tight, clear, and concise material.”

On the basis of the sign language study, DTV is suitable for learning via sign language, because the instructions for the assignments can be given with sign language and because DTV supports visualised presentation forms. According to the study conducted as a part of this thesis, the three main benefits of TV for the deaf people are: visualised media, the familiarity of the medium, and good accessibility. The high quality of pictures and videos and adjustable contrast are advantages of TV which benefit deaf people. The familiarity of TV and its ease of use make it easy to start using TV for learning.

8.6 Conclusions

The T-learning system model consists of:

- repository system
- information system
- communication system.

The model can be used in the construction of an iTV learning system.

Transmission of learning material and self-assessment type of assignments, which requires only local interaction, can be performed without an interaction channel. An adequate combination of a broadcasting and interaction channel enables all the pedagogic requirements of the T-learning model to be used in a single learning service.

According to the empirical studies, T-learning can be used in at least the following situations, cases and groups:

- A 1 formal and informal learning
- A 2 assessment
  - self-assessment
  - active participation in group assignments
  - graded
- A 3 interaction
  - synchronous/asynchronous communication
  - virtual communities
  - multi-channel communication
  - communal learning
- B 1 form of learning material
  - textual
  - visual
  - connection to a TV programme
- C 1target groups
  - adults working as well as learning
  - children
  - deaf people
- C 2 special groups
  - sign language

9 Content production

The thesis aims to create guidelines for suggesting best learning to be supported and content production performed via iTV. It is partly performed by using the content production model described in this chapter (Aarreniemi-Jokipelto, 2005 E). Also, features of TV needed to be recognized in the content production process are presented (Aarreniemi-Jokipelto, 2005 D). The special requirements of content production for persons with hearing-impairments are described. The chapter on purpose mainly concentrates on the content production of textual learning material and especially DVB-HTML-based content in formal learning. No literature was found concerning the content production of T-learning with DVB-HTML. The chapter also includes research concerning deaf and hearing impaired persons' special requirements for a T-learning service. The T-learning model can be used in T-learning content production.

The T-learning content production process consists of: preproduction, production, and postproduction. This chapter examines their themes.

The list of problems extracted from the picture (see Figure 57) in creation of the T-learning model is solved in this chapter. The problems are:

- How can learning material be produced?
- How can learning material be stored?
- What is technology?
- How can students' learning be assessed?
- How can learning material and assignments be presented?
- How can students and a teacher communicate?
- How can assignments be performed?
- How can knowledge, skills, and edutainment be created?

In addition, the content production process takes advantage of the T-learning model in the preproduction phase and of the T-learning system model in the production phase.

9.1 Value net in T-learning

Because none of the value chain/net models for T-learning found in the literature, a T-learning value net was created. The T-learning value net is illustrated in Figure 94.

Content production demands co-operation of different experts to enable the best possible results. Figure 94 illustrates the functions of the value net in T-learning. The value net includes, but is not limited to the following functions:

- content creation
- technology development and providing
- interaction
- storage of learning material
- packaging of learning material
- delivery
- learning
- legislation.

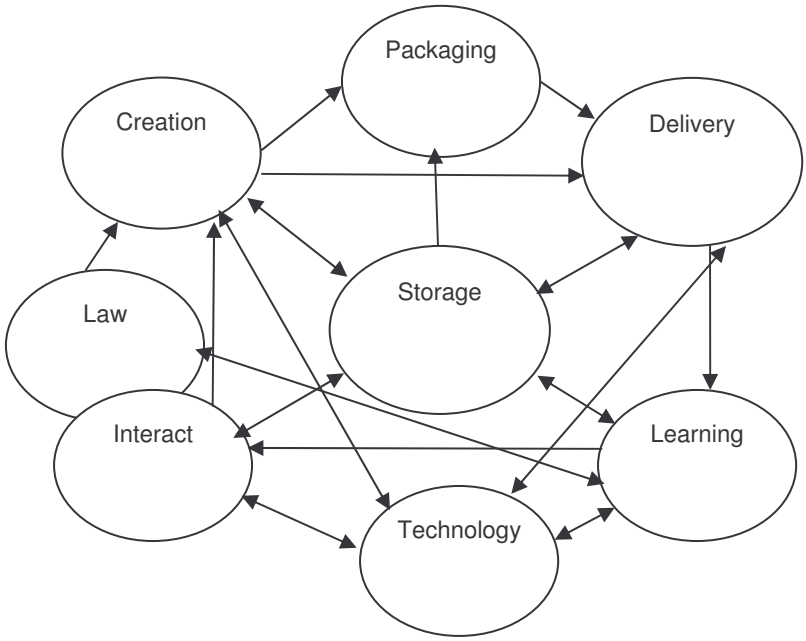


Figure 94: Value net in T-learning

9.1.1 Content creators

Content creators of learning materials are:

- schools
- content providing companies
- publishing companies
- broadcasting companies.

In Finland, the public broadcasting company YLE is obligated according to the Finnish law to provide learning opportunities for citizens through television. Furthermore, content providing companies are involved. In schools, teachers participate in content production. Schools also need to have a pedagogical and a technical content producer or else the service has to be bought to be able to produce a T-learning service. Similarly, educational companies need to have a pedagogical and technical producer. According to the interviews in ArviD research (Aarreniemi-Jokipelto, 2005 B), publishing companies in Finland have been interested in participating in the content production of learning materials for iTV. A book of a publisher, for example, could be linked to a DVB-HTML page. Schools and educational companies may also use services of content creation companies in the form of software.

9.1.2 Technology developers

Technology developers are the following but not limited to them:

- standard developers
- application producers
- interactive application providers
- educational software companies.

Standard developers are developing and publishing standards to be also used in learning, like ETSI and ITU. The application developers are, for example, platform developers which are selling their platforms, based on different standards, to be used for presenting content

via iTV. To enable creation of learning material, tools to produce the material are needed. Text editors that enable the creation of learning material creation are commercially available. Schools and educational companies can also develop their own tools based on their special requirements. In addition, application developers are required to produce customized software. Interaction software developers are needed. They can be the same companies that provide platforms and customized applications.

9.1.3 Storing and packaging

Learning materials are stored in databases for digital learning materials. Databases can be located in- or outside of the content creators. Schools can use the materials of the broadcasting companies such as BBC and NHK in the future.

According to the interviews in ArviD research (see Chapter 2), learning materials could be packaged by commercial, regional or public DTV channels for learning services. Educational companies are able to use commercial or local DTV channels. Schools in Finland are more interested in using DTV channels like YLE, because of problems to finance content production and broadcasting.

9.1.4 Broadcasters

In Finland there are three types of broadcasters for T-learning services: public, commercial, and regional. The following information is based on the interviews in the ArviD research. The co-operation partners of public broadcasters can be publishing companies, schools, and content producer companies. Commercial broadcasters are interested in co-operation with educational companies, who can buy broadcasting services which are limited only to paying customers and does not affect the brand of commercial broadcaster. Regional broadcasters could co-operate with content producers and publishing companies when the end-users are schools and their students.

Students can participate in formal or informal learning via DTV. Examples of formal learning organizations are schools, like municipal and vocational education, polytechnic, universities, and adult education colleges. An informal learning student may study, for example, with YLE programmes or be a student at an institute of education. In addition, a student may participate in a course provided by an educational company.

Table 15 describes functionalities, usability, and quality attributes of T-learning that need to be implemented with technology or recognized in the use of technology in different phases of a T-learning lifecycle. In the content production phase, usability of the content takes priority in order to gain satisfaction among students. Content production tools developed by companies and organization need to support usability.

In the maintenance and organizing phase, the produced learning objects are stored in the database. Content consists of several learning objects: produced learning material and course assignments (e.g. individual multiple choice questions). This phase has security and usability as its main requirements. The learning objects should be organised to be easily accessible and the same learning objects should be usable in several courses. Access control is also necessary to ensure that only authorized persons are able to modify and view the materials.

In the delivery phase, the learning material is transmitted to students. The transmission must be secured to restrict unauthorized access to the learning material.

Table 15: Technical requirements of T-learning model to be used in the implementing of technology in different T-learning process phases

	Content production	Maintenance, organising	Delivering	Learning, guidance, assessment
Transmission			X	X
Interaction, communication				X
Security		X	X	X
Accessibility				X
Controlling				X
Usability	X	X		X

The last phase is learning, guidance, and assessment. This phase has the following requirements: transmission of the learning content, accessibility, security, usability, controlling, and interaction/communication. First, the services need to be accessible to students. Second, the learning environment is needed to ensure the student's desire to study there and reliable assessment. Third, usability and controlling the platform is important, since students should be able to concentrate on learning, instead of the platform. Fourth, interaction and communication are important.

9.2 Defining the content lifecycle

T-learning lifecycle refers to the chain which includes functions from content production to the consuming of T-learning services. Before the T-learning lifecycle is possible, co operation between several organizations and companies is required for the development of iTV standards, platforms, content production and communication tools, and theory of T-learning. Figure 95 illustrates the phases of the T-learning lifecycle, which are:

- content production
- maintenance and organizing
- delivering of learning material to students
- learning, guidance, and assessment.

The rest of the chapter deals with the first phase of T-learning lifecycle, content production.

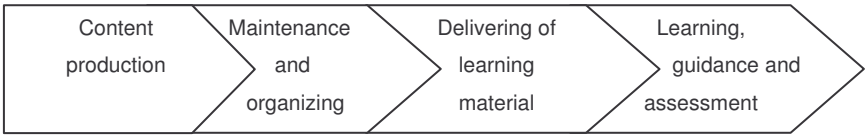


Figure 95: T-learning lifecycle (Aarreniemi-Jokipelto et al., 2005G)

9.3 Preproduction phase in T-learning

Preproduction phase defines the goal of service and sets requirements for the learning service. The requirements of the service depend on the goal of the service.

Since the TV screen can display less text at a time than a typical web page on the Internet, the content production is challenging. The decisions made in the preproduction phase have great influence on the final T-learning service.

In the preproduction phase requirements defined in the T-learning model have to be examined as illustrated in Figure 96.

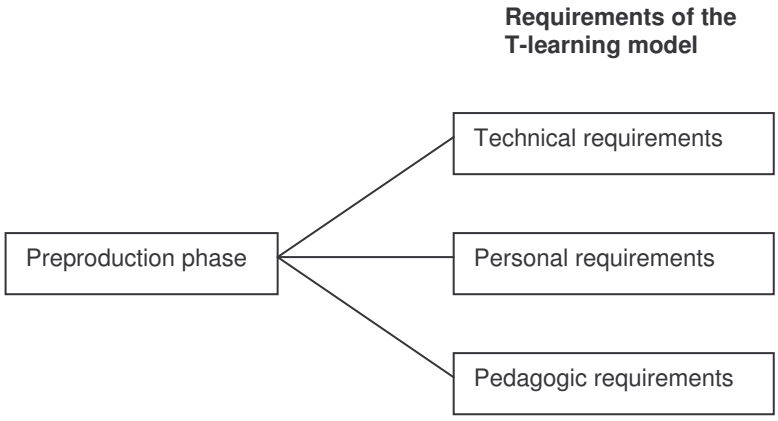


Figure 96: Features of the preproduction phase

9.3.1 Defining technology

When the goal of the service is defined, the requirements of the service are defined based on the T-learning model. The model defines the general technical requirements for an iTV-learning system. The requirements should be noted when making decisions about the technology. Table 16 illustrates the general requirements and options.

In making a technology decision, it is necessary to consider:

- the target group of a learning service
- the learning subject
- the goal of learning.

The chosen technology needs to be suitable for the content, support the learning process, and bring added value to learning. Students' age, background knowledge, technical knowledge, and comfort and experience using the technology affect the technical choices. In addition to the students' needs, the need of the teachers should be considered in the selection of technologies. By determining the target group, it can be made sure that the medium and technology are appropriate. Technology choices suitable for the elderly and young people, are not necessary the same. In addition to cultural differences, potential language barriers, and potential wide variation in geographic location can affect the content production. The subject matter affects the choice as well. Some subjects can be presented in a textual form, but others require a more visualized form.

The decision of the technology is crucial because technology enables distance learning. In T-learning many factors need to be taken into account: transmission of learning material, the kind of functionalities the chosen technology should provide, and whether the students are comfortable with the technology and willing to use it. Also, accessibility to the technology must be considered.

If the learning type is formal learning and the technology is DTV, it is needed to consider issues such as how to assess learning in DTV. The way to assess has to be defined in formal learning. In the case of informal learning, assessment is less important, even though the service can include possibilities for self-assessment.

Table 16: Technical requirements of iTV learning system for preproduction phase

Technical requirements	
Transmission	
Role of iTV technology	• iTV –the only technology in general • Separate technologies • Multitechnologies
Service availability	• Push service • On-demand – pull service
Time shifting	• PVR • On-demand
Interaction / Communication	• 1-way interaction • 2-way interaction • Interaction between a student and a teacher • Student-learning environment
Security	• Data integrity • Authentication • Data privacy
Accessibility	• Suitable, reliable technology • Applications • Content production tool • Open standards • Infrastructure
Devices	
Input	• Control • Write • Make choices • Respond • Participation
Output	• Present
Usability	
Student-Learning environment interaction	• Learning ability • Feedback from the system • Guidance from the system • Devices working smoothly together
Inside the learning environment	• Relevant information presented • Supportive images • Videos to support text • Clearly marked exits
Student's experience	• Support learning • Valuable • Usable

9.3.2 Defining personal features

Table 17 presents the general personal requirements of the T-learning model which need to be examined in the preproduction phase. According to the empirical research the personal requirements are crucial for T-learning.

The students' personal features which affect their learning are strong criteria. If it is expected that the target student group includes persons with disabilities, this must be recognised early in the preproduction phase. The same applies to informal learning.

Table 17: Personal requirements in preproduction phase

Personal requirements	
Purpose of learning	• Informal learning • Formal learning
Accessibility	• Geographical • Personal • Technical accessibility
Motivation, expectations	• Motivation to use iTV • Expectations of devices • Earlier experiences in WBE
Special needs	• Visual and hearing impairment • Age

If the target group includes people with visual impairments, the visual appearance and layout of the material, including colours and font sizes must take this into account. MHP subtitling and sign language are options for the hearing impaired, and TV subtitles can also be reproduced by a voice synthesizer for the visually impaired.

Based on HUT experiments (see Sub-chapter 6.2), for the students, motivation to use a particular medium and expectations for that medium affect the final satisfaction with learning. Accessibility and availability means that the students need to have access to:

- the technology in the location where they will study
- the required devices.

Limited accessibility has been one of the problems in E-learning as described in Section □. In most Western countries the accessibility of television is wider than the accessibility of computers. The main problem is the devices, or lack thereof. People have access to television and to DTV, but in case of interactive services, the access to the interaction channel can be limited. The other problem has been the availability of the MHP STBs. During the thesis research, there has not been MHP STBs commercially available for cable networks. The first MHP STBs for cable networks were launched in Finland on April 2006.

9.3.3 Defining pedagogic functions

The general pedagogic functionalities of the iTV learning system exist. They can be examined in defining the specific pedagogic functions of a T-learning service. Table 18 illustrates the general functionalities and the values in them.

Table 18: General pedagogic requirements in preproduction phase

Pedagogic requirements	
Role of T-learning	• Supplementary • Partial • Substitute
Content in iTV	• Yes/No
Interaction in iTV	• Yes/No
Assessment in iTV	• Yes/No
Construction of knowledge in iTV	• Yes/No
Learning process in iTV	• Yes/No
Personalized learning	• Yes/No
Connected to a TV programme	• Yes/No

Decisions concerning the interaction and communication affect whether or not an interaction channel is needed. If only local interaction is required, there is no need for the interaction channel. In addition, if students are expected to study at different times, asynchronous communications have to be enabled. If television is used for assessment the interaction channel is required, but self-assessment can be obtained with the help of local interaction.

There are also additional features to be recognized in the preproduction phase. Two requirements exist for the content production of a formal T-learning course. First, there has to be a concrete need for the T-learning course or a need to reproduce an existing course. Second, the teacher has to be interested in T-learning. If a teacher is reluctant to use the technology or views the use negatively, it affects the final service negatively. Those responsible for teacher training need to consider iTV as a learning tool and provide teachers with the basic skills needed for using iTV in learning situations.

The preproduction phase in the context of a formal T-learning course also includes the following issues:

- Demonstrate and train the teacher about the possibility educational uses of DTV.
- Define
    - the object and the background theory of a course
    - the content and modules of the course
    - the types of learning material and assignments
    - guidance
    - assessment
    - tests
    - efforts to support the learning process.

First, the teacher has to be trained for the possibilities and the basics of DTV, as in E-learning. Second, the object and pedagogical background theory of the course is defined and described. For formal learning, the object of the course should also be accepted by the administration.

The amount of learning material and the number of modules are defined by a teacher and a content producer. Because of the limitations of the television screen, it is important to plan what needs to be in textual form and how to present the content compactly.

The use of animations in a MPH-based environment is limited, so whether or not a simple animation brings added value to learners needs to be considered.

The required assignments and their type should be decided. The assessment criteria are defined and provided for the test design.

The guidance of the learning process should be designed. In the DVB-HTML environment, the guidance is even more important than in *Web-based education (WBE)* because iTV is a new media and the character of the environment is different from WBE environments. Because the medium is new for interactive learning purposes, it should be recognized by providing enough guidance.

9.4 Production phase in T-learning

During the production phase, the subsystems needed to achieve the goal, are constructed.

9.4.1 Production of repository system

Figure 97 illustrates the repository system of the T-learning system model. It consists of transformation of the content into a form suitable for iTV, storing of the content in databases, metadata description of the content, definition of the required mediums and content format of them, and search of the content from a database.

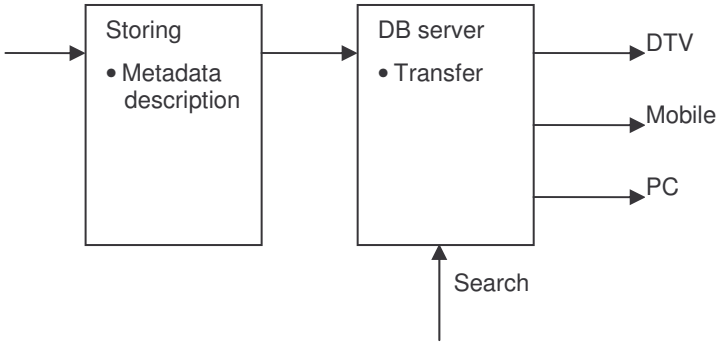


Figure 97: Functions of a repository system in production phase

Compared with the HTML pages in WBEs, an advantage of the DVB-HTML is that the content and appearance are separated from each other. It allows the content be used on different platforms. The reuse of content is of primary importance when publishing in a multichannel environment. If it is planned to use the same material with different devices, then XHTML is a good candidate. Searching for material is possible from the database.

9.4.2 Production of information system features

Figure 98 illustrates the functions of the information system. There needs to be a way to present learning material and assignments and to store graded assignments. The content needs to have a structure and students should have a way to navigate through the content. Television as a medium sets requirements for presenting content and navigating in content. These features need to be recognized in the content production of an information system.

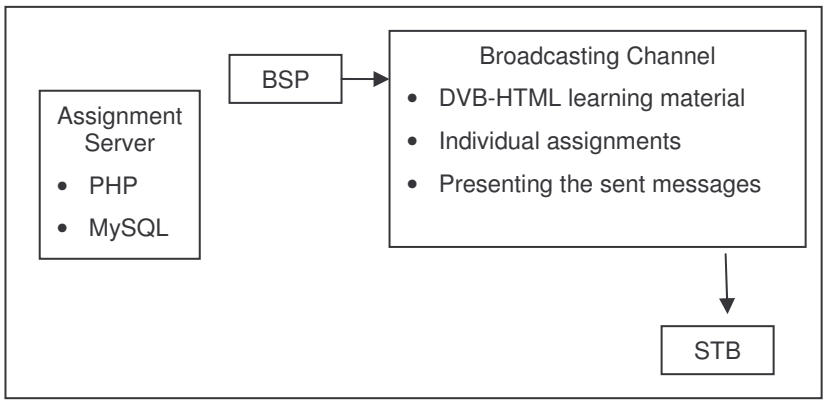


Figure 98: General Information system

The phases in producing textual content for iTV are:

- teacher produces the material
- DTV writing
- DVB-HTML transfer
- image design
- navigation design.

The teacher produces the learning material and assignments based on decisions in the preproduction phase. During the writing process, the material is reviewed a few times. Depending on the decisions in the preproduction phase, the material is produced in video, animation, and/or textual forms.

Then, the textual material is written for DTV. When an entity is so large that it does not fit onto a single page or television screen, it must be divided into sub-pages. This means that the text is divided into the smaller pieces. The text has to be more compact and clearer than in E-learning environments. During the writing process, new headings are added to allow a compact format, and at the same time to make sure that non-linear structure allows clear navigation and that the student will not get lost in the material. The material is then transferred to DVB-HTML form.

In the production of textual material, the use of still images and tables should be considered. iTV benefits from the use of images, although, for some subjects, it can be difficult to find images which support the text. Images must be used in accordance to their copyright permissions.

Next, the navigation is designed. It is important to have a link from all pages to the beginning of the material. It is good to have enough navigation paths. In addition, whether or not a separate navigation map should be provided for the students should be considered.

All the forms require that the material be viewed on the television screen. The learning material is delivered to the students via the broadcasting network. If the learning material includes textual material, the browser application needs to be broadcasted as well. In the MHP environment it is broadcasted through a broadcasting channel, but in the IPTV environment the STB includes a browser. Also, other necessary applications are delivered through a broadcast channel.

In the DVB-HTML applications, the browser is used as a presentation and navigation engine and the DVB-HTML standard as a presentation format.

During the literature review, no evidence on the use of DVB-HTML-based material in learning was found. However, the DVB-HTML enables the assignments to be integrated as part of a course with help of links. After the students have sent their responses to the assignment, it is important to send a conformation message as a reply so that the student knows that the message was delivered properly. The response to a command should arrive in a few seconds. If they do not receive instant feedback, students can try to send the messages many times and get frustrated.

The hypertext format in the context of a WEB-based learning environment is widely used, but in the context of T-learning it is a new approach. A hypertext acts like a database that stores materials and grants students freedom to navigate through content. The DVB-HTML is a structural language enabling the use of both the linear and non-linear course structure

After the learning material has been produced, the navigation should be designed to ensure flexible navigation in the learning material. The navigation is limited, because it is based on the use of arrows, selection, and colour buttons with the help of a remote control. In the user interface it is important that the content and navigation elements are clearly separated, for example, by grouping functional buttons into one screen part and navigational buttons into another. The basic navigation should always have a sub-second response time, including moving to or from different levels. In addition, the navigation of the assignments has to be designed carefully. Links are used in moving between pages. When the link is selected, the desired page is opened. Triangular icons or arrows are generally used to represent the arrow keys and indicate which direction the highlight moves. The pages can

also be named in the link. Instead of the previous/next word or the triangular icon or arrows in the links, the name of a page can be shown.

The colour buttons of the remote control are also used in navigation. They can be defined to have different functions, but it is recommended that they have a consistent use in the application. If a particular page includes fewer than four colour prompts, their position should still be maintained. It is also possible to make a link from the learning material to the content located on an Internet server. To retrieve this kind of content, the return channel is required.

Due to the limitations of television screen, the navigation is important in the DVB-HTML content. The number of button presses the user must take to use the screen should be minimized. The content has to be more structured than with the WBE, and the links have to be designed properly to enable fast navigation between levels and entities. To enable fast navigation, the list of links has to be added to the text. However, the use of a colour button to return to the previous page can solve many problems.

9.4.3 General requirements of television as a medium

The Sub-chapter presents the general requirements of television as a medium. According to the field studies (see Chapter 6), the presentation has to be meaningful and has a very compact format in iTV. With DTV even more challenges are faced than with the PC, because of the iTV user interface. Thus, the content producer has to consider the following issues while designing and producing the learning material:

- limited screen
- remote control of a STB as the only control device
- television screen is watched from a longer distance
- navigation
- scrolling is not possible
- writing
    - Tiresias is the only built-in font.
    - Functionality of the television is limited.
    - Television environment is different from the PC.
    - Virtual keyboard the only means of writing.
    - Virtual keyboard is controlled with a remote control.

The screen of the DTV is very limited, the only available built-in font is “Tiresias” (Tiresias, 2005), and provides only four different font sizes. However, the Tiresias font makes it easy to distinguish characters on the television screen. Because the television screen is limited, the amount of text displayed at one time is much smaller than in the WBEs. According to the field studies (see Chapter 6), sentences have to be shorter than in the WBE and usually changes are required in the text structure. In addition, the text has to be divided into smaller pieces to be presented on the television screen. Thus, additional lists of the topics are needed to be used as links to smaller subjects. In addition, the entities have to be divided meaningfully in different pages. A full screen of text should contain a maximum of 90 words (BBC, 2002).

Also, the control devices are very limited. The remote control includes:

- number buttons (0-9)
- colour buttons (red, green, yellow, blue)
- arrow buttons (left, right, up, down)
- selection button.

Navigation, selections, responses and writing all have to be accomplished using the remote control of a STB. On the remote control, only arrow, colour and selection buttons are available, which means that significant effort is needed to create meaningful presentation for the learning material. The arrow buttons are used to move in the desired direction in the learning material; the selection button is used to make choices, and colour buttons are used for page navigation and options.

The WBE is controlled by a mouse and a keyboard, but in the television environment the control is performed solely using the remote control of a STB. Due to the nature of the medium, scrolling of text is not available. The remote control is not as fast and precise as a mouse and a keyboard. According to the field studies (see Chapter 6), the learning materials have to be presented so that they do not require the constant use of a remote control.

iTV applications allow the use of different screen modes, which means that, for example, in the full screen mode the whole television screen is used by the iTV application. It is also possible that a broadcasted video is shown is some place of the television screen while other areas are reserved for textual use.

The **interlacing** refers to the way the lines on television screen are shown to the viewer and affect the user's vision of colours and fonts. Thus, half of the scan lines are drawn at a time, which requires avoiding small decorations or design with horizontal lines because lines which are only one pixel high tend to flicker or pulse. The safe area around the television screen must be left empty and the text must be oversized compared with the computer text so that it can be read.

According to the field studies (see Chapter 6), blues are very stable and make a good background. Based on sign language in T-learning research (see Sub-chapter 6.3), green was also a good background colour. Red tends to bleed and spill into neighbouring pixels and is not recommended to be used as the text. Similar kinds of problems were noticed with thin red figures in sign language research (see Sub-chapter 6.3) Also, attention must be paid to character shapes, to make similar letters, such as upper case I, lower case l, and the number 1, distinctive. There are also characters, such as 6, 8, and 9, which are most commonly misread by the visually impaired.

9.4.4 Visual and hearing impaired people as a specific target group

Many specific target groups exist, but the sub-chapter concentrates on visual and hearing impaired people. **Audio-Description service** consists of adding to a television programme an audio track where a narrator describes what is happening on-screen for persons who are blind or have severe visual impairments. There is a need for this kind of service because, for example, in Finland about 80.000 individuals suffer from visual impairment. This kind of service exists in several countries like the UK, Spain, and Portugal (Quico et al., 2005). The 'Subtitling-to-speech' project (ArviD, 2005) in Finland aimed to develop a similar system to create an additional soundtrack for TV programmes through voice synthesis.

In Finland it is estimated that there are 740.000 hearing impaired people, 8.000 of them are deaf people. Hearing impaired persons may benefit from the use of a subtitling service or the use of sign language in the service. **Subtitling service** adds subtitles to the programme so that the audio track of the programme can be read from the subtitles. In Finland, the subtitles have been tested in a MHP subtitling project (ArviD, 2005B). Subtitling services can also be used in language learning.

According to the empirical studies (see Sub-chapter 6.3), the deaf people have special requirements for the use of sign language and textual material. In the signed videos, the signer needs to wear one-coloured and dark clothing. The background of the signer needs to be light to enable high enough contrast. Blue works well as a signer's background colour.

It is recommended to use one-coloured background or colours which do not form clear figures. The change of the colours in the background needs to be soft. The background behind the signer's upper body needs to be especially quiet and one coloured. If the videos are used for assignment performing, it is recommended to have a pause option for videos. If it is not available, the videos should be divided into smaller parts. Any figures should be avoided on the area.

According to the field study (see Chapter 6.3), the background of textual content is also recommended to be one-coloured. Also, figures affect negatively to readability of text. The contrast need to be high enough between the text colour and the background. Before use, the readability can be tested with visual impaired people.

According to the field study (see Chapter 6.3), it is recommended that a glossary be used in textual material. Some people have sign language as a mother tongue, and can have problems with Finnish or other languages used in the content. According to the sign language study, a recommendation is to have the words both in textual and in sign language form.

9.4.5 Production of communication system

Figure 99 illustrates the general communication system of an iTV learning system.

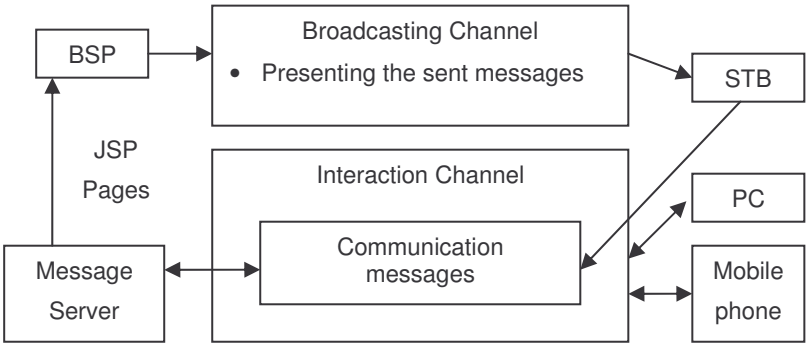


Figure 99: Functions of a general communication system of an iTV learning system

There are four types of interaction in T-learning as in Section 7.2.1.2:

- student – student
- student – teacher
- student – learning material
- student – learning environment.

According to the T-learning model, the communication system should enable message writing, message reading, and multichannel use. In addition to a broadcasting channel, the solution should include an interaction channel. The solution should be designed during the content production. 'Student-user interface' interaction can influence both student attitudes and learning outcomes. In this way, the user interface plays an important role in learning and special care is needed in the construction of the user interface.

If in the preproduction face it is decided that the course will include interaction between students and between 'student and a teacher', the interaction must be designed. Learning together in small groups can be more effective than learning alone. iTV enables the exchange of ideas between students and teachers.

The technical prerequisites for the interactivity in the DTV-based learning environment are a return/interaction channel and a broadcast channel. A return channel enables student responses and additional functionality.

The messages via DTV have to be written using the on-screen virtual keyboard, due to the lack of commercially available wired or wireless keyboards available for MHP STBs. The virtual keyboard looks like a keyboard used in mobile phones, but is displayed on the television screen and can be operated with the help of a remote control of a STB. Therefore, the assignments have to be developed so that they do not demand too much writing. If they require much writing, other mediums for writing should be considered.

Interaction in online environments shares at least partly the same characters as the face-to-face learning: discussions and input of ideas. Discussions and input of ideas are also allowed in iTV.

The DTV allows the users to take an active role in the use of television. It also enables the students' active role in learning, which is supported by the tutor's guidance. The active role is much more than just pressing buttons of a remote control or just watching TV. The learning is based on active participation in conversation, sharing ideas and responding to peers. Interaction with other students activates intellectual processing and reflection of ideas. In the process, students have to put their ideas and thoughts into writing form. As a result of active participation, the learner has a chance to gain and create new and deeper knowledge, and in the creation of new knowledge, problem solving of real-life cases plays an important role.

In the traditional face-to-face situations only one student at a time may speak and quite often the same students always speak while the others remain passive. In digital TV, even shy students can be active participants in conversations, because digital TV allows students to take the required time for communication and small groups' own goals force everyone to participate.

The teacher's role in digital TV is different from the role in face-to-face-lessons. She plans the activities but after that she follows the flow of conversations and guides the conversation as necessary instead of giving strict orders.

9.5 Postproduction phase

During the postproduction phase, different types of learning materials such as DVB-HTML, videos, and animations are combined to form the course. At the end it is important to check that the learning process is enabled during the whole course. The guidance of the learning and interaction has to be ensured and instructions for the learning environment have to be written. Content might be packaged as broadcasting services or on-demand services.

According to the field studies, content production in a DVB-HTML-based learning environment differs from content production in an HTML based environment First, writing in the DVB-HTML environment is more compact and the sentences must be short. Second, DVB-HTML includes more levels and links. Second, links enable the combination of different subjects to create new learning paths and allows students to have more freedom in navigation. Third, in the DVB-HTML environment, special attention is required to make sure those students will not disappear in the learning material; a navigation map good be a useful tool. Fourth, in the DVB-HTML content, special attention is necessary to ensure that pieces of learning material are logically connected. On the other hand, it is easy to develop more personalized learning paths in DVB-HTML environments because the content is naturally forced into smaller pieces.

9.6 Results

Table 19 presents the results of content production relating to the research objectives.

Table 19: Research objectives, and results of content production

Research objective	**Results**
How can a T-learning service be produced?	With the help of content production process/model described in Chapter 9.
How can the problems concerning the limitations of television be solved?	Solutions are described mostly in Sections 9.4.2 and 9.4.3
How can the learning material be produced?	Production of DVB-HTML learning material is described mainly in Section 9.4.2.
How can the learning material be stored?	Production of a repository system is described in Section 9.4.1.
What is technology?	Technology is defined in Section 9.3.1
How can student learning be assessed?	Assessment is described in Sections 9.3.1 and 9.3.3.
How can learning material and assignments be presented?	Presentation of learning material is described in Section 7.2.5 and assignments in Section 8.2.3
How can participants communicate?	Communication system is described in Section 9.4.5
How can assignments be performed?	Assignments are described in Section 7.2.7
How can knowledge, skills, and edutainment be created?	Content production affects the possibility to create knowledge and skills. The most important factor is how content production has been able to solve the requirements of T-learning model in content production, but all phases of the T-learning process described in Sub-chapter 9.1 affect the final service. During the learning situation, for example, technical issues described in Table 15 affect learning.

9.7 Conclusions

Content production is crucial in T-learning. TV as a medium has special requirements for content production of a T-learning service. In the current DTV environment, moreover, the content producer has to consider the following issues:

- limited screen
- remote control of a STB as the only control device
- navigation

- scrolling is not allowed
- writing
    - Tiresias is the only built-in font
    - television screen is viewed from a longer distance
    - functionality of the television is limited
    - television environment is different from the PC.

When the limitations are recognized, the most appropriate solutions can be found. Because of the screen size, the amount of text on a television screen needs to be limited. The use of DVB-HTML means a very compact form, dividing the text into small pieces, and presenting only the required text.

Because text input is limited, the use of other media can be needed. Short messages can be written with a virtual keyboard, but in designing assignments and communication the limitations need to be recognized.

High enough contrast between the background and text is needed to ensure readability. Blue serves well as a background colour. Yellow has served well to mark the activated text when the other text has been white. According to students' feedback, it is important to provide a full screen mode or to allow students to choose the screen mode.

Special care has to be taken to allow proper navigation with a remote control. On the main level it is needed to enable easy navigation between learning material, assignment, and study guide. The exit needs to be easy to find. The navigation need to be learnable and memorable. The use of a colour button to go to the previous page has proven quick navigation. In the self-assessment assignment a link to the learning material in case of an incorrect answer has been appreciated as it allows faster navigation.

Multichannel use has proven to be a good solution for working adults. It supports lifelong learning. Self-assessment assignments guide the learning process. When the requirements of a TV set is recognized in content production, both DVB-HTML and IPTV allow many opportunities for lifelong learning. The main issue is that the learning process in designed for iTV.

New iTV services enable the student's active participation in her own learning process. In addition to the individual learning, T-learning enables online community to be formed. Students are not required to gather together to watch educational TV programmes but instead they can study asynchronously at home and with the help of iTV, form learning communities.

The T-learning model can be used in T-learning content production in the preproduction phase. The T-learning system model serves the production phase in DVB-HTML and IPTV with defined implementations.

According to the field studies (see Chapter 6), the presentation has to be meaningful and has a very compact format in iTV. Sentences have to be shorter than in the WBE and usually changes are required in the text structure. In addition, the text has to be divided into smaller pieces to be presented on the television screen. Thus, additional lists of the topics are needed to be used as links to smaller subjects. In addition, the entities have to be divided meaningfully in different pages. According to the field studies (see Chapter 6), blue and green are very stable and make a good background.

According to the empirical studies (see Sub-chapter 6.3), the deaf people have special requirements for the use of sign language and textual material. In the signed videos, the signer needs to wear one-coloured and dark clothing. The background of the signer needs to be light to enable high enough contrast. Blue works well as a signer's background colour. It is recommended to use one-coloured background or colours which do not form clear

figures. The change of the colours in the background needs to be soft. The background behind the signer's upper body needs to be especially quiet and one coloured. If the videos are used for assignment performing, it is recommended to have a pause option for videos. If it is not available, the videos should be divided into smaller parts. Any figures should be avoided on the area.

10 Discussion, conclusions, and future research objectives

10.1 Discussion

The sub-chapter presents a discussion of several aspects of the study:

- T-learning and lifelong learning
- Educational programmes will adopt edutainment characteristics
- Sign language via iTV
- Instant messaging to enable online learning via iTV
- MHP, DVB-HTML, and IPTV
- Towards on-demand services, communities, and the use of several media
- Challenges concerning devices

First, the new definition of the learning will be presented and it is described how the learning could be a partial solution for lifelong learning and demands of the Knowledge society. Second, the entertaining character of T-learning is discussed. Next, the use of the sign language and instant messaging is discussed. Fifth, the suitability of iTV standards for the learning is shown on the basis of the field experiments. Finally, the challenges which are related to the future and devices are discussed.

10.1.1 T-learning and lifelong learning

The definition of T-learning was redefined during the research carried out for this thesis. **T-learning** refers to learning, enhancing of learning experience, and knowledge construction with the help of several technologies, such as iTV and mobile technologies, and IP. Television or a device suitable for viewing broadcasted contents is the primary medium and the others are secondary media. T-learning may be totally technically mediated or include partly traditional face-to-face lectures and printed books. T-learning is utilised in educational and corporate organizations and it supports lifelong learning by acting as a vehicle to learning at various ages.

T-learning is widening the access to distance learning. As described in the introduction, access to computers is seen as the major problem in E-learning. More than fifty per cent of the world's population does not have access to computers, and utilisation of Internet is restricted because of the lack of competence among teachers. However, television is an easy-to-use device, people are very used to the TV as a medium, and TV can deliver learning services for those who do not have access to computers and the Internet.

Education is no longer a once-in-a-lifetime experience, but rather a continuous lifelong process. According to the results of the performed interviews and field studies, the iTV learning system enables lifelong learning. The implementation of subsystems defined in the developed T-learning model has differed, but the results prove that iTV can be used in children's, adults', and deaf people's learning. Research with new contents and larger numbers of participants are needed with adult, children, and the deaf to find out more, for example, about such subjects as personalized learning, online communities and interaction via iTV. Furthermore, more research is required with new target groups: older and young people, and topics such as edutainment and games in T-learning.

The results from Motive learning environment prove that formal T-learning can be performed via iTV. The requirements of our T-learning defined in the T-learning model includes functions needed for formal learning and enable to be implemented with the help of the T-learning system model.

What will happen in the future if visions of schools are implemented, and half of the learning is Web-based as was envisioned in the research in the summer of 2004? Probably more than one member of a family will be studying via a Web-based environment concurrently. However, most families have only one computer with an Internet connection so far. The number of Internet subscriptions in Finland in 6/2005 was 1.306.446 (Ministry of Transport and Communications Finland, 2005), which was twenty-five per cent of the population. At the same time, most families have digital TV. In Finland ninety-four per cent of families had at least one television set in year 2004 (Finnpanel, 2005). Hence, the use of digital TV for learning purposes may be a partial solution to lifelong learning and requirements of the Knowledge Society.

In Finland, during the past couple of years, students' backgrounds have changed in higher education. An example of this is the so-called Muunto education (INIT, 2005), an alternative MSc programme aimed at students with already another or lower degree. It is now typical that in addition to young people, there is a growing number of middle-aged persons who need to study. In many cases, they have families and they are working in addition to their studies. This means new requirements for the suppliers of educational services, which should be recognized in the planning of the learning process and decisions on the adequacy of new technologies. Because adult students tend to have more job experience than young people, there is a need for personalized learning.

How far T-learning can compete with traditional lectures and other educational technologies depends more on the quality of the learning service and process than on the particular technology. **The content production is in a key role.**

10.1.2 Educational programmes will adopt edutainment characteristics

The 50 years' history of educational TV programmes shows that television has been an important medium in formal learning all over the world. It has provided formal education for outside education system children as well as for adults in developing countries. In the Western countries, a different type of learning services through television has supported university learning mostly in a partial role in the learning service.

Although the number of edutainment types of learning services will increase in the future, formal learning will co-exist with informal learning. The traditional educational services based totally on videos will not disappear for years, even as the first countries switch off analogue broadcasting and start digital broadcasting. In the first phase, the additional services connected to the videos broadcasted via digital broadcasting will be available via Internet pages. Examples of this kind of service are the broadcaster's archives such as BBC (BBC, 2005) and *Japan Broadcasting Corporation (NHK)* (Sumiyoshi et al., 2002, Sumiyoshi, 2002) available on broadcasters' web pages. In the second phase, new types of educational services will be launched via iTV.

As indicated in the Sub-chapter 3.2 formal learning has existed during the whole history of T-learning in a form of traditional educational services. Some of the programmes other than educational have been watched for entertainment, but characteristic for the produced educational programmes has not been entertainment. Edutainment will have an importance in the educational services to be launched in coming years. During the T-learning history few of the educational programmes have had a grade as a goal, but they have in most of cases aimed to increase knowledge or skills. In the future T-learning will serve both formal and informal learning.

When comparing educational TV programmes described in Sub-chapters 3.2, 3.3.2, and 3.3.3 to correspondence learning at the beginning of distance learning described in a Sub-chapter 1.1, it can be seen that the reasons for using of traditional educational programmes have similarities, as Table 20 illustrates.

Table 20: Similarities between correspondence learning and traditional educational programmes

Correspondence learning	**Traditional educational programmes**
Desire to entertain and educate people	To provide education
Needs were not shared by enough people in the area	A need to distribute a course over a wide geographical area
	An instructor with appropriate expertise is not always available locally
Jobs prevented people from attending face-to-face courses	Studying alongside work
	Need for individualized and personalized learning
	Overcrowded classes
	Financing

Based on the experiences gained during the research conducted, the reasons to use interactive educational services are expected to be almost the same as in traditional television programmes, despite the fact that the new services allow totally new features to support learning, illustrate subjects, and enable interaction.

10.1.3 Sign language via iTV

It is possible to use sign language in T-learning with the help of a T-learning system model for IPTV. The IPTV-based sign language solution is constructed on the basis of the information system described in the T-learning system model in Figure 82. It allows the content to be presented with non-linear structure.

A combination of textual and sign language forms has special requirements and recommendations for content production. A glossary to define difficult words in the text can help understanding of the text. A recommendation by the author is to have the dictionary both in a textual and sign language forms. The text and background need to have a high enough contrast. To ensure the readability, the background of the text needs to be monochromatic and not to include any figures. In the sign language form a signer's upper body area is especially important. To gain high enough contrast between the signer and the background, the signer should use dark, single-coloured clothes and the background needs to be light enough. Blue colours have worked well in television; it is the same in the signer's background colour. The background should not include any bright figures or include many colours. To enable understanding of signs, the size of the videos on the television screen need to be large enough.

A combination of sign language and textual form seems to work well in DTV. According to the results obtained in the research project conducted as part of the thesis, this kind of solution can be used for the informal and formal learning of both the deaf and hearing impaired persons. New field studies are required with new content. In the future, in addition to the local interaction, full interaction in the content needs to be tested with participants.

In the field study, videos did not include a pause function. The function was requested by the participants. Another solution for pause is dividing a video into the small enough pieces which allow time for performing assignments.

10.1.4 Instant messaging to enable online learning via iTV

Instant messaging enables online community following the principles of T-learning system model. The instant messaging implements part of the T-learning system model needed in communication.

An online community (described in the Sub-chapter 3.1) includes four parts: people, purpose, rules, and technology. The instant messaging via iTV satisfies the online community criteria including the same four parts. The participants are children who are watching the *Tuu juttuun* programme. The purpose is to allow a safe option for lonely afternoons when children are alone at home. According to the children, the main purpose of the instant messaging is to allow active participation in the programme. The children were creating the rules on how to work via the instant messaging. They felt that messages including swearing and bad mouthing should be rejected. Half of them felt that also messaging concerning irrelevant subjects should be rejected. The technology is MHP. The field study fulfils the definition on an online community. However, the results are based on the use of instant messaging constructed for MHP, but used with a PC emulator. Thus, more results via iTV are required to confirm the results and to be able to say more about the character of community via iTV.

The moderator's role depends on the purpose of the instant messaging service. If the service is goal directed, the moderator's role is important. According to the research results, the moderator needs to guide and activate the communication with comments and questions in addition to accepting and rejecting the sent messages.

According to this research, a programme-specific instant messaging service can be used to comment on a programme, to answer questions, and to participate in quiz programmes. The application includes an option for using several messaging rooms. It would allow communication about a particular topic longer than if only one messaging room was available. It allows deeper communication about the topic.

The character in a programme specific instant messaging differs from instant messaging on the Internet. On the Internet the participants message with friends, but not via iTV. In this sense the MHP-based instant messaging has similarities to *Internet Relay Chat (IRC)* systems that tend to be used for communication between strangers around topics or activities of common interest.

According to the literature review of *Instant messaging (IM)* conducted as a part of this thesis, multitasking is characteristic of teenagers' IM use. According to the performed research, the situation will not be the same for children. Most of them will not do multitasking while using IM via iTV in the future. Watching the programme and participating in messaging does not allow other activities because they demand constant concentration. One of the reasons for this can be that the subjects in the programme change so fast that there is no extra time to do other activities. Whether the situation will be the same, if there is more time for one topic, is uncertain. Also, whether children as a target group act differently from teenagers while using IM is unclear. These issues need to researched more in the future.

10.1.5 MHP, DVB-HTML and IPTV

Any evidence of the use of the new teletext services for presenting text-based learning materials and assignments in DTV were not found in the year 2001. The results of the field studies prove the DVB-HTML and HTML have been suitable formats for presenting learning material via DTV. They have allowed a clear and expressive form for content to be navigated on the desired order by students. The combination of the information and communication subsystems enabled the same browser to be used for presenting both the

content and sent messages. An open standards-based browser enabled T-learning without extensive programming efforts. Programming was needed for the multi-channel communication system and for the repository system in the Motive learning environment.

Also, the use of IPTV in a learning context is a new contribution. Based on the results, the IPTV seemed to be a good choice for implementing T-learning. Compared with MHP, an advantage is video viewing in IPTV. In MHP, the videos are so far in a loop and when a student starts watching them, the video does not necessarily start from the beginning. In IPTV, when a student turns on the video, it starts from the beginning.

10.1.6 Towards on-demand services, communities, and the use of several media

What will happen to T-learning in the future? So far, the educational services have been push services, but students have been able to record the programmes and shift the learning times to suit their own schedules. In the future on-demand educational services will offer learning opportunities at the desired time. Television will be used both for the individual and group activities. The students will act individually at home, but via iTV they will form virtual communities where they actively work in groups and communicate asynchronously. The students want to have more anything, anytime, anywhere, and on any device. In addition to the traditional TV set, it can be assumed that mobile devices and PCs will be used for watching programmes. An example of this is the use of the DVB-H standards in Nokia's mobile phones (Finnish Mobile TV, 2005). Young people, in particular, are used to consuming the way they like, when they want to and where they want to (Looms, 2005). An important aspect of T-learning is also pleasure. In the sitting room it is possible to lean backwards on a sofa while learning, while PCs require people to lean forward towards the screen.

10.1.7 Challenges concerning devices

The availability of devices is crucial for learning. The penetration of MHP has suffered from the lack of STBs. During the research no MHP STBs were commercially available for cable broadcasting. The first MHP STBs for cable broadcasting were launched in Finland on April 2006. In the second Motive field study, the number of students was limited because it was not possible to find more MHP STBs for cable broadcasting. The IM field study had to be performed at the YLE building and, instead of using a television and a MHP STB, a PC emulator was used for communication because the new MHP STBs with an Ethernet connection as a return channel did not arrive in Finland on time. **The future of MHP depends on the availability of STBs.** It has been proved that MHP facilitates learning but it cannot be used for learning purposes if adequate STBs are not available. **There are also problems concerning writing capability of the devices used.** The current virtual keyboards cannot be used for the writing of long messages, so other solutions are needed. If any traditional types of keyboard are not commercially available, it means that the use of other media will be required to enable all the required functions for T-learning.

10.2 Unresolved issues and biggest challenges

The biggest challenge during the whole research process has been the lack of STBs, content production tools, and controlling and writing devices. The technology existed, but the devices were lacking. There has been a lack of MHP STBs for cable broadcasting since the year 2002, when the first research project was started, funded by the Finnish government. Several companies participated. At the time of starting with the first research project on T-learning, there was no content available. Thus, in addition to solving the technical problems of DTV, interaction, and STBs, the content itself was a challenge. An associated challenge lay within the design and implementation of the content: no editing tools existed outside the offices of a project partner – every time a content needed to be

implemented for further development of the course material, a trip to the company's premises in another city was required.

The T-learning value net is wide. If one participant is missing or cannot serve the common goal, the final service suffers and cannot produce the added value that was planned.

10.3 Conclusions

10.3.1 Guidelines for the construction of an iTV learning system and facilitating learning

The goal of the thesis was to gain an understanding of T-learning and to create a T-learning model to solve the construction problems relating to facilitating learning via iTV and T-learning content production. Figure 100 illustrates the solution.

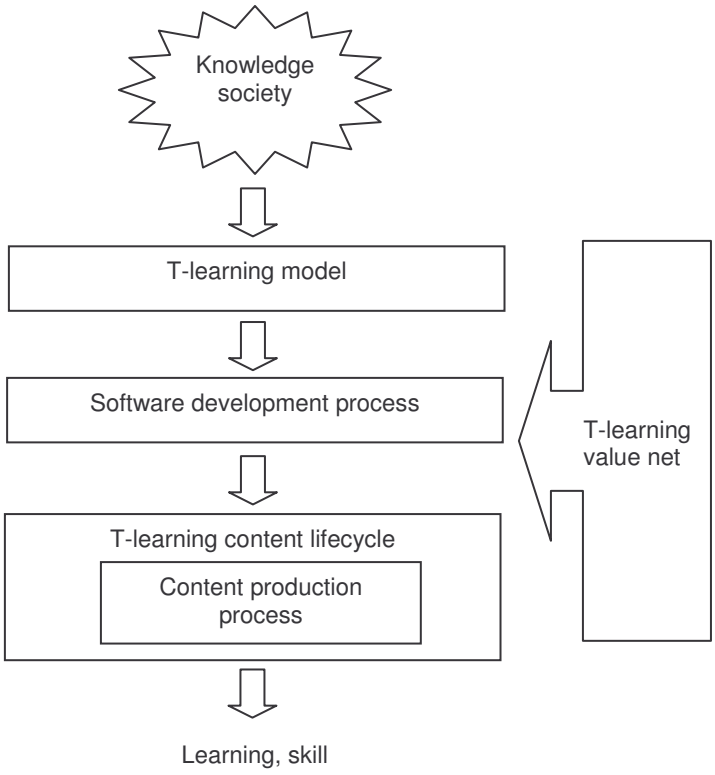


Figure 100: Issues affecting T-learning process and content production

A Knowledge Society requires new kinds of knowledge and skills from its members. The EU requires lifelong learning and learning for all. These all affect the construction of an iTV learning system and learning via the system.

The T-learning model describes the features and functions needed in the T-learning process via iTV. The technical requirements of the T-learning model can be used to discover whether the technology implementation of the platform allows the functionalities needed in learning via iTV. The technical requirements include functional and usability requirements and quality attributes. These are: transmission of learning environment, transmission of assignments, interaction/communication, security, accessibility, controlling of system, and usability. The use of only a broadcasting channel allows a partial or supplementary role in formal learning, meaning that only a part of the course is implemented via iTV. Thus, a course can include also, for example, face-to-face lectures. Some form of informal learning is also enabled. **A combination of broadcasting and**

interaction channels fulfils the pedagogic requirements defined in the T-learning model.

According to the empirical studies, T-learning can be used in at least the following situations, cases and groups:

A 1 formal and informal learning
A 2 assessment
- self-assessment
- active participation in group assignments
- graded

A 3 interaction
- synchronous/asynchronous communication
- virtual communities
- multi-channel communication
- communal learning

B 1 form of learning material
- textual
- visual
- connection to a TV programme

C 1target groups
- adults working as well as learning
- children
- deaf people

C 2 special groups
- sign language

The next phase is software development process. It is not necessary to develop software by oneself. Commercially available is browsers for presenting the content and software for communication. If customized software for learning is required, the software development process can be performed by oneself or together with a company based on the T-learning model.

The third phase is the T-learning content lifecycle, the first part of it is content production. The content production process is described in chapter 6.

The T-learning value net affects the whole construction process and T-learning lifecycle. **The T-learning value net is wider than in E-learning.** However, the co-operation of the participants has a crucial impact on the quality of the final learning. If one participant is missing or is not aiming at the common goal, the final service and learning outcomes suffer.

As a result of the process, learning and skills can exist. A learner has a key role in her own learning process, which affects the final results.

10.3.2 Content production process

Content production is crucial in T-learning. TV as a medium has special requirements for content production of a T-learning service. In the current DTV environment, moreover, the content producer has to consider the following issues:

- limited screen
- remote control of a STB as the only control device
- navigation
- scrolling is not allowed
- writing
    - Tiresias is the only built-in font

- television screen is viewed from a longer distance
- functionality of the television is limited
- television environment is different from the PC.

Because of the screen size, the amount of text on a television screen needs to be limited. The use of DVB-HTML means a very compact form, dividing the text into small pieces, and presenting only the required text. Because text input is limited, the use of other media can be needed. Short messages can be written with a virtual keyboard, but in designing assignments and communication the limitations need to be recognized. Special care has to be taken to allow proper navigation with a remote control. On the main level it is needed to enable easy navigation between learning material, assignment, and study guide. The exit needs to be easy to find. The navigation need to be learnable and memorable. When the requirements of a TV set is recognized in content production, both DVB-HTML and IPTV allow many opportunities for lifelong learning. The main issue is that the learning process in designed for iTV. New iTV services enable the student's active participation in her own learning process. In addition to the individual learning, T-learning enables online community to be formed. Students are not required to gather together to watch educational TV programmes but instead they can study asynchronously at home and with the help of iTV, form learning communities.

10.4 Future research objectives

A new interest group for T-learning is older persons who have finished full-time employment and have time to pursue educational activities for personal fulfilment. No research results were found concerning this subject. Older persons are very used to television and have seen the whole history of educational TV programmes, thus the threshold for using a T-learning service is not necessary high. In addition, corporate learning and learning on the job are new objects for T-learning which should be researched in the future.

BBC is opening their 1,5 million programme archive for the public to use for own non-commercial creation (Dam, 2005). The other broadcasters will follow. Metadata is an area which is coming to T-learning. In the future, students will be using broadcaster's material and editing it. This will require studies to find suitable metadata solutions for T-learning.

The sign language field study was performed as a stand-alone IPTV version. In the near future, field studies should be performed via IPTV networking. According to preliminary results, IPTV is worth further research.

Accessibility to T-learning services for all is an important research subject. People with disabilities and older persons can face problems in accessing both DTV services and T-learning services. eAccessibility is a subject that will be researched in the EU in 2006. The aim is to overcome the technical barriers so that people with special needs can participate in the Knowledge Society. In November 2005 the European commission's call for "Study on sustainable policy models for e-accessibility in digital television" closed. In the future, accessibility to participation on equal terms to the Knowledge Society will require a great deal of research and co-operation between several participants.

The Knowledge Society requires new kinds of knowledge and skills, which means that schools will have students with very different backgrounds and there will be a need for personalized learning. As described in Section 7.2.10 personalized learning paths were not implemented in the Motive project, but it is a subject that has potential for future research. DVB-HTML can be used for the construction of personalized learning paths, depending on the student's background knowledge.

References

Aarreniemi-Jokipelto, P., Instant Messaging for communal learning via Interactive Television – a synchronous communication between children in “Get along” programme, Proceedings of EuroITV 2006, the 4th European Conference on Interactive Television, Beyond Usability, Broadcast, and TV, 2006, Pages: 272-280

Aarreniemi-Jokipelto, P., T-learning Model for Learning via Digital TV, Proceedings of 16th EAEEIE Annual Conference on Innovation in Education for Electrical and Information Engineering (EIE), 2005 A, Paper 21,

Aarreniemi-Jokipelto, P., The Current State and the Future of T-learning in Finland – Results of a Study, Proceedings of Society for Technology and Teacher Education 2005, SITE 2005, 2005 B, Pages: 1859-1866

Aarreniemi-Jokipelto, P., Tuominen, J., Kalli, S., Riikonen, T., Experimenting with Digital Television Learning Environments, E-Train 2003, In a book: T-Training Practices for Professional Organizations, Nicholson, P., Thompson, J., Ruohonen, M., Multisilta, J., (eds.), Kluwer Academic Publishers, 2005 C, Pages: 231-238

Aarreniemi-Jokipelto, P., Non-linear course structure in learning in digital TV, Proceedings of the IASTED International Conference on Web-based education 2005 D, Pages: 386-391

Aarreniemi-Jokipelto, P., Content Production for the T-learning Environment, In a book: Methods and Technologies for Learning, Chiazzese, G., Allegra, M., Chifari, A., Ottaviano, S., (eds.), First International Conference on Methods and Technologies for Learning 2005, Witpress, 2005 E, Pages: 127-131

Aarreniemi-Jokipelto, P., Kalli, S., Open standard-based digital TV browser in T-learning, Proceedings of EuroITV 2005, the 3rd European Conference on Interactive Television, User-Centered ITV Systems, Programs and Applications, 30 Mar.- 1 Apr. 2005, 2005 F, Pages: 69-77

Aarreniemi-Jokipelto, P., Kalli, S., Open standard-based digital TV browser in T-learning, in Rasmussen, T., Jensen, J., (eds.) Interactive Television, the Media landscape, the Users & the Applications, will be published 2006, 2005 G

Aarreniemi-Jokipelto, P., Interactive Learning Environment in Digital TV: Results and Experiences, Proceedings of World Conference on E-learning in Corporate, Government, Healthcare, & Higher Education, E-Learn 2004, 2004 A, Pages: 1602-1609

Aarreniemi-Jokipelto, P., Tuominen, J., Experiences with an Interactive Learning Environment in Digital TV, Proceedings of the 4th IEEE International Conference on Advanced Learning Technologies, ICALT 2004, 30 August-1 September 2004, 2004 B, Pages: 296-300

Aarreniemi-Jokipelto, P., Tuominen, J., Interactive Value-added Services for Educational Purposes in Digital TV, Proceedings of World Conference on Educational Multimedia, Hypermedia & Telecommunications, ED-Media 2004, Volume 2, 2004 C, Pages: 1237-1242

Aarreniemi-Jokipelto, P., Tuominen J., MHP based interactive learning environment in digital TV, Proceedings of Society for Technology and Teacher Education 2004, SITE 2004, 2004 D, Page(s) 1670-1676

Ahonen, A., Turkki, L., Saarijärvi, M., Lahti, M., Virtanen, T., Guidelines for designing easy-to-use interactive television services: experiences from the ArviD programme, Proceedings of the 4th European conference on Interactive television, Beyond usability, broadcast, and TV, 2006, Pages: 225-233

Anderson, R. M., Evaluation of graduate engineering education by television at Purdue University, Proceedings of the IEEE, Volume 66, Issue 8, Aug. 1978, Pages: 918-926

AOL Inc., AOL Instant Messenger, 2005, http://www.aim.com/index.adp, 30 September 2005

Argillander, T., Esiselvitys digi-tv-alan klusteriohjelmasta, Liikenne- ja viestintäministeriön esiselvitys, 2003 (Available from the researcher)

ArviD, Digi-tv-klusteriohjelma, Arvid 2004-2005, 28.1.2004 Gustavelund, www.arvid.tv, 2 January 2006

ArviD, Text to speech, http://www.arvid.tv/java/Index?oid=489, 2005, 20 September 2005

ArviD, MHP subtitling, http://www.arvid.tv/java/Index?oid=495, 2005B, 20 September 2005

Axel, Axel Technologies Ltd, Instant Messaging for digital television, Chat with your friends and family from your couch ! http://www.axel.fi/messenger/messenger.pdf, 16 November 2005

Azimi, M., Ward, R., Nasiopoulos, P., New interactive services for digital TV, Proceedings of the 2001 International Conference on Image Processing, Volume: 1, 7-10 Oct. 2001, Page(s): 814 – 817 vol.1

Baas, K., Van den Eijnde, J., Junger, J., A practical model for the development of web based interactive courses, Proceedings of the 31st Annual Frontiers in Education Conference, Volume 1, 10-13 Oct. 2001, Pages: T2F-8-T2F-13 vol.1

Bailey, T., Courses, ACM SIGCSE Bulletin, Volume 4, Issue 3, 1972, Pages: 8-11

Bates, P., T-learning Study, A study into TV-based interactive learning to the home, Final Paper, Pjb Associates, UK, 2003, http//www.pjb.co.uk/t-learning.htm, 5.3.2005

BBC, British Broadcasting Corporation, Interactive Television Style Guide, Version 2.1, 2002, http://www.bbc.co.uk/commissioning/newmedia/pdf/styleguide2_1.pdf, September 9 2005

BBC, Press release: BBC releases first offerings from the BBC Archive, August 15, 2005, http://creativearchive.bbc.co.uk/news/index.html, 13 September 2005

Bernardini, A., Delogu, C., Ragazzini, Problems of DTT Interface and Some Suggestions from Web Accessibility, Proceedings of the 3rd European Conference on Interactive Television, User-Centred ITV Systems, Programmes and Applications, 2005, Pages: 151-157

Boulet, M., Learner-controlled situation with distance education, Proceedings of the 1995 ACM Symposium on Applied computing, 1995, Pages: 36-39

Boulet, M., A television distance education course to teach the management of software projects, Proceedings of the IEEE International conference on Multimedia Engineering Education, 3-5 July 1996, Pages: 129-133

Boulet, M., Distance learning of the management of software projects, Proceedings of the 2nd conference on Integrating technology into computer science education, Volume 29, Issue 3, 1997, Pages: 136-138

Boulet, M., Boudreault, S., Guérette, L., Effects of the use of television for an undergraduate course in computer science, ACM SIGCUE Outlook, Volume 26, Number 1, 1998, Pages : 3-14

Boulet, M., Jebara, F., Boudreault, S., Teaching process modelling to undergraduate computer students: Effects of using Lotus Notes and Television programmes, Proceedings of the 6th annual conference on integrating technology into computer science education changing the delivery of computer science education, Volume 30, Issue 3, 1998 B, Pages: 32-36

Boulet, M., Jebara, F., Bemmira, F., Boudreault, S., A comparison of three delivery systems for teaching an information technology course, Communications of the ACM, Volume 45, Number 4, 2002, Pages : 129-135

Brecht, R., Kunert, T., User requirements and design guidance for interactive TV news applications, Proceedings of EuroITV 2005, the 3rd European Conference on Interactive Television, User-Centred ITV Systems, Programs and Applications, 30 Mar.- 1 Apr. 2005, Pages: 159-164

Carey, J., The Evolution of TV Viewing, 2002, http://www.bnet.fordham.edu/carey1/, 13 September 2005

Carmichael, A., Style guide for the design of interactive television services for elderly viewers, 1999, www.computing.dundee.uk/projects/UTOPIA/Publications.asp, 18 November 2006

Cenelec, Standardisation Requirements for Access to Digital TV and Interactive Services by Disabled People, November 2003, http://www.cenelec.org/NR/rdonlyres/5C6E5124-6034-422A-A1CC-62B2229746C3/664/FinalreportTVforAll.pdf, 6 March 2006

Cesar, P., Vierinen J., Vuorimaa, P., Open graphical framework for interactive TV, Proceedings of the Fifth International Symposium on Multimedia Software Engineering, 10-12 Dec. 2003, Pages: 21-28

Chi, Y.-L., Improving the evaluation of programming courses, 33rd ASEE/IEEE Frontiers in Education Conference, Volume 3, 5-8 Nov. 2003, Pages: S3F – 17 -20 vol.3

Cho, C., Han, I., Jun, Y., Lee, H., Improvement of channel zapping time in IPTV services using the adjacent groups join-leave method, The 6th International Conference on Advanced Communication Technology, Volume: 2, 2004, Pages: 971-975

Commission of the European Communities, Communication from the commission to the council, the European Parliament, the European Economic and Social Committee and the Committee of the regions on the transition from analogue to digital broadcasting (from digital “switchover” to analogue “switch-off”), COM(203) 541 final, 2003, europa.eu.int/comm/secretariat_general/ impact/docs/COM_2003_0541_F_EN.pdf, 6 March 2006

Costabile, M., De Marsico, M., Lanzilotti, R., Plantamura, V., Roselli, T., On the Usability Evaluation of E-Learning Applications, Proceedings of the 38th Annual Hawaii International Conference on System Sciences, 3-6 Jan. 2005, Pages: 10 pages

CSS2 specification, Cascading Style Sheet, level 2, W3C Consortium, REC-CSS2-19980512, 12 May 1998, Available in address: http://www.w3.org/TR/CSS2/css2.pdf, 2.4.2004

Dam, A., User created content and user communities in interactive television, Proceedings of EuroITV 2005, the 3rd European Conference on Interactive Television, User-Centred ITV Systems, Programs and Applications, 30 Mar.- 1 Apr. 2005, Pages: 39-41

Damásio, M., Quico, C., T-Learning and Interactive Television Edutainment: the Portuguese Case Study, Proceedings of World Conference on Educational Multimedia, Hypermedia & Telecommunications, ED-Media 2004, 2004, Pages: 4511-4518

Damásio, M., Quico, C., Ferreira, A., Interactive television usage and applications: the Portuguese case-study, Computers and Graphics, Volume 28, Noumber 2, Pages: 139-148, 2004 B

Darnell, M., Effects of Font Style, Size and Color on the Readability of Text on TV, Proceedings of the 3rd European Conference on Interactive Television, User-Centred ITV Systems, Programmes and Applications, 2005, Pages: 125-131

Deafvoc, Deafvoc, http://www.deafvoc.fi/pages.php?class=project&realplayer=TRUE, 13 March, 2006

De Oliveira, J., Waisman, T., da Silva, F., Horbe, B., Maia, O., Morenghi, F., T-learning in Amazon: The Interactive Education Project, Proceedings of the 4th Euro iTV Conference, 2006, Pages: 290-295

Digita, Rules of Operation of Service Information in the DTTV Network v1.4, April 2002, 36 p.

DiSessa, A., Changing Minds, Computers, Learning and Literacy, Cambridge: MIT Press, 2000

Dosi, A., Prario, B., New Frontiers of T-Learning: the Emergence of Interactive Digital Broadcasting Learning Services in Europe, Proceedings of World Conference on Educational Multimedia, Hypermedia & Telecommunications, ED-Media 2004, 2004, Pages: 4831-4836

DVB-Schene, Erkki, Liikanen, Support for MHP-implementation, in DVB-Schene 01, MHP out of the box, April 2002, www.dvb.org//documents/newsletters/DVB-SCENE01.pdf, 9 November 2005

EBU Project Group B/CA, Functional model of a conditional access system, EBU Technical Review, Winter 1995, Pages: 64-77

EBU, European broadcasting union, Proposed EU regulatory framework for electronic communication, EBU comments for the European Parliament's second reading, 26.10.2001/5, www.ebu.ch/departments/legal/pdf/leg-pp-communications_261001.pdf, 11.11.2001

Edusolutions Oy, EduLink – verkkotoimintaympäristö, http://www.edusolutions.fi/Page.aspx?SectionId=5823, 7 March 2006

Eierman, M.,Niederman, F., Adams, C., DSS theory: A model of constructs and relationships, Decision Support Systems 14, No 1, 1995, Pages: 1-26

Eisenhardt, K., Building theories from case study research, Academy of Management Review, Volume 14, No 4, 1989, Pages: 532-550

Elbaz, R., Torres, L., Sassatelli, G., Guillemin, P., Anguille, C., Buatois, C., Rigaud, J., Hardware engines for bus encryption: a survey of existing techniques, Proceedings of Design, Automation and Test in Europe, Volume 3, 2005, Pages: 40-45 vol.3

EN 301 192, Digital Video Broadcasting (DVB): DVB Specification for Data Broadcasting, European Telecommunications Standards Institute (ETSI), v1.4.1, 2004-11

Eskola, J., Suoranta, J., Johdatus laadulliseen tutkimukseen, Jyväskylä: Vastapaino, 2005, (in Finnish)

ETS 300 706, Enhanced teletext specification, European Telecommunication Standardization Institute (ETSI), 1997

Eronen, L., User centered research methods for interactive television, Proceedings of EuroITV 2005, the 3rd European Conference on Interactive Television, User-Centred ITV Systems, Programs and Applications, 30 Mar.- 1 Apr. 2005, Pages: 15-26

EU Council, Council Resolution of 27 June 2002 on lifelong learning, Official Journal of the European Communities, C 163/1, 2002

European Parliament resolution on Television without Frontiers (2003/2033(INI)), 2003, http://www.europarl.eu.int/omk/sipade3?SAME_LEVEL=1&LEVEL=2&NAV=X&DETAIL=&PUBREF=-//EP//TEXT+REPORT+A5-2003-0251+0+DOC+XML+V0//EN#title1, 6 March 2006

Falchikov, N., Learning together, Peer tutoring in higher education, New York: Routledge Falmer, 2001

Fallahkhair, S., Pemberton, L., Masthoff, J., A dual device scenario for informal language learning: interactive television meets the mobile phone, Proceedings of the 4th IEEE International Conference on Advanced Learning, Technologies, 2004, Pages: 16-20

Faulkner, X., Usability Engineering, Great Britain: Palgrave, 2000

Finnish Mobile TV, Press release: Consumers also want to watch TV programs on their mobile, 30 August, 2005, www.finnishmobiletv.com/default.aspx?f=25&d=46, 8 September 2005

Finnpanel, TV-taloudet Suomessa 2004, 9.2.2005, http://www.finnpanel.fi/tulokset/tv/tvtaloudet/2004/kaikki.html, 9 November 2005

Fortes, R., de Almeida, F., The communication of the Cossack system's components, Proceedings of EuroITV 2005, the 3rd European Conference on Interactive Television, User-Centred ITV Systems, Programs and Applications, 30 Mar.- 1 Apr. 2005, Pages: 219-227

Frees, S., Kessler, G., Developing collaborative tools to promote communication and active learning in academia, Proceedings of the 34th Annual Frontiers in Education Conference 2004, 20-23 Oct. 2004, Pages: S3B-20-5 vol.3

French, T., Springett, M., Trusted and trustworthy digital interactive TV: paradise lost or a paradise (to be) regained?, Proceedings of EuroITV 2005, the 3rd European Conference on Interactive Television, User-Centred ITV Systems, Programs and Applications, 30 Mar.- 1 Apr. 2005, Pages: 53-59

Frølich, O., How to establish MHP application development environment, EBU Technical Review, July 2002, 6 pages

Fötschl, H-P., Plösch, R., Interactive applications for the Multimedia Home Platform, Proceedings of the Fourth International Symposium on Multimedia Software Engineering, 11-13 Dec. 2002, Page(s): 264 – 271

Gentikow, B., Limiting factors for embracing ITV: Television as a cultural form and the embodiment of media use, Proceedings of EuroITV 2005, the 3rd European Conference on Interactive Television, User-Centred ITV Systems, Programs and Applications, 30 Mar.- 1 Apr. 2005, Pages: 61-67

Gil, A., Pazos, J., Díaz, R., Fernández , A., Fernández, M.,Ramos, M., Internet-TV convergence in DVB-MHP, Proceedings of the 4th EURASIP – IEEE Region 8 International Symposium on VIPromcom, Video/Image Processing and Multimedia Communications, 16 – 19 June 2002, 2002 A , Page(s) 447-451

Gil, A., Pazos, J., López, C., López, J., Rubio, R., Ramos, M., Díaz, R., Surfing the Web on TV: the MHP approach, Proceedings of 2002 IEEE International Conference on Multimedia and Expo, Volume 2, 26-29 Aug. 2002, 2000 B, Pages: 285-288 vol.2

Gooley, A., Skippington, P., Towers, S., Lifelong learning: generating new learning opportunities, in a book: Innovation in Open & Distance Learning, Successful Development of Online and Web-Based Learning, Ed. Lockwood, F., Gooley, A., Kogan Page Limited, 2001

Granic, A., Glavinic, V., Usability evaluation issues for computerized educational systems, Proceedings of IEEE 11th Mediterranean Electrotechnical Conference, 7-9 May 2002, Pages: 558-562

Grinter, R., Palen, L., Instant Messaging in Teen Life, Proceedings of the 2002 ACM Conference on Computer Supported Cooperative work, 2002, Pages: 21-30

Hakkarainen, K. Lonka, K. Lipponen, L., Tutkiva oppiminen älykkään toiminnan rajat ja niiden ylittäminen, Porvoo: WSOY, 2001, p.175-206

Handel, M., Herbsleb, J., What is chat doing in the workplace?, Proceedings of the 2002 ACM conference on Computer supported cooperative work, 2002, Pages: 1-10

Harper, K., Chen, K., Yen, D., Distance learning, virtual classrooms, and teaching pedagogy in the Internet environment, Technology in Society, Volume 26, Issue 4, November 2004, Pages: 585-598

Henriksson, J., DVB-X, DVB-X-Schene, DVB, March 2003

Hentea, M., Shea, M., Pennington, L., A perspective on fulfilling the expectations of distance learning, Proceedings of the 4th conference on information technology curriculum, 2003, Pages: 160-167

Herrero, C., Cesar, P., Vuorimaa, P., Delivering MHP applications into a real DVB-T network: OtaDigi, Proceedings of the 6th International Conference on Telecommunications in Modern Satellite, Cable and Broadcasting Service, Volume 1, Oct. 1-3, 2003, Pages: 231-234 vol.1

Hevner, A., March, S., Park, J., Ram, S., Design science in information systems research, MIS Quarterly 28, No 1, 2004, Pages: 75-105

Hulsen, P., Kim, J-G., Lee, H-K., Kang, K-O., Delivering T-learning with TV-anytime through packaging, Proceedings of the 2004 IEEE International Symposium on Consumer Electronics, 1-3 Sept. 2004, Pages: 614-619

IEEE Standard for Learning Object Metadata 1484.12.1, IEEE Computer Society, 2002, http://itsc.ieee.org/wg12/20020612-Final-LOM-Draft.html, 18 Oct. 2005 ,

Ikehata, Y., Shigeno, H., Okada, K., Matsushita, Y., Experiments and evaluation in group work distance learning: the use of Internet collaboration system with “interactive image control” universal canvas, Proceedings of the 19th IEEE International Performance, Computing, and Communications Conference, 20-22 Feb. 2002, Page(s): 314-320, 2000

ILSMH European Association, Make it simple – European guidelines for the production of easy-to-read information for people with learning disability, June 1998, www.inclusion-europe.org/documents/SAD64EETREN.pdf, 8 March 2006, 21 pages

INIT, Industrial IT Laboratory, www.init.hut.fi, 18 December 2005

Isaacs, E., Walendowski, A., Ranganthan, D., Hubbub: A sound enhanced mobile instant messenger that supports awareness and opportunistic interactions, Proceedings of the SIGCHI Conference on Human factors in Computing Systems: changing our world, changing ourselves, Volume 4, Issue 1, 2002, Pages: 179-186

Isaacs, E., Walendowski, A., Whittaker, S., Sciano, D., Kamm, C., The character, functions, and styles of instant messaging in the workplace, Proceedings of the 2002 ACM conference on Computer supported cooperative work, 2002, Pages: 11-20

ISO DIS 9241-11, Ergonomic requirements for office work with visual display terminals (VDTs) - Part 11 : Guidance on usability, 1998

ISO/IEC, 13818-1, Information technology: Generic coding of moving pictures and associated audio information, Part one, Systems, 2000

ISO/IEC, 13818-2 Information technology: Generic coding of moving pictures and associated audio information, Part two: Video, 2000

Isomursu, P., Perälä, M., Tasajärvi, L., Isomursu, M., Internet-based amateur video delivery: the users and their requirements, Proceedings of the 37th Hawaii International Conference on System Sciences, 5-8 Jan. 2004, Pages: 97-104

ITC guidelines on Standards for Sign Language on Digital Terrestrial Television, Requirements relating to sign language interpretation, 1997, http://www.ofcom.org.uk/static/archive/itc/itc_publications/codes_guidance/sign_language_dtt/signing_2.asp.html, 6 March 2006

ITU-T, International Telecommunication Unit, Rec. J.110, Transmission of television, sound program and other multimedia signals, Interactive service, Basic principles for a worldwide common family of systems for the provision of interactive television services, 04/1997

Jaeger, R., Neubauer, J., Video and interactive Internet access in a DVB network, Proceedings of the 1st European Conference on Universal Multiservice Networks, 2-4 Oct. 2000, Pages: 439-445

Jain, R., I want my IPTV, IEEE Multimedia, Volume 12, Issue 3, 2005, Pages: 95-96

Jan, J., Chen, Y.-H.., A new efficient MAKEP for wireless communication, Proceedings of the 18th International Conference on Advanced Information Networking and Application, Volume 2, 2004, Pages: 347-350 vol.2

Jensen, J., Toscan, C., (eds), Interactive television, TV of the future or the future of TV? Ålborg, Aalborg University Press, 1999

Jensen, J., Interactivt tv – lille mediehistorie, (in Danish), in Interaktivt tv… vent venligst…, 11 bidrag til forståelse af tv's digitale merværdi, (eds.) Holmegaard Christensen, L., Aalborg Universitetsforlag, 2004

Jensen, F., Beyond Usability: From Usability Engineering to Experience Design Research, Proceedings of the 4th Euro iTV Conference, Beyond Usability, broadcast and TV, 2006, Pages: 569-572

Jiang, T., Zheng, S., Liu, B., Key distribution based on hierarchical access control for conditional access system in DTV broadcast, Proceedings of IEEE Transactions on Consumer Electronics, Volume 50, Issue 1, Feb. 2004, Pages: 225-230

Järvelä, S., How to prepare learners to the rapidly changing society? – Trends and prospects of the ICT in Finnish education, in eReflections – Ten Years of Educational Technology Studies at the University of Oulu. Essays contributed by the network builders,

eds. Latomaa, T., Pohjonen, J., Pulkkinen, J., Ruotsalainen, M., University of Oulu, 2004, Pages: 27-35, http://herkules.oulu.fi/isbn9514276329, 9.8.2005

Järvinen, P., On research methods, Opinpajan kirja, Tampereen yliopistopaino Oy, Tampere, 2001

Järvinen, P., On research methods, Opinpajan kirja, Tampereen yliopistopaino Oy, Tampere, 2004

Järvinen, P., Järvinen, A., Tutkimustyön metodeista, Opinpajan kirja, Tampereen yliopistopaino Oy, Tampere, 2004

Kaplan-Leiserson, E-learning circuits glossary, www.learningcircuits.org/glossary.html, 16 September 2005

Kasanen, E., Lukka, K., Siitonen, A., The constructive approach in management accounting research, Journal of Management Accounting Research, Volume 5, 1993, Pages: 243-264

Kim, Y., Yang, J., Park, M., Ahn, S., Ahn, C., Interactive broadcast terminal system using MPEG-2 and MPEG-4, Proceedings of the 2000 IEEE International Symposium on Circuits and Systems, Volume 3, 28-31 May 2000, Pages: 682-685 vol.3

Kjus, Y., The Liveness of Cross Media Formations, The Proceedings of the 3rd European Conference on Interactive Television, User-Centred ITV Systems, Programmes and Applications, 2005, Pages: 87-91

Kl-deaf, The Finnish Association of the Deaf, Other Services, http://www.kl-deaf.fi/page.asp?_item_id=2345, 6 March 2006

Kl-deaf, The Finnish Association of the Deaf, Facts about Finland and FAD, http://www.kl-deaf.fi/page.asp?_item_id=2314, 6 March 2006, 2006B

Kogan, N., Shavitt, Y., Wool, A., A practical revocation scheme for broadcast encryption using smart cards, Proceedings of the 2003 Symposium on Security and Privacy, 11-14 May 2003, Pages: 225-235

Koli, H., Silander P., Web-Based Learning: Designing and Guiding an effective learning process. Häme Polytechnic. Hämeenlinna, 2003

Kotus, The Languages of the Research Institute, The Finnish Sign Language, http://www.kotus.fi/kielet/viittoma/ind_inenglish.shtml, 6 March 2006

Laukka, S., The Image of Man – Learning Environment, Interaction and Educational Technology, in Campus Futurus –Perspectives on Learning and Technology, eds. Järvelä, S., Laukka, S., Pulkkinen, J., Saarenkunnas, M., University of Oulu, Oulun yliopiston kasvatustieteiden tiedekunnan elektronisia julkaisuja 2, 2000, Pages: 43- 50, http://herkules.oulu.fi/isbn954255313, 9.8.2005

Lee, B., Lee, S., Satellite remote education system design and implementation using MPEG-4 under DVB compliant network, Proceedings of 2002 IEEE International conference on Multimedia and Expo, 26-29 Aug. 2002, Pages: 393-396 vol.2

Lee, N., Chang, C., Lin, C., Hwang, T., Privacy and non-repudiation on pay-TV systems, IEEE Transactions on Consumer Electronics, Volume 46, Issue 1, Feb. 2000, Pages: 20-27

Lemos, R., Teaching programming languages: a survey of approaches, Proceedings of the tenth SIGCSE technical symposium on computer science education, Volume 11, Issue 1, 1979, Pages: 174-181

Lilja, D., Comparing Instructional Delivery Methods for Teaching Computer Systems Performance Analysis, IEEE Transactions on education, Volume 44, Number 1, February 2001, Pages: 35-44

Ljungstrand, P., af Segerstad, Y., Awareness of presence, Instant Messaging and WebWho, SIGGROUP Bulletin, Volume 21, Issue 3, December 2000, Pages: 21-27

Looms, P., PVRs and the free-to-air television market in Europe, Proceedings of EuroITV 2005, the 3rd European Conference on Interactive Television, User-Centred ITV Systems, Programs and Applications, 30 Mar.- 1 Apr. 2005, Pages: 27-35

López-Nores, M., Pazos-Arias, J., Díaz-Redondo, P., Blanco-Fernández, Y., García-Duque, J., Rey-López, M., Barragáns-Martínez, B., Fernández-Vilas, A., Gil-Solla, A., Ramos-Cabrer, M., Bringing Standard into T-learning, Proceedings of EuroITV 2005, the 3rd European Conference on Interactive Television, User-Centred ITV Systems, Programs and Applications, 2005A, 30 Mar.- 1 Apr. 2005, Pages: 79-86

López-Nores, M., Pazos-Arias, J., Blanco-Fernández. Y., Rey-lópez, M., García-Dunque, J., Barragáns-Martínez, B., Fernández-Vilas, A., Díaz-Redondo, R., Gil-Solla, A., Ramos-cabrer, M., Solutions for personalized T-learning, Proceedings of EuroITV 2005, 3rd European Conference on Interactive Television, User-Centred ITV Systems, Programs and Applications, 2005B, Pages: 235-236

Luckin, R., Peer to Peer Convergence: Designing a Pedagogigal Framework for Personal Learning Networks, Proceedings of the Internetional Conference on Computers in Education, ICCE´02, 2002, Pages: 19-22, Vol.1

Lugmayr, A., Lyytinen, J., Mailaparampil, A., Tico, F., Maijala, S., Tuominen, S., Pihlajamaeki, T., Rautavirta, P., Oksanen, M., Spieker, J., Niiranen, S., Kalli, S., –The future interaction TV project developing deit – digital interaction environment for TV, Proceedings of the 5th Nordic Signal Processing Symposium, 4-7 Oct. 2002, 6 p.

Lugmayr, A., Niiranen, S., Kalli. S., Digital Interactive TV and Metadata; New Paradigms in Interactive Broadcast Media, Springer, 2004

Lytras, M., Lougos, C., Chozos, P., Pouloudi, A.., Interactive television and e-Learning convergence: examining the potential of t-Learning, European Conference on e-Learning 2002, 2002, 11 p.

Ma, M., Wilkes-Gibbs, D., Kaplan, A., IDTV Broadcast Applications for a Handheld Device, Proceedings of 2004 IEEE International Conference on Communications, 20-24 June 2004, Volume 1, , Pages: 85-89 vol.1

Mankoff, J., Dey, A., Hsieh, G., Kientz, J., Lederer, S:, Ames, M., Heuristic Evaluation of Ambient Displays, Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, 2003, Volume 5, Issue 1, Pages: 169-176

Maloney-Krichmar, D., Abras, C., Preece, J., Revitalizing an Online Community, International Symposium on Technology and Soviety, ISTAS'02, 2002, Pages: 13-19

Mara, W., Fortran IV on videotape – An experiment in Televised Programmer Training, Proceedings of the 1964, 19th ACM national conference, 1964, Pages: 111.101-111.104

March, S., Smith, G., Design and natural science research in information technology, Decision Support Systems, Volume 15, 1995, Pages: 251-266

Marttunen, M., Laurinen, L., Student's collaboration during dyadic debates in secondary school, Proceedings of the Fourth IASTED International Conference on Web-based education, 2004, Pages: 63-67

McGivney, V., Informal learning in the community: A trigger for change and development, National Institute of Adult and Continuing Education, Leicester, 1999

Microsoft, MSN Messenger, 2005, http://messenger.msn.com, 30 September 2005

Milenkovic, M., Delivering interactive services via a digital TV infrastructure, Multimedia, Oct.- Dec. 1998, Volume 5, Issue 4, Pages 34-43

Ministry of Education, Information Society Program for Education, Training and Research 2004 -2006, Publications of the Ministry of Education, Finland 2004:14

Ministry of Transport and Communications Finland, Liikenne-ja viestintäministeriö, Internet-markkinat Suomessa 2005, Liikenne- ja viestintäministeriön julkaisuja 77/2005, Helsinki, 2005, in Finnish

Morigaki, T., Matsuura, K., Sudo, O., An Analysis of Detailed Electronic Time-Stamping Using Digital TV, Proceedings of the 2004 IEEE International Conference on e-Technology, e-Commerce and e-Service, EEE´04, 28-31 March 2004, Pages: 277-284

MySQL, http://www.mysql.com/, 24 November 2005

Nardi, B., Whittaker, S., Bradner, E., Interaction and outeraction: instant messaging in action, Proceedings of the 2000 ACM conference on Computer supported cooperative work, 2000, Pages: 79-88

Neal, L., Miller, D., Tutorial: The basics of e-learning: an excerpt from Handbook of Human factors in Web Design, eLearn Magazine, Volume 2005, Issue 8, 2005, Pages: 23 pp

Nielsen, J., Molich, R., Heuristic evaluation of user interfaces, Proceedings of the SIGCHI Conference on Human factors in computing systems: Enpowering people, March 1990, Pages: 249-256

Nielsen, J., Iterative User-Interface Design, IEEE Computer, Volume 26, Issue 11, November 1993, Pages: 32-41

Niiniluoto, I., Johdatus tieteenfilosofiaan – käsitteen- ja teorianmuodostus, Otava, Helsinki, 1980, (In Finnish)

Niiniluoto, I., Tiede, filosofia ja maailmankatsomus, Filosofisia esseitä tiedosta ja sen arvosta, Keuruu: Kustannusosakeyhtiö Otava, 1984, (In Finnish)

Niiranen, S., Lugmayr, A., Lamminen, H., Kalli, S., Security in the health care applications of digital television, Proceedings of the Fifth Nordic Signal Processing Symposium, NORSIG 2002, Pages:5 pp

O´Hagan, C., The Integration of Television and the Internet, Proceedings of the IEEE International Conference on Advanced Learning Technologies, 6-8 Aug. 2001, Pages: 475-477

O'Leary, S., Ryan, F., Wynne, B., Gilliam, C., Interactive Digital Terrestrial Television – The Wireless Return Channel and the EU Sponsored WITNESS Project, Proceedings of the IEEE Transactions on Broadcasting, Volume: 47, Issue: 2, June 2001, Pages: 160-163

Olkkonen, T., Johdatus teollisuustalouden tutkimustyöhön, Report No 152, Otaniemi: Helsinki University of Technology, Industrial Economics and Industrial Psychology, 1993

Ortikon Interactive Ltd, www.ortikon.com, 18 December 2005

Pahwa, A., Gruenbacher, D., Starrett, S., Morcos, M., Distance learning for Power Professionals, IEEE Power and Energy Magazine, Volume 3, Issue 1, Jan.-Feb. 2005, Page(s): 53-58

Parker, R., The Economics of Digital TV's future, In D. Gerbarg, The economics, technology and content of digital TV, 1999, USA: Kluwer Academic Publishers

Parolini, C., The Value net, A Tool for Competitive Strategy, Chichester.UK: John Wilew & Sons Ltd, 1999

pjb Associates, Development of Satellite and Terrestrial Digital Broadcasting Systems and Services, and Implications for Education and Training, 1999, www.pjb.co.uk

PHP, http://www.php.net/, 24 November 2005

Pelkonen, T., Kalli, S., Seppä, M., Heikkinen, S., Riikonen, T., Toiva, P., Hannula, M., Digitaalisen television ansaintalogiikat. Toimintakenttä, liiketoimintamallit ja tulevaisuudennäkymät, Liikenne- ja viestintäministeriön julkaisuja 25/2002, Helsinki: Edita

Pemberton, L., Fallahkhair, S., Beyond Usability: evaluating a cross-platform language learning service for iTV and mobile phone, Proceedings of the 4th Euro iTV Conference, Beyond usability, broadcast and TV, 2006, Pages: 456-457

Peraton, H., Creed, C., Applying New Technologies and Cost-Effective Delivery Systems in Basic Education, World Education Forum, Education for All 2000 Assessment, Thematic Studies, UNESCO, 2000, http://unesdoc.unesco.org/images/0012/001234/123482e.pdf.

Preece, J., Online communities: Designing usability, supporting sociability, Chichester.UK: Wiley& Sons, 2000

Pulkkinen, J., The paradigms of e-Education An analysis of the communication structures in the research on information and communication technology integration in education in the years 2000–2001, Doctorial Thesis, University of Oulu, 2004

Päijät-Visio Oy, http://www.paijat-visio.fi/, 13 September, 2006

Quesenbery, W., Reicharrt, T., Designing for Interactive Television, www.wqusability.com/articles/itv-design.html, 13 September 2005

Quico, C., Costa, C:, Damásio, M., User centred design methodologies applied to development of an electronic programming guide: the partnership experience of PT Multimédia and Universidade Lusófona, Proceedings of EuroITV 2005, the 3rd European Conference on Interactive Television, User-Centred ITV Systems, Programs and Applications, 30 Mar.- 1 Apr. 2005, Pages: 43- 49

Rasmussen, T., Television and Internet use in the home: patterns of use, In: Tarkka, Minna (ed.) Digital television and the consumer perspective, Pages: 55-62, Report, National Consumer Research Centre in Finland, discussion paper 34, 2003

Rasmussen, T., The sociability of Interactive Television, Proceedings of the 3rd European Conference on Interactive Television, User-Centred ITV Systems, Programmes and Applications, 2005, Pages: 99-103

Redwine, S., Riddle, W., Software technology maturation, Proceedings of the international conference on software engineering, 1985, Pages: 189-200

Rey-López, M., Díaz-Redondo, R., Fernández-Vilas, A., Pazos-Arias, J., Entercation Experiences: Engaging Viewers in Education through TV Programs, Proceedings of the 4th EuroITV Conference, Beyond Usability, Broadcast and TV, 2006, Pages: 310-319

RFC 791, (IP) "Internet Protocol", Postel, J., 1.9.1981

Rinnetmäki, M., A guide for digital TV service producers, 2004, ArviD publications 02/2004, Helsinki, Finland: Ministry of Transport and Communications

Rissanen, T., Argillander, T., Järvelin, A-M., Kalli, S., Seppä, M., Tuovinen, T., Digitaalisen television ansaintalogiikat – Palvelujen ansainnasta ja kustannuksista digi-tv:ssa, ArviD-julkaisuja 03/2004, Helsinki 2004

RNIB, Guidelines for the design of accessible information and communication technology systems, 2005, Royal National Institute for the Blind, www.tiresias.org/guidelines/television.htm, 18 November 2006

Robinson, J., Canelos, J., Innovative Format Using Television And Teaching Assistants In A Heavily-Enrolled Electrical Engineering Service Course, Proceedings of the Frontiers in Education Conference, 1989, Pages: 317-322

Roibás, A., Sala., R., Ahmad, S., Rahman, M., Beyond the remote control: Going the extra mile to enhance iTV via mobile devices & humanizing navigation experience for those with special needs, Proceedings of EuroITV 2005, the 3rd European Conference on Interactive Television, User-Centred ITV Systems, Programs and Applications, 30 Mar.- 1 Apr. 2005, Pages: 133- 141

Rose, K., Gutmann, R., Impact of Cable television on education, IEEE Transactions on Communications, Volume 23, Issue 10, Oct. 1975, Pages: 1164-1171

Sakai, S., Narahara, T., Mashita, N., Shigeno, H., Okada, K., Matsushita, Y., An Integrated Distance Learning System Capable of Supporting Interactions for Asynchronous Distance Learning, Proceedings of 22nd International Conference on Distributed Computing Systems Workshops, ICDCSW'02, 2-5 July 2002, Page(s): 116-121

Sandbank, C., P., Digital TV in the Convergent Environment, IEEE, Computer Graphics and Applications, January/February 2001, Volume 21, Issue 1, Pages: 32-36

Sanyal, B., New functions of higher education and ICT to achieve education for all, Paper prepared for the Expert Roundtable on University and Technology-for-Literacy/Basic education Partnership in Developing countries to be held in Paris, 2001, Unesco, literasy.org/products/ili/pdf/UTLPsanyal.pdf, 19 September 2005

Sawyer, T., Anderson, R., McCuaig, G., Is it live or is it Memorex?, Proceedings of the 14th annual ACM SIGCSE conference on user services: setting the direction, 1986, Pages: 225-258

Schiano, D., Chen, C., Ginsger, J., Gretasdottir, U., Huddleston, M., Isaacs, E., Teen Use of Messaging Media, Proceedings of ACM Conference on Human Factors in Computing Systems CHI ,02, 2002, Pages: 594-595

Schlosser, C. Distance Education: What the literature Says Works, The Proceedings of the 26th Annual Conference Frontiers in Education, Fie '96, 1996, Volume 2, Page(s): 553-555 vol.2

Schneiderman, B., Leonardo's laptop: human needs and the new computing technologies, London: MIT Press, 2002

Shim, K., Crytanalysis of Mutual Authentication and Key Exchange for Low Power Wireless Communications, IEEE Communications Letters, Volume 7, Issue 5, 2003, Pages: 248-250

Shrimpton-Smith, T., Geerts, D., Usability evaluation of iDTV application in Flander, The Proceedings of the 3rd European Conference on Interactive Television, User-Centred ITV Systems, Programmes and Applications, 2005, Pages: 143-150

Sillanpää, P., Selkokieli, 1999, http://staff.oamk.fi/~pesillan/selkokieli.html, 8 March 2006

Simmons, D., E-learning: Adoption Rates and Barries, The Forum Report, Volume 1, Issue 1, 2003, 4 pages

Smith, M, Informal learning, 1999, http://www.infed.org/biblio/inf-lrn.htm, 20 November 2006

Son, J., Triple Play Service: Broadcast TV and VoD over IP, Netmanians Network Newsletter, Vol. 1, No. 1, Sep., 2003

Song, R., Lyu, M., Analysis of privacy and non-repudiation on pay-tv systems, IEEE Transactions on Consumer Electronics, Volume 47, Issue 4, Nov. 2001, Pages: 729-733

Song, R., Korba, L., Pay-TV System with Strong Privacy and Non-Repudiation Protection, IEEE Transactions on Consumer Electronics, Volume 49, Number 2, 2003, Pages: 408-413

Sorensen, C., Evaluation of Distance Education Instruction: An Evaluation Case Study, Proceedings of the 26th Annual Conference on Frontiers in Education Conference, FIE '96, Volume 2, 6-9 Nov. 1996, Page(s): 560-564 vol.2

Spielvogel, R., Learning Link: A model for low – cost educational networks, ACM SIGCUE Outlook, Volume 19, Issue 3-4, 1987, Pages: 60-70

Spikins, D., After school, IEE review, September 1991, Pages: 299-302

Sumiyoshi, H., Yamada, I., Yagi, N., Multimedia education system for interactive educational services, Proceedings of IEEE International conference on Multimedia and Expo, Volume 2, 26-29 Aug. 2002, Pages: 385-388 vol.2

Sumiyoshi, H., Multimedia educational system, NHK, Research & Development No 30, 2002/1, www.nhk.or.jp/strl/publica/dayori-new/en/rd-0201e.html, 19 September 2005

Teasley, S., Roschelle, J., Construction in joint problem space: The computer as a tool for sharing knowledge, In: Lajoie, S., Derry, S., Computer as cognitive tools, Hillsdale: Lawrence Erlbaum, 1993

Tiresias screenfont, http://www.tiresias.org/fonts/about_sf.htm, 7 October 2005

United Nations, Standards Rules on the Equalization of Opportunities for Persons with Disabilities, General Assembly resolution 48/96 of 20 December 1993, A/RES/48/96, March 1994,
http://www.unhchr.ch/huridocda/huridoca.nsf/(Symbol)/A.RES.48.96.En?Opendocument, 8 March 2006

Van Aken, J., Management research based on the paradigm of the design sciences; the quest for field-tested and grounded technological rules, Journal of Management Studies, Volume 41, Issue 2, March 2004, Pages: 219-246

Varis, T., Medialukutaidon tila ja toteutus Euroopassa, Varis (ed.), Uusrenesassiajattelu, digitaalinen osaaminen ja monikulttuurisuuteen kasvaminen, Helsinki: Okka-säätiö, 2005

Varis, T., Digital Literacy and e-Learning in the Global University, in Tuominen, M., Wihersaari, J., (eds.), Ammatti ja kasvatus, Ammattikasvatuksen tutkimuksia vuonna 2004, 2005 B, Saarijärvi: Tampereen yliopisto.

Vuorimaa, P., A Digital Television Service Architecture, IEEE International Conference on Multimedia and Expo, ICME 2000, Volume 3, 30 July -2 Aug., 2000, Pages: 1411-1414 vol.3

Vuorimaa, P., Sancho, C., XML Based Text TV, Proceedings of the 1st International Web Information Systems Engineering, Volume 1, 19-21, June 2000, Pages: 109-113 vol.1

Weber, R., Theoretically speaking, MIS Quaterly 27, No 3, 2003, Pages: iii-xii

Webster, J., Watson, R., Analyzing the past to prepare for the future: Writing a literature review, MIS Quartely, Volume 26, Number 2, June 2002, Pages: xiii-xxiiii

Weippl, E., Improving Security in Mobile E-Learning, Proceedings of ED-MEDIA 2002, the World Conference on Educational Multimedia, Hypermedia & Telecommunications, Volume 1, 2004, Pages: 209-216

Weippl, E., In-depth tutorials: Security in e-learning, eLearn Magazine, Volume 2005, Issue 3, 2005, Pages: 3-6

XHTML, W3C Working Draft 22 July 2004, http://www.w3.org/TR/2004/WD-xhtml2-20040722/, 6 September 2006

Yle, Tuu juttuun, http://www.yle.fi/tuujuttuun/, 13 September, 2006

Yu, Z., Zhou, X., TV3P: An Adaptive Assistant for Personalized TV, IEEE Transactions on Consumer Electronics, Volume 50, Issue 1, Feb. 2004, Pages: 393-399

Zhao, L., Interactive Television in Distance Education: Benefits and Compromises, International Symposium on Technology and Society, ISTAS'02, 6-8 June, 2002, Pages: 255-261

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