Chapter 1

Objective of Research & Research Methodology

Introduction

Research is very essential and most powerful tool for progress of the society and mankind. In order to study and solve problem in education, development and learning, the research scholars have to undertake several steps in a regulated manner. The steps must be planned carefully, failing in any step leads to critical lapse in the whole attempt and it ends in unsatisfactory results. Research methodology is the search for knowledge through set objectives and systematically designed method of finding solutions to a defined problem. The aim and objective of research is to discover answers to questions through the applications of unique scientific procedures. The main aim of research is to find out truth which is hidden or undiscovered so far due to various reasons. Research is basically needed to test the hypothesis. The reliability of research study depend on the methodology adopted & followed, therefore the methodology used in this study is being presented as follows. The problem of study here is concerned with “Study and Analysis of various e-Learning Mechanisms for supporting Innovative Online Training and design of a Generalized e-Learning system”.

Hypothesis

Hypothesis is a compounded word of two words i.e. ‘hypo’ and ‘thesis’ and literally hypo means under or below and thesis means a reasoned theory or rational view point. Accordingly, hypothesis would mean a theory which is not fully reasoned. In other words, hypothesis is a theory entertained in order to study the facts and examine the validity of the theory.

As per Coffey ,“A hypothesis is an attempt at explanation: a provisional supposition made in order to explain scientifically some fact or phenomenon.” And, according to
Cohen and Nagel, “A hypothesis directs our search for the order.” It is not essential for a hypothesis directs our research for the order.” [1] So, it is not always necessary and essential for a hypothesis to be true. So, hypothesis is a bridge in the process of inquiry or search which begin with some felt difficulty or problem and end without the resolution of the problem.

The current research is based on empirical investigation, analysis and design of e-learning mechanism for effective learning using generalized e-learning model. The proposed research give insight into

- How learners perceive online learning environment using Learning Management System
- Investigation of learner and trainers perception of online learning quality and their satisfaction during learning
- Does web based and multimedia attributes influence e-learning satisfaction
- Will increase in performance of specific attributes or a new attribute will lead to increased satisfaction of users of e-learning system
- Various issues related to security and privacy aspects in e-learning system
- Various issues related to content management system and reusability of the contents in e-learning system
- Investigation of social impact of e-learning on higher education institutes etc.

1.1 Need of e-Learning

Need of e-learning is due to various reason. Web Based Training and its newer and more general synonymous term e-Learning are two of today’s buzz-words in the academic and business worlds. Decision-makers associate with them new ways of learning that are more cost efficient than traditional learning strategies and which allow students to better control the process of learning because they can decide when, where and how fast to learn. However two questions immediately arise:

1. What exactly does e-Learning mean and how it differs from traditional learning from the learner approach?
2. Is it really the best way to acquire new knowledge in current scenario?

The first question can only be answered partly and vaguely because it is still under heavy discussion what exactly e-Learning should look like as many of the learner still feel traditional learning as better option over e-learning, and different opinions even exist about what components it consists of. e-Learning therefore can be roughly defined in the following way and focus later on some of its aspects in more detail:

Definition: e-Learning consists of

- At least one or more e-Learning students who try to achieve a special learning goal in a simulated environment

- e-Learning contents which represents or at least describes the learning subject, the learning objectives and guidelines on how to achieve them. E-Learning content can be multimedia based and interactive.

- An e-Learning environment which works as an interface between the students and their learning objectives and provides different means to achieve the learning goal. Usually the e-Learning environment can be accessed using a Web browser over the Internet or Intranet and supports several learning strategies and different ways of interaction, communication and collaboration. Additionally e-Learning environments often include administration and management utilities and interfaces to other systems to support the organizational part of learning as well. Other terms for e-Learning environments, which are often used as synonyms or with slight variations in its feature-set are e.g. (among many others):
  - Computer Managed Instruction System (CMI-System)
  - Learning Content Management System (LCMS)
  - Learning Management Platform (LMP)
  - Learning Management System (LMS)
  - Virtual Learning Environment (VLE)
o Web Based Training System (WBT-System)

- Preferably one or more e-Learning coaches (or teachers/trainers) that assist and guide students when trying to achieve their learning goal.

Much more comprehensive descriptions of e-Learning and its technical architecture are discussed in IEEE-Learning Technology Systems Architecture. Strictly speaking e-Learning is just one part, the learning part, and needs to be complemented by e-Learning and e-Teaching. Both terms can be summarized under the term e-Education. However because most people understand e-Learning as the overall process, so the most suitable synonym to use is e-Education.

The second question is easier to answer, because the answer is simply no, e-Learning is not yet the best way to acquire new knowledge but it has the potential to be the most efficient one for many situations, if it is used in the right way. This can be explained by asking and answering the question “What does the ideal learning environment look like?”

1.1.1 An ideal environment for learning

To answer this question we do not have to deal with a lot of technology. We just need to look at the roots of learning and teaching as it was probably already practiced in e.g. ancient Greece.

In this ideal learning situation we have a very qualified teacher who trains and guides one or just a few students whom he knows quite well (their personal background, their strengths and weaknesses, their personalities, how fast they can understand etc.). If there is more than one student then all students should have about the same level of knowledge and agreeable personal profiles, know each other quite well and love working together and helping each other. Direct face to face communication between teacher and students (and among students) allows to immediately react to requirements of students (questions, speed of teaching etc.). Thus the teacher can individually respond to each of the students and motivate them. Also all necessary illustration material is available that the students can use to understand the teaching subject more quickly and there are plenty of
possibilities to practice and test the already learnt and use knowledge gained to solve problems with it.

This ideal situation will most probably lead to a very efficient learning process, no matter whether the learning goal is just storing some facts, carrying out processes, or whether they are as complex as finding new solutions for difficult problems of a certain category (the learning subject).

However, although it might be the ideal learning environment in reality it is not usable most of the times for at least one or more of the following reasons:

- It is limited to a very small number of similar students (in a group of 1-3)
- Usually the teacher and the students do not know each other well enough during the starting period of learning
- Generally e-learning is time and place dependent
- It is very expensive because of the one to one or one to few relation between teacher and students and the enormous investment in time.

Especially the fact that this scenario and all similar traditional learning strategies can not deliver new knowledge to a large number of students fast enough is the strongest argument which displaces instructor led training in the way described above. Additionally new requirements such as life long learning and just-in-time learning arise out of short development and deployment cycles and continuously changing working profile. That is the reason why we and our economy need a new way of learning to continue to be successful.

Psychologists such as Ivan Petrovich Pavlov (1849-1936), Edward Lee Thorndike (1874-1949), John B. Watson (1878-1958), Burrhus Frederic (BF) Skinner (1904-1990), Lev Vygotsky (1896-1934), Jean Piaget (1896-1980), John Dewey (1859-1952), and more psychologists are still trying to find out what the basic principles behind our way of learning are and found the learning concepts of Behaviorism, Cognitivism and Constructivism.

1.1.2 Application scenarios for e-Learning and Prerequisites
With e-Learning it seems that we have a new strategy which meets all demands and still provides an efficient way of learning by incorporating learning theories and combining them with new technological advances. Analysts such as META, GARTNER, Forrester, IDC etc. confirm this when they predict tremendous growth for e-Learning.

Several factors are facilitating this substantial growth of e-learning:

- E-learning growth is caused by large and growing base of installed computers in the home and workplace.
- E-learning is boosted with high Network security, available IT infrastructure, and dedicated bandwidth improvements.
- Advances in the speed of personal computers and modem & xDSL performance.
- With constant growth in cheaper and more reliable access to the Internet.
- Consumer wide acceptance of online commerce.

The most essential requirement and prerequisite for a successful implementation of e-Learning is the change of the learner’s and the organizer’s mind because the way of learning is so much different compared to traditional learning (e.g. learner centered vs. teacher centered) and offers other possibilities to integrate in the overall working or living process. In addition to that there is no single ideal way of using e-Learning efficiently, because there are different application scenarios which require different approaches. Maybe e-Learning alone is not the best way because it might be wise to combine it with traditional instructor led training, so-called “blended learning” (the mixture of different learning concepts and techniques). But at the bottom line we want to stress that e-Learning can help to improve the efficiency of learning tremendously if done properly.

Main application scenarios where e-Learning can be used are:

- Primary, secondary and post-secondary education. This includes schools at different levels, high schools and colleges & universities. New possibilities here are, just to name a few:
Objective of Research & Research Methodology

- Virtual universities which provide access to (high quality) education otherwise not possible for some students due to time or spatial constraints or because it is too expensive to implement.

- Bringing together pupils and students from different countries to better understand other cultures and prepare for the globalized world and ensure peace between nations.

- The chance to better support pupils and students with different needs e.g. by providing more individual supervision, support and possibilities for practicing, or by offering a broader or deeper spectrum of information for highly interested individuals.

- With the new communication and collaboration functionalities of e-Learning, which are also available outside school, change the drill and practice fact learning to more independent but guided knowledge acquisition.

However the amount of e-Learning in the sense of virtual learning that seems to be useful differs much between primary and post-secondary education schools, because primary education also has the additional goal of socializing children which can not be done yet by e-Learning in a sensible way. Therefore in this case it is more an additional way of learning and teaching and not a replacement.

• Working life (corporate training sector). Here e-Learning has its main advantage in its elimination of the border between learning and working. However this does not mean that learning can be done completely on the side, because learning is a mental process that still needs its time and environment. It means that learning can be better integrated in the working process. Examples for this are:

  - Just in time (JIT) knowledge: learn what and when you need it. This requires that the learning system is accessible at any time and easy to use to concentrate on the knowledge and problem solution and not on the system.
Objective of Research & Research Methodology

- Assured rapid knowledge transfer: Inform employees about things they do not even know exist in a controlled way so that it is verifiable that the information has been consumed and understood.

- Quick distribution of information about new products and strategies which have a short life span to a large number of employees. Traditional learning strategies are not able to perform a “rollout” to several hundred or thousand employees within short time.

- Human Capital Management (HCM): This is a more focused and strategic training of employees depending on their future employment and career path. The training can be done with blended learning (mixing different learning strategies, e.g. ILT and e-Learning), but coordinated and controlled by skill gap analysis and skill management (as part of an overall e-Learning architecture).

- Virtual corporate universities: Especially in large enterprises with many employees it makes sense to have one centralized trainings department, the so called corporate university. However quite often large companies have many branches and offices which are distributed over several countries or even continents. In this case it is much more efficient to make large parts of the training virtual to cut down traveling costs and absence of the workplace and offer distant education within a virtual corporate university.

- Life-long learning: Short production cycles, the short half-life period of knowledge and new ideas continue to revolutionize business and our everyday life. As an individual or as an employee "What you Know" equates to "What You Are Worth". Employers buy Skills and Know How. Keeping up in times of rapid change increases the individual’s worth and is the prerequisite for career advances. Even in our everyday life new tools
and concepts have an impact and require ongoing learning. E-Learning could be a good and cost efficient solution which allows learning at home.

1.2 The Importance of e-Learning

“Good Teaching is good Teaching, no matter how it’s done” –that stands true for e-learning, as e-learning brings new dimension to education.

In India, globalization of education has generated sudden quantitative growth in higher education, specially professional education like engineering. But to meet this sudden growth in engineering education, there is acute dearth of high quality trained teaching faculty, specially in most of the private state engineering colleges and private state universities everywhere in India. An effective education system must provide harmonious balance between the theory and practical knowledge in order to understand the technical aspects and applications of various engineering subjects in real life. Most of the universities are having their distance learning program divisions (DLPD) and virtual classrooms. These virtual classroom and virtual institutes are growing at high speed to replace the traditional classroom learning (c-learning) with the emerging e-learning technology.

**Unique features of e-learning over traditional learning are**

1. 24 x 7 accessibility to allow easy schedules and grater number of participants to attend the virtual classroom
2. Reducing students cost in terms of tuition fee, hostel fee and traveling expenses
3. Lower cost for companies and academic institutions by reducing the salary expenditures of trainers and faculty
4. Making learning self paced inline with the speed and grasping power of learners
5. Learners can choose the contents and tools as per their interest, needs and skill levels
6. Enhancement of computer and internet skills even for non-computer savvy persons
7. Eliminating geographical barriers
8. Facilitating great student interaction and collaboration
9. Providing opportunity to learn anywhere, anytime
10. Convenience of reading material online or downloading for later reading.
11. Choice available for wide range of courses as per needs of learner
12. e-learning is a wholesome learning

Along with unique features, various benefits provided by e-learning are

**Just-in-Time (JIT) access to timely information:**
Online learning system provide the flexibility to instructors for uploading the latest materials across the network instantly. This mechanism keeps the content fresh, consistent and up to date and provides immediate access for the learners to the most correct and updated information.

**e-learning facilitates fast/slow learning for learners**
The grasping power of learners is not same. Some students learn fast while others take considerable time to learn. As per the learning speed of students, e-learning system allow to adjust the output of information displayed on the monitor and its changing frequency as per the required level of the learner providing the flexibility of fast and slow learning. The slow and fast learners can take required time to learn the content. It removes the stress and embarrassing situation felt by slow learners seating with fast learners in the traditional classroom system.

**e-learning provides flexibility**
In e-learning, playback of recorded sessions are possible, so the absentees can play the recorded sessions and slow learners can listen the recorded session as many time as they want. This is unique flexibility provided by e-learning.

**e-learning is economic for learners and institutes/trainers**
e-learning is economic from learners point of view, as it provides best course material and expert lectures with the convenience of anytime, anywhere that too at an affordable rate, which cut down the traveling and hostel expenses, extra cost for learners. Also from the institutes/trainers point of view, the overall cost is reduced in terms of fixed liabilities like salaries of the faculty/trainers, building infrastructure cost, meeting room rentals, transportation expenses, lodging and boarding expenses, canteen expenses etc. Thus, e-learning is a WINWIN scenario from both the learners and trainers point of view.

**e-learning provides integrity**

In India, there are many states, many religions. e-learning provides the integrity of all institutions, research institutions, various regulatory bodies, academicians and professionals, students from various communities. e-learning provides sharing of knowledge, experience, technology, infrastructure and resources for the best utilization.

**e-learning facilitates learning by experience**

Professional education specially engineering education involve very difficult subjects and every subject is associated with its own subject practical. In order to make these difficult subjects more interesting for the learners, the subject is too be taught by highly experienced or expert trainers. But due to the globalization of education and acute shortage of experienced faculty, this difficulty can be resolved by e-learning. e-learning seems to be more appealing in this situation, as it can make difficult subjects much easy, practical and interesting. Also, there is a Chinese proverb “Tell me, and I will forget. Show me, and I may remember. Involve me, and I will understand”. This proverb fits well in this scenario. Studies had also proved that absorption and retention rate of learners are approx. 25% higher in e-learning compared to c-learning.

**e-learning facilitates modeling and simulation**

Modeling and simulation software can make learning really interesting, as the software promote learning through experience. Research proved that
learning done with experience has more rate of understanding and retention. e-learning facilitates interactive learning through modeling and simulation. The famous scientist Albert Einstein Says “I do not teach my pupils. I provide conditions in which they can learn”, so e-learning provides the right conditions, where learning becomes fun. Also,

- e-learning is unbiased in terms of sex, religion, caste, nationality
- e-learning facilitates dust free / chalk free environment.
- e-learning provides best faculty and study material at anytime and anywhere facilitating distance learning and virtual classrooms
- e-learning facilitates uniformity of content, information delivered is consistent for all users and possibilities of misinterpretations are almost negligible
- e-learning can provide customized contents for individual learners
- e-learning is also zero opportunity cost time, as e-learning facilitates learning after regular working hours, weekdays or on holidays.
- e-learning is a wholesome learning, it creates right conditions for learning so learning becomes fun

The collaborative learning theory says that, human interaction is most important in the learning process. The unique feature of c-learning are personal touch, eye contact and face to face interaction with the students of classroom. Body language is one of the most stimulating and motivating factor of traditional classroom learning. The unique advantage of c-learning are the major drawbacks of e-learning. Hence, e-learning can not completely take over traditional c-learning, still e-learning can bring considerable revolution in Indian professional education system. So, e-learning has tremendous potential in India, but adoption of e-learning in Indian education system has been very slow. Indian e-learning market is at a nascent stage and has very bright future.
For, success e-learning system in India, designing of e-learning packages need to be done carefully. Human interactions are very important in learning, so interaction of human with e-learning tools should be encouraged through audio/video conferencing programs. The drawback of e-learning however can’t be completely eliminated, still interactions of students seating in virtual class rooms can be made more frequent with the expert faculty using electronic boards, chats, emails and teleconferencing systems. There should be a fixed time or slot in which teleconferencing / chat sessions can be arranged.

Many of the engineering students are going abroad to pursue the graduation studies and doctorate studies. The demands of these students can be fulfilled in India, by setting state of the art e-learning infrastructure of international standards in India itself. This will not only retain the Indian students in the country but will also attract affordable students from abroad. It will also create employment opportunities in India, for e-learning course material designers. The people who can develop multi-lingual courseware which can address special and complex topics will be on high demand. It will boost the revenue of Indian companies involved in the business of e-learning. As there is high demand of virtual classrooms (trainer free classroom) in India. Virtual classroom can really enhance virtual reality. Basically, virtual reality is a 3D learning environment which provide the learner to explore the learning concept. Modeling and simulations can make more experienced learning environments. To successfully, promote e-learning in Indian professional education, it is desirable that engineering colleges and universities should prepare virtual reality modules for various subject and the respective topics.

Potential barriers to successful development of e-learning require huge one time cost in terms of development of educational content, installing large numbers of computers, providing internet facility in the rural areas with cost of installing optical fiber cables as well as training
students as well as teachers about usage of computers. Technology is dominant in e-learning, and is also expensive, unpredictable and can become obsolete. So, initial cost of implementation is very high.

In summary, the real limitations to e-learning are high bandwidth network connections, which may become as common telephone in near future of a decade. Human contact greatly impacts e-learning. Another limitation is use of audio and video for creating realistic job simulations and accommodating different learning styles. Designing, course content for e-learning in multi-lingual is another major problem.

1.3 Planning an e-learning system

The distribution of quality education is possible through proper synchronization and integration of multimedia in e-learning system. Audio and video when used in e-learning system can have an intense effect on the learner. If the text to speech system can make better use of environment audio clubbed with superior music quality, it could well improve the ambient sound quality because great sound quality enhances and reinforces the impact of e-learning course, by providing a rich, immersive environment.

Other problem with e-learning in India is lack of course content, english language content and tutorial like courses. There is high requirement of people to develop multi-lingual courseware that addresses various topics. According to Gartner, “The top 10 positions among global 1000 companies of future will be that of online learning material designers”. Due to the globalization of education, foreign universities are also coming to India to join the competition with Indian players. In today’s scenario of recession, attracting students is very difficult and hence the less effective institutes will either merge with efficient institutes or they will quit the market. Being a critical period of transition for both knowledge sellers and knowledge buyers, this transitions period is very critical. In current scenario, there is vast potential of e-learning system in all the states of India.
The only need for adopting e-learning is major marketing effort and awareness about the benefits of e-learning. As an initiative, Ministry of Human Resource and Development (MHRD), University Grant Commission (UGC), All India Council of Technical Education (AICTE). Many programs like EDUSAT (education through satellite) and INFONET are existing e-learning programs conducted successfully by UGC. There had been tremendous growth in IT industry but the same had been not reflected in education due to various limitation of traditional learning. However, proper implementation and use of e-learning can narrow down the gap between the industry and academics. By following the international standards, the Indian engineering colleges and universities can attract affordable international students. There is tremendous need of promotion of e-learning by the way of marketing and awareness program at national level.

The institutes need to maintain standards in terms of infrastructure and resources to meet the basic requirement to implement e-learning systems for the students. Collaborations between expert faculties of various institutes is desired. E-twinning of two or more institutes/universities at state and national level is also the demand of e-learning systems in order to better exchange information and expertise. Also inter country information exchange program will promote the Indian education system to international standards.

1.3.1 An ideal e-learning system Requirement

*Ralph W. Emerson said "The man who can make hard things easy is the educator."*

An ideal e-learning system, the pedagogical, technical and functional requirements are important which must be fulfilled to design an ideal e-Learning system. [2]

1.3.1.1 Pedagogical requirements
Up to now many e-learning systems consist of several parts and functions (like administration, runtime environment, communication, etc.) that are either loosely connected or not connected at all and where no overall educational idea lies behind them. However in a pure virtual learning environment the learners have mostly total control of from where, when and how they acquire the desired knowledge. Therefore the learners have to be guided by the content, the tutors and the system to prevent that they are distracted by too many possibilities. It is also necessary that the system helps the authors when creating and structuring the learning theme and modeling a didactic concept which the trainers have to support. We need “guidance without dictatorship” but must avoid the “lost in hyperspace” problem).

1.3.1.2 General Learning Theories

We talk about learning when we can detect a relatively stable change in some-ones behavior or behavioral dispositions, which is a result of learning-activities. Examples of learning are learning to speak language, to calculate equations, to think before you act, to spend less money or to play a piano part by heart. In all these cases learning has occurred when we are able to perform those activities, which we were not capable of before. Learning is an active process, in which we can speak of learning-activities. [3][4] We have to focus our attention, decode information and understand the information. Learning takes place in a learning environment. This means that learning occurs under certain conditions that are specially designed to improve learning. In this chapter We focus on three different views on learning environments: behaviourism, cognitive and constructivism.

1.3.1.3 Behaviorism of Learner

Behaviourism concerns itself solely with measurable and observable data and excludes explicit ideas, emotions, and the consideration of inner mental experiences and activities and is not interested in conscious (cognitive) control processes. The brain is understood as a “black box”
which gets certain input ("stimuli") and reacts in a deterministic way. In
behaviourist thinking, the focal point of learning is in shaping the
responses of the learner. The theoretical and didactical problem is to
research the appropriate stimuli and to enforce the correct behaviour with
adequate feedback.

Behaviourism is therefore well suited for:

- simple drill & practice patterns, such as
  - learning vocabulary in a language lab or
  - with classical learning software
- learning psychometrics abilities, such as
  - typewriting, piloting, laboratory work, playing a piano
- to generate models and mathematical formulas for explaining learning
  (quantitative description)

But it also has the disadvantage that this kind of learning hardly leads to a deeper
understanding of the learning content but mainly to factual knowledge. One of the
big dangers is also that stereotyped procedures de-motivate the learners.

If we map Skinner’s teaching machine to a Virtual Learning Environment (VLE)
we can develop the following requirements for it to support the behaviouristic
learning theory:

- The learning content needs to be separated into several small chunks
  (learning units).

- The VLE has to provide a strict navigation through these chunks of
  information, which guarantees that:

  - Only relevant chunks are presented to the learner, meaning that the
    required skill level is not too high and not too low for the student.
    This could be done e.g. by pre-tests and learning paths. A learning
    path defines which learning units are presented in which order. As
    an extension the concept can also be expanded from the content to
    the whole user interface of the VLE, meaning that only those
functions are available that are relevant for the current knowledge of the user and in the current situation.

- The information is processed by the learner and if not it is reinforced, meaning e.g. immediately repeated. This could be done by post-tests and repetitions which are included in the learning paths.

Note: Both requirements above lead to the necessity for tests and tracking and processing the progress of each student and also to provide some kind of reporting tools for the teacher and the student to monitor the progress.

- Open questions from students are answered and that the direct (through questions and remarks) or indirect (expressed by their collective failing of some questions) feedback of students is incorporated into the learning content to increase the quality of the learning units. To increase or at least maintain the motivation several measures can help:

  - Add multimedia, interactivity and humor to the learning content, so that it is fun to “drill and practice” it.
  - Add background libraries, so that the students are not restricted to the material presented and which they have to go through but can also explore other material.
  - As Skinner notes he sees his teaching machine only as a tool which should be used as an extension to the teacher. Thus one possible way to enhance motivation is to combine the behaviouristic learning approach with instructor-led training. This approach is often called “Blended Learning”.

1.3.1.4 Cognitivism of Learner
In general, the term Cognition refers to mental processes that can be described as an experience of knowing as opposed to an experience of feeling or of willing.
Cognition includes all processes of consciousness by which knowledge is built up, including topics like conception, perception, recognition and reasoning.

In Cognitive problem solving is the main way of learning: Not one answer or reaction to a certain question or stimulus needs to be practiced but more generally the right method(s) and procedure(s) have to be learned and understood and which of them leads to one or more of the right solutions. It is quite possible that not only one way leads to the optimum result but that several procedures can do this; however all of them will be trained explicitly. [5]

Cognitive theories emphasize making knowledge meaningful and helping learners organize and relate new information to existing knowledge in memory. Instructions must be based on a student’s existing mental structures, or schema, to be effective. Teachers should organize information in such a way that learners are able to connect new information with existing knowledge in some meaningful way. Analogies and metaphors are examples of this type of cognitive strategy. Such cognitive emphases imply that major tasks of the teacher/author include:

- understanding that individuals bring different learning experiences to the learning situation which can impact learning outcomes;
- determining the most effective manner in which to organize and structure new information to tap the learners’ previously acquired knowledge, abilities, and experiences; and
- Arranging practice with feedback so that the new information is effectively and efficiently assimilated and/or accommodated within the learner’s cognitive structure.

If we map the cognitivistic model to e-Learning environments we can derive the following requirements:

- Emphasis on the active involvement of the learner in the learning process such as learner control and Metacognitive training. Metacognition is the process of thinking about thinking. Flavell, describes it as follows: "Metacognition refers to one's knowledge concerning one's own cognitive processes or anything related to them, e.g., the learning-relevant properties of information or data. For example, I am engaging in
metacognition if I notice that I am having more trouble learning A than B; if it strikes me that I should double check C before accepting it as fact." [6] To support these techniques an e-Learning system should support the following tasks with built-in functions and tools:

- Self planning the learning process (by e.g. offering several different ways of acquiring the information, by offering a calendar or simple planning tools such as tasks and milestones lists)
- Monitoring learning progress (by e.g. including exercises or self-assessments and offering statistical reports to learners about their own learning progress)

- Emphasis on structuring, organizing, and sequencing information to facilitate optimal processing. Support of the use of cognitive strategies such as outlining, summaries, synthesizers or advance organizers by offering tools such as
  - An individual workspace, including simple authoring and structuring tools to summarize and reprocess information about learning
  - Powerful search facilities to locate relevant information
  - Private annotations and typed links and bookmarks, automatically summarized by a learner’s diary.
  - Mind maps of the learner
  - Semantic networks for the connectivity

- Use of hierarchical analyses to identify and illustrate prerequisite relationships (cognitive task analysis procedures). Here again Mind Maps could be of great value.

- Creation of learning environments that allow and encourage students to make connections with previously learnt material. This should support the
recall of prerequisite skills, use of relevant examples and analogies. This could be provided by an:

- Acquired-skill inventory (could be part of the skill management functionality), which is created partly automatically, by summarizing the difference between the pre- and post-test results after successfully finishing a course, and also includes private entries to reflect additional experiences.

- Private knowledge base (or workspace) organized in a hierarchical or semantic structure and containing collected articles, summaries, annotations and bookmarks.

1.3.1.5 Constructivism of Learner

Constructivism is a theory which is based on results of Piaget's research. It differs from the traditional view that knowledge exists independently of individuals.

Piaget postulated that there are mental structures that determine how data and new information are perceived. If the new data make sense to the existing mental structure, then the new information is incorporated into the structure. Rather than simply absorbing ideas through endless, repeated rote practice, constructivism posits that students actually invent their ideas. [7] Learning is considered as a reconstruction rather than a transmission of knowledge. Learners assimilate new information to simple, pre-existing notions, and modify their understanding in light of new data. They will reformulate their existing structures only if new information or experiences are connected to knowledge already in memory. Inferences, elaborations and relationships between old perceptions and new ideas must be personally drawn by the students in order for the new idea to become an integrated, useful part of their memory.

If the data are very different from the existing mental structure, it does not make any sense to incorporate them into the structure. The new information is either rejected or the information is assimilated or transformed so that it will fit into the
structure. In short, the learners must actively construct new information onto their existing mental framework for meaningful learning to occur. However one logical disadvantage of the constructivist learning theory is that it is not well suited to approach a topic which is totally new for the students.

According to Yager, the constructivist learning approach leads to the following suggestions on how teachers should proceed in their lessons. [8] These recommendations are initially made for instructor base teaching in schools, however they also give an idea how this could be supported by Virtual Learning Environments in e-learning courses:

- Seek out and use student questions and ideas to guide lessons and whole instructional units.
- Accept and encourage student initiation of ideas.
- Promote student leadership, collaboration, location of information and taking actions as a result of the learning process.
- Use student thinking efficiently, their experiences and interests to drive lessons.
- Encourage the use of alternative sources for information both from written materials and experts.
- Encourage students to suggest causes for event and situations and encourage them to predict consequences.
- Seek out student ideas before presenting teacher ideas or before studying ideas from textbooks or other sources.
- Encourage students to challenge each other’s conceptualizations and ideas for better learning.
- Encourage adequate time for reflection and analysis; respect and use all ideas that students generate.
- Encourage self-analysis, collection of real evidence to support ideas and reformulation of ideas in light of new knowledge.
Objective of Research & Research Methodology

- Use student identification of problems with local interest and impact as organizers for the course.
- Use local resources (human and material) as original sources of information that can be used in problem resolution.
- Increase student involvement in seeking information that can be applied in solving real-life problems.
- Extend learning beyond the class period, classroom and the school.
- Focus on the impact of the learning topic on each individual student.
- Refrain from viewing content as something that merely exists for students to master on tests.
- Emphasize career awareness—especially as related to the learning topic.

Many of these suggestions are relevant for the e-learning content author and the teacher who prepare the learning topic and do only little coaching, but most of them can be supported by various tools which the learning environment should provide. In reality this could work like this:

The Teacher will only provide instructions on how to start with the knowledge acquisition. This could be some basic introductory material describing the topic with suggested guidelines and some hints on how and with which means to start.

The teacher should decide which tools are offered for the students and are appropriate for them to use to prevent an overload and distracting with too much technology. During the course the teacher has to coach the students with answers to their questions or motivate them by expressing conflicting opinions on the topic, raise new questions or give some hints, but the teachers should not influence the students too much and should not play an active role, because according to Constructivism personal experience is in the foreground and not the helping tutor. At the end or even in between the verification whether the desired knowledge has been really acquired will not be done by an assessment but by a delivery describing and summarizing what they have learnt which can also be
judged by other students working on similar topics. The presented material can also be used as an input for new topics.

This leads to the following requirements for the tool set of the learning environment:

- Authoring tool for the teacher to package all descriptions, contents, references and supporting tools which are required to work out the target topic by the students. This package goes beyond what is understood as typical instructional course material.

- Simple structuring and authoring tools to summarize gained knowledge and present it to others.

- (Background) libraries and glossaries which include internal material (background stories, electronic books and publications etc.), simulations (emulations of the real world or a connection to a real remote lab) and external material (such as rated and reviewed references) to browse for information.

- Rich and powerful search facilities including full-text, similarity and experts search and scheduled agents which allow learners to search within the internal and the external information.

- Personal annotation, rating and linking tools which allow working on the material.

- Cognitive tools such as mind maps and semantic networks to structure gained knowledge.

- Collaboration features such as team building with shared workspaces and group annotations. Shared calendars and task lists might help to coordinate advanced students and schedule their jobs. Rating/voting tools could support sorting out and rating relevant material, and during the presentation phase allow the other students and the teacher to assess the prepared material.
Objective of Research & Research Methodology

- Synchronous and asynchronous communication features, such as discussion forums, messaging with mailing lists, text-, audio-, video chat, question/answer dialogs, shared whiteboards and application sharing tools to communicate with other learners, experts and tutors.

After recognizing the cognitivistic and constructivistic approaches to learning and the required tools have quite a lot of similarities to knowledge management, where information also has to be collected, organized and structured and then processed and prepared for delivery to the right people. The tasks of a student are quite similar to those of a knowledge worker.

Learning which is integrated in everyday tasks, such as learning by doing, learning from mistakes, learning through networking or learning from interpersonal experiments is also summarized under the term “incidental learning”. According to Holzinger, incidental learning is more efficient than intentional learning because learners rather concentrate on the learning goal than on the learning process itself because they are not conscious of the fact that they are learning at the moment. That is also the way children learn, and they do it quite effectively. [9]

Another strategy which can make learning more effective is to increase the motivation for (incidental or intentional) learning which is dependent on increasing arousal. According to Holzinger there is an optimal level of arousal for the most effective learning behavior. Important sources of arousal are stimulation, meaningfulness and the novelty of situations. Brehm & Self also define “motivational” arousal as a function of the extent to which learners assume personal responsibility for the outcomes of their behavior. [10] Holzinger used this background to produce a prototype system called VRfriends. Here a virtual avatar, the VRfriend, from time to time asks questions about a certain topic which the student has to answer. The problem of how to find the right answer has to be solved by the users themselves. If the answer is correct the VRfriend stays happy, otherwise it gets sad.
All this strategies and theories support the conclusion that learner centered knowledge acquisition is an efficient way of learning which has to be supported by a good virtual learning environment.

**The collaborative e-Learning environment Coronet**

One example of an e-Learning system which supports the cognitivistic and constructivistic approach is WBT-Master, which was also developed at the IICM. WBT-Master integrates collaborative learning with knowledge management by linking a sequence of learning activities with knowledge creation, knowledge structuring and knowledge dissemination processes in a manageable way. Of special interest are the following learning concepts:

- **Learning Goals:**

  A learning goal consists of a structured collection of learning actions and is defined by a tutor. A complex learning action is a collection of other learning actions. A simple learning action is a request to carry out a particular action to move a user one step closer to the learning goal. Such an action can be a reading session, communication with a tutor or another expert, passing a test, publishing a learner’s own material or solving a training problem such as doing a real work. This learning action is accompanied by a number of so-called learning resources, e.g. a course, document, learning unit, discussion forum, brainstorming session, etc... Tutors can assess the learning actions carried out by learners during online sessions and, thus, communicate with the learners, track their activity and certify their results.

- **Knowledge Cards**

  A knowledge card is a description of a particular concept and allows the definition of a conceptual view to a number of associated learning resources and can be also related to other knowledge cards. In addition to specially prepared training materials and any other type of document the system supports the involvement of human subject matter experts as learning resources. Learners may create their own knowledge card to
structure their learning resources and experiences and may combine them into a semantic network using just one type of relationship: “is a part of”, the inverse relationship is called “consists of”.

- **Knowledge Domains:**

  Global structures of learning resources can be organized within knowledge domains. Each knowledge domain is a set of documents belonging to a number of predefined semantic categories. A semantic category also includes the definition of a number of attributes (key-value pair). If for example a semantic category “module” has been created with an attribute “programming language” then each author who assigns a document to that category also needs to specify the used “programming language” of that “module”. The main goal of knowledge domains is to create and maintain well structured repositories which can also be browsed and searched.

- **Brainstorming sessions**

  A brainstorming session is a structured collection of articles of different types (e.g. question/answer, idea, supporting/contra argument, comment). Additionally all contributions can be ranked to elaborate the best idea. Brainstorming sessions are initiated and organized by a moderator and can be used for collaborative problem solving where a number of knowledge workers have to solve a given problem.

- **Mentoring sessions**

  Mentoring session can be used for problem solving with the help of an experienced knowledge worker (so called mentor) via synchronous communication sessions. During such a session all learning resources the mentor selects will be also transmitted to all learners. The mentor and the learners may also communicate by means of a special chat facility. Mentoring session may be also recorded and viewed asynchronously later on.

1.3.1.6 The BCC Together
The different theories about the learning process also mean a different view about teaching and the way knowledge and skills should be imparted. In Behaviourism it is a matter of producing suitable input to cause the correct reaction. Appropriate feedback, which has been created outside, has to support this process. From this concludes an authoritarian teacher model: The teacher knows what is wrong and what is right and has to find ways and means to get it across to the students, which have to remember the correct factual knowledge to produce correct answers for predefined questions.

In Cognitivism this evens out a little bit: Learners have to solve offered problems relatively independently (procedural knowledge: “know how”). However, the tasks are already didactically cleaned, meaning that all irrelevant facts have been removed, the situation has been simplified and has been presented as a concrete problem. The tutors coach the learning process, supervise and if necessary also help the learners.

In Constructivism the learner’s own personal experience is given priority. Learners have to cope with complex situations and at the same time have to create the actual problems and tasks which they have to solve (social practice: “knowing-in-action”). Teachers play the role of coaches or moderators. They lose parts of their apparent infallibility because they are, together with the learners, exposed to the criticism of the actual situation. Their teaching role arises solely from their bigger experience (of life) and from their ability to support other people to cope with complex situations.

In real life there is not a single theory that fits well for all situations. Which of the learning theories are best suited to a certain situation depends on the background knowledge, the learning content, subject and goal of the learner.

According to Baumgartner, we can distinguish five levels of knowledge which correlate to recommended learning theories.[11]

- **Level 1 – Novice – “Know that”:** Novices are not familiar with the learning topic yet and have not made any related experiences so far. First
they need to learn basic facts and rules which they can not question and which they can only apply to real situations with guidance from outside because they can not decide on their own what the best rule to fit is.

In most cases the Behaviouristic model would fit the needs of novices quite well.

- **Level 2 – (advanced) Beginner – “Know how”**: Beginners start to perceive different cases and situations and to apply rules according to their contexts. Skills are executed in more variations but beginners still can not act on their own without close guidance and controlling.

  Beginners achieve good results with a combination of the Behaviouristic and the Cognitivistic learning model.

- **Level 3 – Competence – “Rational understanding”**: Competent persons know all relevant facts and rules and can distinguish between a wide spectrum of different cases and which solutions apply to them. Thus they can act independently within their areas and solve occurring problems.

  Competency also means responsibility, taking a view and self-critical reflection. However decision making is still cumbersome and difficult, competent persons are far away from sudden intuitions real experts can have.

  Competent learners can be brought to the next step by a combination of the Cognitivistic and Constructivistic learning model.

- **Level 4 – Proficiency “Implicit understanding”**: At this stage the learners move from analytical realizations with subsequent applications of solution procedures to holistic perceptions of given situations. The learners seem to see the presented tasks together with their possible solutions.

  In most cases only the Constructivistic learning model can bring proficient learners to the expert level.

- **Level 5 – Expert “Intuitive action”**: Experts perfect the holistic perceptions because various difficult tasks look familiar to them. This works because of an improvement of their ability to perceive and construct
family likeness between different appearances. The art of this ability manifests itself in constructing cases, out of amorphous, unclear situations, which already contain their own solutions.

Experts complement their knowledge best by constructing new one.

1.3.1.7 Learning Styles of the Learners
According to Meeker, students must be able to receive, process, assimilate, store, and use the information that is being presented in order to learn. Most people have a preference for the type of information they can handle most easily. [13] This is a person’s learning style, which also has to be taken into account when creating e-Learning content:

  o **Figural:** A Figural is what we can see, hear, and touch directly. It could be a photograph, a sound, or a gesture. It may be visual, auditory, or kinesthetic. A learner whose figural abilities are high would be able to manipulate figures mentally or manually and would have good spatial perception and judgment. Typically such people are architects, surveyors, graphic artists or carpenters.

  o **Symbolic:** A symbol is an arbitrary sign that has no significance in itself, only that meaning which society ascribes to it. Examples include numeric codes, alphabetic characters, musical notes, mathematical signs, and other such symbols. Persons having high symbolic abilities do well with numbers or letters, and are often good with music. Typically such people are programmers or mathematicians.

  o **Semantic:** Semantic or verbal information includes the meanings society attaches to words. It is reading or writing, listening or speaking. A student high in semantic abilities is good with words and ideas and will frequently do well in formal educational settings. Typically such people are teachers, lawyers, writers or politicians.
Objective of Research & Research Methodology

- **Cognition**: The ability to perceive and understand new information quickly.

- **Memory**: The ability to retain and retrieve information in any form.

- **Evaluation**: The ability to make decisions and to judge correctness, suitability, adequacy, or desirability of information.

- **Convergent production** (sometimes called problem solving): The ability to synthesize new information from given information to arrive at what is normally accepted as the best answer or outcome.

- **Divergent production** (sometimes referred to as creativity): The ability to generate new information from given information, emphasizing the variety and quality of answers.

However it would be beyond the scope of this thesis to go into further detail and analyze what kind of influence this has on the creation of e-Learning content because this thesis focuses on e-Learning environments. As a consequence this chapter results in the requirement that e-Learning systems have to support different learning styles by offering the same content in various forms.

### 1.4 Functional Requirements

Apart from functions that directly support the learning and training strategy and which can be derived from the pedagogical requirements an e-Learning system also has to provide features that support the overall learning process including administration and organizational issues and an integration into other IT systems and infrastructure. In addition to that it might also be useful to support tasks that are closely related to learning such as human capital management, resource management and knowledge management. This chapter tries to summarize all functional requirements a good e-learning environment should fulfil.

#### 1.4.1 e-Learning Management Systems (LMS)
Usually e-Learning systems have been understood as Learning Management systems (LMS) which mainly focus on administrative aspects of learning and on content delivery and support the behaviouristic drill and practice approach. LMS have evolved from the early days of Computer Based Training CD-ROMs (CBT), which only presented the learning content but also needed some kind of course and student management to organize who should learn what and when. LMS offer at least support for planning, organizing and managing learning such as course catalogues and registration, event schedules, assessment services, keeping learner records, organizing group and individual learning paths. In addition to that they have often been extended by functions for skill and competency management for tracking and controlling the personal development of employees and by modules for resource management to also organize trainers, rooms and other types of resources for instructor-led trainings.

Systematically listed the most important functions and parts of an LMS are:

- Personalized learner portal: This module provides the personalized entry to the whole system and views to the most important personal information.

- Course catalogues and registration: This enables learners to access catalogue offerings, register, and enrol in the offerings. It also handles billing issues (which would require integration in e-commerce systems), notifications, schedule changes, waiting lists and drop policies and defines gathered skills when mastering the courses. A curriculum manager tool helps to define and select the courses for the course catalogue and is tightly integrated with the competency management functions. Selected courses can be assigned to trainees individually by the trainers or course managers.

- Learner-records database, with user-profile and competency management for tailoring learning experiences to competence frameworks. Core components of this module are:
  - Learner records: contain stored information about the learner, such as job title, organization, location and skills acquired. These cannot
be directly edited by the user. Personal preferences, such as delivery mode and language, may be edited by the user.

- Learner tracking: Learner tracking tracks a learner’s planned learning and progress through e-learning offerings by recording the history, and current status. A learning diary can also track all articles created and documents uploaded by the trainee.

- Skill gap analysis and personal performance reports visualize the actual skill profile of a certain user, the target skill profile to e.g. reach a certain new position and the potential gap between these two. The gap can be closed by mastering appropriate courses. Trainers can examine the progress of their students by using progress customizable grade reports.

- Management reporting tools (requires integration with performance management systems): With these tools managers can access a learning plan/history for each direct report in their reporting chain. They can approve registration and add to their employees’ future learning plans. They can also review their employees’ progress for both offerings and assessments. Additional tools support team forming according to a given skill profile. That way the LMS works as a support system for the production environment and e.g. can be directly linked to a project management system to form efficient project teams.

- Needs tight integration via interfaces with course catalogues, the assessment services and the content delivery system.

- Assessment services: Pre- and post-assessments are integrated with learning content to deliver a comprehensive curriculum that provides feedback to both learners and managers and adds value to the overall learning experience. Pre-assessments enable learners to study only the necessary material for a task at hand, saving valuable time. Post-
assessments provide results that are used to track completion status and are a key element for progress reporting.

- Resource Management: Resource Management assigns classrooms and instructors for instructor-led training and virtual events, managing the schedules for equipment, facilities, rooms, and instructors and storing additional attributes (e.g. number of trainees booked for a course to define the size of the room etc.). Ideally such modules also support optimization functions.

- Administration management: Here I summarize all other administrative tasks which an LMS can support:

  - Easy administration of users, teams, courses & classes, resources and the system itself. Import of user and group information and integration into external directory services (e.g. LDAP or Microsoft Active Directory) have to be supported.

  - Course management: creating, modifying, removing, trainee specific assigning and monitoring of courses.

  - System management: Configuration, load and failure reports, resources monitoring etc. of the system.

  - Support of numerous roles, at least distinguish between learners, trainers, authors and administrators.

  - Integration with learning-content management systems.

1.4.2 e-Learning Content Management Systems (LCMS)

Within the last two years a new term describing a different kind of e-Learning systems has been introduced: Learning Content Management Systems (LCMS).

An LCMS contains similar features as an (Web-) Content Management System but adapted to the needs for e-Learning. Its main task is the storing and structuring of content files in a database, managing revisions and
modifications, and ensuring that content is tagged for easy retrieval and reuse. Some of its key features are the availability of:
It also makes sense to offer the already built-in collaborative and knowledge construction features for students for their personal workspace. That way the system could support the cognitivistic and constructivistic learning paradigm.

1.4.3 Learning and Tutorial Support Management
Due to its importance I would like to mention a third system component which is usually integrated in parts in either LMS or LCMS: Learning and tutoring support management (LTSM). It supports the learning process through tutoring, peer support, communication and collaboration between learners and / or trainers, ranging from simple e-mail, to forum and virtual classroom.
Important functions of learning and tutoring support management are:
• Communication functions. Communication functions are classified in synchronous (place-independent, but time-dependent) and asynchronous (place- and time-independent) communication:
  o Asynchronous communication features are e.g.:
    Mail
    Mailing lists
    Discussion forum
    Question/answer dialogs
    News ticker (one way, for information distribution)

  Synchronous communication
    Instant messaging
    Text chat
    Voice chat
    Video conferencing
Objective of Research & Research Methodology

- Shared whiteboard
- Application sharing
- Virtual community with avatars
- Group browsing/follow me mode
- Hand raising and/or voting functions

A full set of synchronous communication functions are often summarized under the term “Virtual Classroom”. Here the trainer teaches a class of students completely synchronously like in instructor-based training, just virtually.

- Group work/collaboration
  - Shared/private annotation support for any document within the system
  - Shared/private bookmarking
  - Team forming
  - Participant list
  - Shared workspace
  - General workflow services
  - Recommender system functions: collaborative rating/voting of articles or documents
  - Calendar
  - Task list
  - Cognitive tool like mind mapping
  - Submission, reviewing and marking of assessments and exercises

Personal and team home pages which can be customized and modified by their owners. At least a virtual business card should be provided to tear down the wall between users that can only meet virtually,
increase the personal touch of the environment and therefore encourage communication.

All of the three mentioned systems should of course support all relevant (e-Learning) standards to ensure optimum integration with each others, because each one is a very important part and can not be left out of a complete e-learning environment.

1.5 Non-Functional Requirements

The non-functional requirements describe general conditions the software system must meet to satisfy the needs of the users and are not bound to the specific functions of the e-learning environment. This section gives an overview about the most important issues and tries to explain its relevance.

1.5.1 Technical Requirements

The technical requirements describe technical issues which must be fulfilled to successfully install, operate and maintain a software system. They can be divided into the following categories:

1.5.2 Support of operational environment required

In general an operational environment is the hardware and software environment where the system should run. More specifically it means the operating system and other software the system has to interact with. Usually e-Learning platforms are client-server systems, therefore two different operational environments have to be supported. On the client side in addition to the operating system (such as Windows, Linux, Mac OS and specific versions/distribution of these) also the browser version is important because the system usually runs within the browser environment on the client side. If the system should also run on different devices e.g. PDAs, mobile phones, Braille terminals, then additional requirements concerning user interface design or optimization for narrow bandwidth have to be paid attention to.
On the server side of special importance in addition to the operating systems are other software services with which the system has to integrate: E.g. relational database systems, directory services or other systems which complement the functionality of the e-Learning system.

1.5.3 Interoperability and support of standards
As mentioned earlier within the functional requirements e-Learning environments are not lone islands but are part of a global information system and therefore have to interact with various other systems e.g. enterprise resources planning (ERP); customer relationship management (CRM); payroll and billing systems. But to make all this work together, it would be a good idea to agree on standards. Standards are the condition for interoperability – making content developed for one system run on any other “compatible” system. It is recommended to build a modular and open system which supports many technology standards for connectivity.

1.5.4 Ensuring of performance and scalability
Due to its complexity and high first time implementation costs e-Learning environments are usually used by larger corporations or institutions or by application and learning service providers who offer their services to small and medium enterprises (SMEs). This means that such systems, apart from pilot installations, have to deal with large number of users in the range of several thousand up to several hundred thousand. In addition such a system is usually deeply integrated in organizational processes and thus mission-critical for business operations. These facts raise issues in

- network bandwidth consumption, which can be optimized by using caching and compression techniques for transmitting the Web based user interface as well as the content data;

- special strategies for handling and separating such large numbers of users (i.e. it does not make sense to offer a selection list of several hundred users or more in a user interface for administration purposes);
Objective of Research & Research Methodology

- increasing the server performance by distributing the system over several entities and by using load-balancing mechanisms to switch between system parts of redundant functionality;

- stability, which means that the system does not only not have any critical bugs but also does not break down under heavy/peak load or destroy data in such circumstances. In addition fail-over safe mechanisms have to be provided to ensure a long up-time even in the case of partial hardware failure.

Note: A functional requirement which also support these non-functional requirements would be the support of a hybrid system. Hybrid systems support online and offline working with data synchronization when switching between these two modes. In the case of e-Learning environments this could mean that such a system would support that e.g. large bandwidth consuming e-Learning content is fetched from local sources (e.g. DVD-ROMs) instead of downloaded each time via the network, or courses can be downloaded once locally and then used completely in offline mode. Only when the user goes online all progress information and assessment results will be transmitted and synchronized back to the server.

1.5.5 Security of e-learning systems

E-Learning systems contain a lot of very personal and business critical data which are very sensitive information and therefore needs to be protected against misuse and inappropriate access. The support of secure transmissions (such as https) between each part of the system and data encryption are therefore obvious requirements. Additionally measures have to be taken against hackers and denial of service attacks. Security aspect in e-learning environment are very important and these aspects should be addressed by ensuring that e-learning information security counter measures are implemented.
The security aspects are
1. course material may be altered by unauthorized people
2. bogus course material may be loaded on course websites
3. submitted assignments can be copied from course website by unauthorized parties
4. submitted assignments can be changed/deleted by unauthorized parties
5. marks are changed / deleted
6. access to test paper may be gained, contents may be changed, test can be deleted before scheduled test date
7. people may masquerade as students and write test on behalf of such students
8. student may get unauthorized help during writing of test
9. destruction of course websites and course databases containing marks
10. denial of service attempts against course websites preventing unauthorized students from accessing website
11. logon information of lecturers and students can be intercepted/misused.

So, for each organization and higher education institute, it is necessary to identify that claimed entity (i.e. learner) is authorized or not, and should be ensure about the integrity of data.

1.5.6 Customizations

Customizability and a modular system architecture specify to what degree system functions can be adapted, added or omitted completely and are additional requirements to ensure a system which is perfectly integrated in the customers IT infrastructure and corporate design and fulfils exactly that functionality the customer demands. Customization of look and feel can be done once for the whole system, personalized for groups of users (e.g. belonging to a certain department or a certain role such as trainers) or
individually. Advanced systems support adaptive user interfaces where the UI changes according to the user’s personal profile.

1.6 Quality Requirements

Fulfilling quality requirements and following a defined quality policy is an implicit requirement for every successful software production cycle. However, an in-depth view about this topic would go far beyond the scope of this thesis because it deals just with very high-level issues of the requirements definition process. It is mentioned here for the sake of completeness and to stress the importance of these requirements.

The first step to guarantee high-quality software is to define a comprehensive quality policy. Proven standards and guidelines such as ISO 9000 can help here a lot and also provide the additional advantage of the possibility for certification which increases reputation on the market and in an increasing number of cases is the prerequisite to take part in a call for tender.

The ISO 9000 series of standards represents the essential requirements that every enterprise needs to address to ensure the consistent production and timely delivery of its goods and services to the marketplace. The standards describe what requirements need to be met, not how they are to be met, therefore each industry sector and in detail each company has to define their special implementation rules including roles, processes and documents for quality management. Ideally the quality policy includes each department of a software company including research and development, support and maintenance, professional services, sales and finances, marketing and management. Consistency in production and reliability in delivery are as important as what an organization is selling in today's marketplace. It is essential to consistently meet all customers’ expectations every time, to keep them satisfied and loyal. If an organization does not do this, the marketplace, and with it the customers, will take its business elsewhere.
If we focus on the quality policy for the software development process then the following work scenarios can be identified:

- **Requirements definition**: Here the user requirements including use cases, the operational environment, functional and non-functional requirements are defined.

- **Software requirements definition, analysis and planning**: In this phase the user requirements will be analyzed and translated to software requirements and high level design including first rough project planning. Object oriented design (OOD) and the unified modeling language (UML) may offer a good structured approach here. A complex system may be split into several sub-systems with defined interfaces for easier handling and further sub-divided into modules.

- **Development phase**: In this phase the main development work will be done. Technologies and programming language which support the object oriented approach such as Java are advantageous.

- **Integration and test phase**: After each of the modules have been finished and tested independently within the development phase they need to be combined and tested as a full system.

- **Delivery**: If the system has passed all quality checks including the fulfilment of functional and non-functional requirements it may be delivered to the customer.

- **Maintenance phase**: Even the best quality management can not guarantee 100% bug free code and in addition user requirements can be refined or extended upon use of the software. For these cases the quality policy also has to define appropriate procedures to handle the maintenance phase which closely works together with the quality policies for the support services.
1.7 Usability and Accessibility Requirements

Perhaps the largest impact of all non-functional requirements on total user satisfaction can be summarized under the term usability. Usability has been defined within the ISO standard 9241 part 10 and part 11 as the suitability for use of a product. Crucial for the usability of a product are the following factors:

- Efficiency: the resources expended by a system's users in achieving accurate and complete task performance. An easy-to-use and understandable system reduces training, maintenance and support costs.

- Effectiveness: the degree to which a system fulfils its intended purpose and supports its users by enabling accurate and complete task performance. An effective system fulfils organizational objectives and yields improved operational efficiency, productivity, and customer service.

- Satisfaction: The user's perceived acceptability of the system. A system that supports the user and achieves high user satisfaction leads to increased job satisfaction, improved safety and health, and a reduction of costs.

Simply speaking the degree of usability specifies how easy a system is to use by a certain user. The usability can be increased by following rules and guidelines primarily during the definition of the system architecture and the user interface design; however it is important to mention that usability has an impact on all stages of the software development process. In particular the system integration tests have to be extended by usability tests where the feature complete system is presented to users who do not know the system yet but who represent the later end-user through a similar skill and experience profile. The users have to fulfil several tasks with the new system and are asked to verbalize their thoughts, feelings, and opinions while interacting with
the system. Every action and explanation will be recorded via video or
screen cam and later on examined. This could again lead to a redesign
of parts of the software or at least have an impact on the
documentation.
A more in-depth explanation of this exciting topic would go far
beyond the scope of this thesis; this short overview should just stress
the importance of it.
However a very special form of usability still deserves mentioning
because it gained more attention and importance during the last years:
Accessibility or support for people with special needs or disabilities.