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EPP for Improving Project Quality in Software Engineering Based E-learning Development Process

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Abstract: In the Software Engineering based development process of E-learning software the quality management is the prime issue. The quality of the E-learning software depends upon the E-pedagogy Plan (EPP) because in the E-learning software the content is the king. For simulating the teacher of programming language this issue is more predominant. This study presents E-pedagogy rules and plan for software engineering based development process of E-learning software specially for simulating a teacher of programming languages. The technique developed here has been applied for the developing the 50 h duration audio-visual CBT software for simulating the teacher of C language.

Key words: Software engineering, E-learning, E-pedagogy, multimedia, simulation of teacher

INTRODUCTION

The E-learning software and general software development process are altogether different. The E-learning software development process moves around the content development, learning management system etc. Numbers of E-learning software development methodologies are available but they are not strictly based on Software Engineering principles and thus results in schedule slippage, budget over-run etc. Thus based on software engineering, a new integrated software development methodology for E-learning softwares has been developed (Dharaskar and Thakare, 2005.). This integrated technique or Software Development Life Cycle (SDLC) Model has effectively utilized the well established methods and concepts like object oriented approach, instructional technology, Human Computer Interaction techniques, E-pedagogy, project management, quality management, risk management, content management, user and task analysis etc. (Fig. 1) (Roger and Pressman, 1987; Dick and Cary, 1990; Briggs *et al*., 1991; Edmonds *et al*., 1994; Gagne *et al*., 1992; Chrysostomos and Papadopoulos, 2005; Yannis *et al*., 2003; Paquette *et al*., 2001; Avellis *et al*., 2003; Gilbert *et al*., 2005; Douglas1, 2001; Psaromiligkos and Retalis, 2002; Bajnai and Steinberger, 2005; Hadjerrouit, 2005; Marshall and Mitchell, 2002; Eckelmans *et al*., 2005; Moreno and Mayer, 2000; Kumar, 2005; Boyle, 2003; Zuluaga *et al*., 2002; Morales *et al*., 2003; Gilbert *et al*., 2005; Bouillon *et al*., 2005; Christian and Grebenstein, 2004; Krauss and Ally, 2005; Mavromoustakos *et al*., 2005).

In the software engineering based development process of E-learning software the quality management is the major issue. The content is the heart of E-learning software. The quality of the E-learning software depends upon quality of contents. The quality of contents depends upon the E-pedagogy plan (4.7 EPP). Thus EPP has tremendous importance in the SDLC Model for E-learning software development process. In case of simulating the teacher of programming language through E-learning software the effectiveness, efficiency and quality of contents decides the success or failure of the product. Thus in this case the role of EPP is very crucial.

In the last decade, there is a tremendous grown of multimedia tools and technologies. Better E-learning products can be developed with the help of these technologies. For developing efficient multimedia based E-learning softwares the synchronization of flow of information from computer to human brain is essential. The EPP and HCI steps are responsible for achieving this goal.

The teaching learning is the most complicated psychological phenomenon. The simulation of a teacher through E-learning is a challenging task. It involves the learning about learning. Before developing the E-learning solutions, the developer should know the working of human brain, the human psychology, the process of memorization, the memory retention techniques, memory

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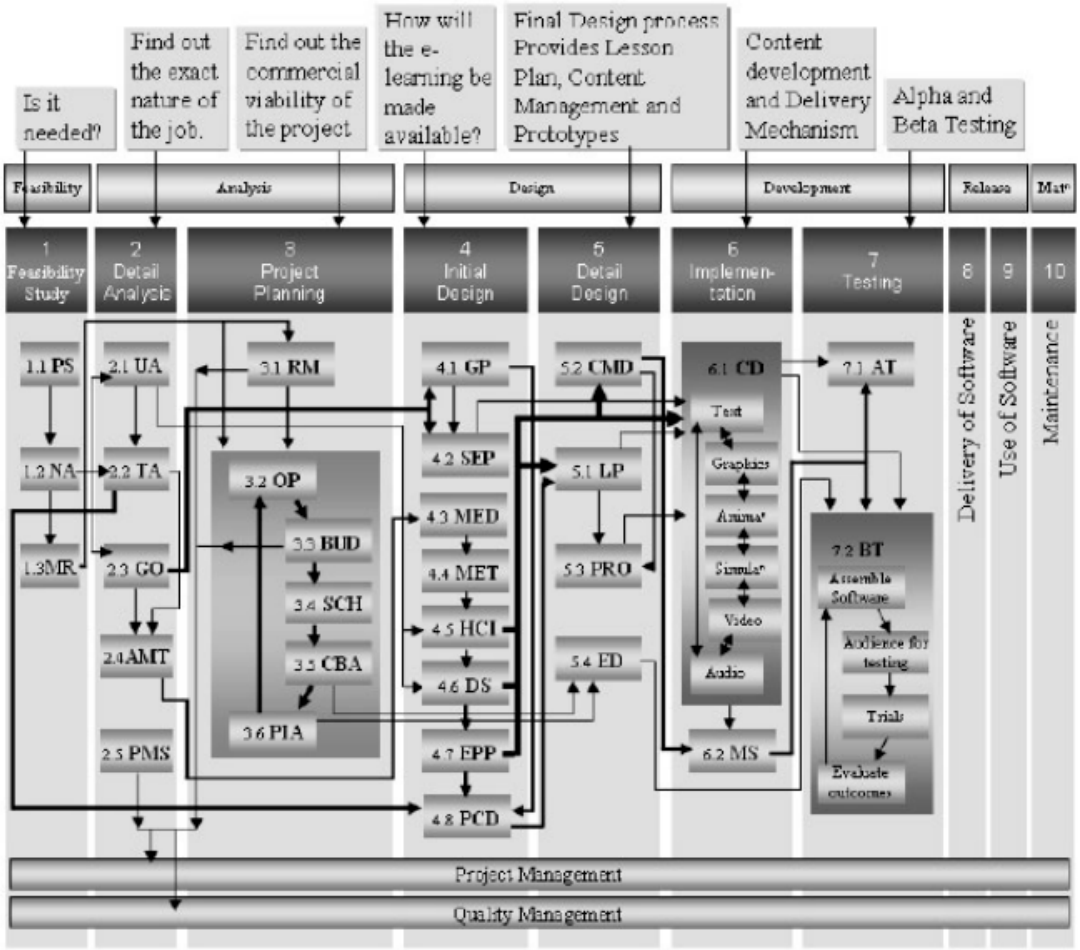


Fig. 1: SDLC model for e-learning

overload problems etc. To develop the better teaching aids and E-learning tools, it is necessary to understand the mind's natural process of learning. There are hundreds of theories of teaching and learning. The developers are always in dilemma for selecting the particular theory. To develop EPP, the crystal clear rules are necessary.

This study focuses on framing the rules for EPP, particularly for the process of simulating the teacher of programming languages through multimedia based E-learning software. The technique developed here has been applied for the development of 50 h duration audio-visual CBT software for teaching C language.

RULES FOR EPP BASED ON MULTIMEDIA AND E-PEDAGOGY

For simulating the teaching of programming language the EPP has been developed which is based on the following 13 rules (Dharaskar, 2004a, b, c; 2003; Dharaskar and Thakare, 2004; Dharaskar and Thakare, 2005a, b; Kumar, 2005; Baddeley and Hitch, 1974; Bagui, 1998; Beccue *et al*., 2001; Chandler and Sweller, 1994; Clark and Mayer, 2003; Ericsson and Kintsch, 1995; Mayer and Moreno, 1997; Mayer, and Sims, 1994; Merchant *et al*., 2001; Miller, 1956; Penney, 1989; Peterson and Peterson, 1959; Shiffrin and Atkinson, 1969; Kruse, 2005; Dale, 1969; http://www.suffolkandnorfolkscitt.co.uk/Student support/Brain Based Learning Theories.htm. Herrmann-Nehdi, 2004; http://www.epub.org.br/cm/n01/ memo/growth.htm; http://www.learning-styles-online.com/; http://www. memletics.com;. All these rules are based on well-established pedagogical theories, practices and published work.

Working of human brain: Generally in the E-learning development process, the more stress is given on

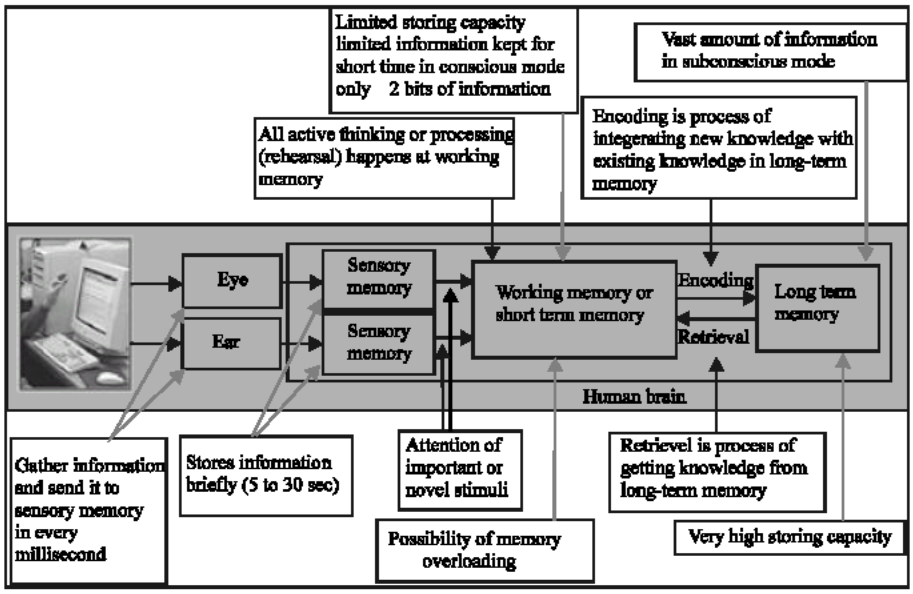


Fig. 2: Memory overloading and Working of brain

teaching methodology and the apprehension level of the students (Dharaskar, 2003; 2004a, b, c; Dharaskar and Thakare, 2004; 2005a, b). It is found that the developer neglects the third aspect i.e., memory retention. The long-term benefits of the E-learning solutions always depend upon this third aspect. The human learning process can be described using the following mathematical model.

$$\text{Learning} = \text{Comprehension} + \text{Memory}$$

The Educational psychologists still do not know for certain how people process and remember things. The information-processing model is the best explanation to date (Kumar, 2005). The Fig. 2 shows the steps involved in processing of information by human brain, which is acquired from a computer. First, the computer provides external stimuli in the form of text, picture, animation, audio and video. That gains the attention of the receptors in the eyes and ears. The receptors pass this information in to sensory storage for automatic processing. Sensory storage processes all stimuli in real time, so as new information comes in, it replaces the previous information. Stimuli or information that has any value to the perceiver will be passed along into Short-term Memory (STM). This memory can hold seven to nine items at a time for about 30 sec. Within STM, there are three basic operations: iconic memory (visual), acoustic memory (audio) and working memory. Iconic memory refers to the ability to hold visual images in STM, while acoustic memory refers to the ability to hold sounds in STM. Of the two, acoustic memory can be held longer than iconic memory. On the other hand, working memory is an active process where the goal is not so much to move the information from STM to Long Term Memory (LTM), but merely to keep it until it is put to use. The ultimate goal of training and education is to get relevant information through STM and push it into LTM, where it can be accessed at a later time. The LTM is a giant warehouse where you keep many of your previous experiences and knowledge. The real challenge is not to store the information at LTM, but storing it for faster accessing and retrieval. The LTM contrasts with STM and perceptual memory in that information can be stored for extended periods of time. LTM allows retrieval of information decades after it is stored and the limits of its capacity are not known (Kumar, 2005).

Memory overloading: It is proved that multimedia technology helps to enhance the memory retention. The pictures, animations, audio and video presentation, interactivity are far better techniques for enhancing the memory retention. But if the cognitive load exceeds beyond certain limit then the learning process may hamper. That is, excessive and uncontrolled use of multimedia techniques may generate more information in short time, which mismatches the mental capability of learner and slow down the learning process.

Extraneous sounds can overload working memory capacity. Similarly extra pictures and words overload working memory. Extra Content: Causes

- Distraction-diverts attention from what is important
- Disruption-learner can't build links among appropriate pieces of material
- Seduction-learner calls on inappropriate existing knowledge to organize the incoming material

Normal distribution curve: People learn more at the beginning and at the end of a learning experience than they do in the middle. Longer duration clips sometimes causes the memory overload problems.

Chunking: The Chunking helps to store the information permanently at Long Term Memory.

Rule 1: Information flow: Use multimedia cautiously to avoid memory overload problems. To reduce the load on sensory storage and processing, maintain the reasonable information flow. Provide limited and relevant information in single content or clip. Cover at a time only one aspect of the topic or concept. Prefer single multimedia component at a time to explain the concept. For minimum load for audio senses and to reduce the load on mental processing, use very simple English words. Avoid the complicated constructions of the sentences and background music. The extra use of graphics diverts the attention of the students. For minimum load for visual senses avoid the extra use of graphics. To reduce the cognitive load the consistency of graphical user interface should be maintained. The single content size or duration should not be more than 5 to 10 min. Develop SCORM based Reusable Learning Objects.

Schemas: The LTM storage is organized into schemas. Thus the designers should take steps to activate existing schemas before presenting new information. This can be done in a variety of ways, including graphic, curiosity arousing questions, movies and sound clips, etc.

Rule 2: Refresh existing knowledge: Before teaching new concept the revision or refreshing of existing knowledge is necessary.

Rehearsal: It is the important factor for retention of learned information in LTM.

Repetition and neural path way: Repetition makes the neural path way more efficient. Recall is dramatically improved when the information is regularly reviewed.

Table 1: Time and learning

Time from learning	Percentage remember (%)
Beginning of lecturer	0
At the end of lecturer	100
After 1 day	50 to 80
After 7 days	10
After 1 month	2 to 3

Without review, the information is forgotten almost immediately.

Simulation and neural path way: Stimulation produces great electrical activity and better learning. Stimulation enhances more pathways and better memory.

Memory management: Management of limited capacity in working memory to allow for rehearsal

Learning and size of brain: Learning changes the brain forever. It 're-wires' every time we learn something.

Memory retention power: The general learner forgets 97% of what he has learned just within one month. Just 10 min after the lecture the learner starts forgetting. The Table 1 shows the details. The reasons of forgetting are fading (trace decay) over time, Interference or overlaying new information over the old and Lack of retrieval cues.

Emotion: The emotion plays very important role in learning.

- Personalization is an important factor in the process of learning. Instead of addressing as a third person prefer the words like you, your, I, our and we.
- The brain learns best when it trying to make sense of something.People remember dramatic, emotional, unexpected experiences.
- People remember context much more than content.
- When the brain is challenged learning is enhanced.
- When the brain is threatened it reverts to a fight and suffers learning. Focused attention is an important aspect of learning. People do not learn effectively when placed under negative stress- low stress, high challenge is the ideal state for learning.

Rule 3: Revision of new knowledge: After teaching new concepts, the facility of frequent revision of the concepts must be inbuilt in the E-learning software. While recording content for revision or alternate method of teaching for same concept

- Ask interesting questions
- Create challenging situations
- Force the students to think

- Complicated concepts threaten the brain. Teach them very carefully. Use various alternative teaching approaches to teach them.
- Prefer personalization

The subsequent clips or content should clarify each and every possible difficulties and quarries.

Perception: Long Term Memory (LTM) has a strong influence on perception. The processing of sensory information depends upon the prior knowledge stored at LTM. Our expectations regarding a particular sensory experience influence how we interpret it.

LTM and attention: The LTM influences the human attention (i.e., focusing) on relevant information as well as discarding the irrelevant information.

Rule 4: Check existing knowledge level and quality: The efficiency of teaching of any subject depends upon existing knowledge level of the student, which is already stored in Long Term Memory of the human brain. Before teaching through E-learning software it is necessary to check this level. Apart from this for proper human focusing it is necessary to check the quality of existing knowledge.

Integration: Integration of information in working memory with existing knowledge from long-term memory helps to store the new information in Long Term Memory and increases the memory retention capacity. Thus the new information should be always linked to the existing knowledge (mental hooks) for better retrieval of knowledge from LTM.

Correlation: While explaining the concept if the correlation with Practical situations in the day-to-day life can be established then it helps for better understanding and retrieval of knowledge from LTM.

Rule 5: Links with existing knowledge: While teaching new concept the utmost care should be taken for linking it with existing knowledge. Whenever possible take the help of day-to-day practical situation to explain the concept.

Sense and memory: Sensations are handled by two different subsystems. Verbal input is handled by a subsystem that specializes in language, while non-verbal input is handled by a subsystem that specializes in images or sensations. The two subsystems interact when transferring sensations into LTM. Memories of images are more easily recalled, while verbal memories are more easily applied, synthesized and transferred.

Dual coding theory: The illustrated text increases the learning efficiency because the brain simultaneously process visual and verbal information with separate cognitive processes. The learning and recall of verbal information are strengthened with images.

Effect of multimedia: At the University of Maribor in Slovenia, Electroencephalography (EEG) was used to measure brain activity when exposed to different media. The results show that multimedia helps a lot for forming the mental model. With the help of text alone it is little bit difficult (Beccue *et al*., 2001; Mayer and Moreno, 1997; Mayer and Sims, 1994).

Human vision: The Vision is well-developed faculty and thus there are more visual learners in any classroom. Vision is man's primary sense around which his mind has evolved. This remarkable sense has the largest cortical area (almost 50%) devoted to its activities. The visual cortex is split into many areas, each processing an aspect of sight such as color, shape, size, stereo, depth, etc. Observed images are reflected by matching patterns of neuronal activity on the surface of the visual cortex, which are then converted into higher-level abstract mental models.

Human language: Human Language has few thousand years' history. It is still very young and not fully integrated into brain. Printed text has only few hundred year history and hence not yet become natural ability of the brain. Sound has changed the human brain radically because complex language has recently annexed large parts of the left hemisphere (previously given over to visuo-spatial functions), thereby creating the asymmetry not found in any other animal. The implication is that, in evolutionary terms, human language, which is very young, is still under construction and is far from being fully integrated into the brain. Although analyzing a stream of spoken words is highly complex, infants do not need to be taught the basics of hearing and speaking language. By contrast, reading and writing are difficult to learn at any age.

Printed text: Printed text is only a few hundred years old and therefore, on the evolutionary time-scale, reading has not even begun to become an innate ability. Hence, the unnatural nature of reading and writing has serious implications for learning.

Rule 6: Use of multimedia: Prefer graphics for better memory retention process. Prefer audio, when faster teaching is necessary. Prefer Graphics than audio and avoid printed text. Simultaneous use of printed text and Graphics overload the visual memory. Thus prefer audio and graphics. Whenever possible prefer multimedia for teaching rather than plane text.

Cone of learning and technology: Figure 3 shows how the human being remembers the things. The right hand side shows the supporting computer technology. At bottom the graph show the level of E-learning design complexities for the corresponding computer technology (Dale, 1969).

Rule 7: Appropriate technology selection: Use appropriate tools and technologies for better memory retention level.

Mental model and thinking maps: Figure 4 shows the mental model along with long as well as short-term memory and the thinking maps, which help for memory retention process.

- The centre with the main idea is more clearly defined
- The relative importance of each idea is indicated-more important ideas near centre
- Memory works by creating a network of associated ideas. A mind map imitates this pattern and so the brain can relate to the information more easily
- Key words linked to pictures are easier to remember as they use both sides of the brain
- Meaning is vital to memory-a mind map develops understanding and meaning as the links between topics are made clear

Rule 8: Thinking maps: Brain can understand the classified information. Use standard methods of classifications (thinking maps) to associate new ideas with existing ideas in the brain.

Use both sides of brain: Keywords along with pictures relate both side of brain and hence more effective. The learning process and memory retention greatly enhances when whole brain is engaged. The brain processes and stores the text, audio, visual information at different hemisphere of the brain and hence the associated-information can be retrieved easily form LTM. Always the care has been taken that multiple senses should be involved in learning process (Fig. 5-8).

Rule 9: Use both sides of brain: Better learning occurs when whole brain is engaged. So try to use both sides of the brain while developing the E-learning software.

Multiple Intelligences: According to constructivist approach to learning, integrating multimedia and multiple intelligences can improve the active participation of the learner and improve the quality of learning. Dr. Howard

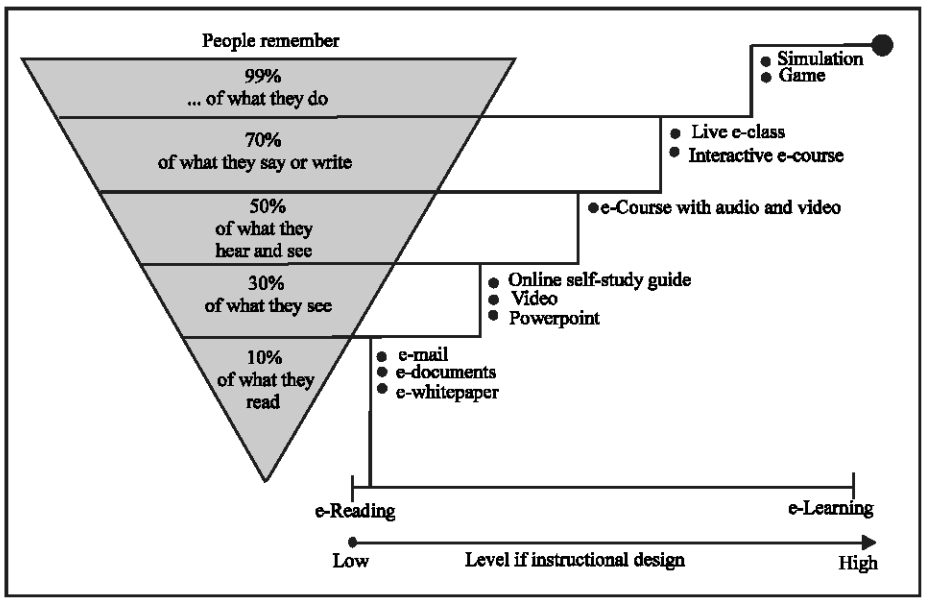
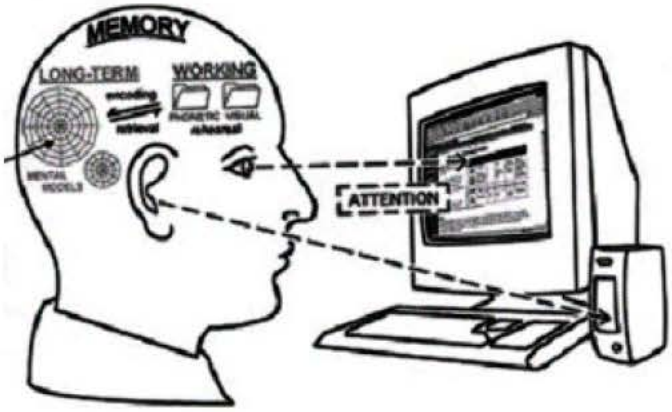


Fig. 3: Cone of learning and technologies



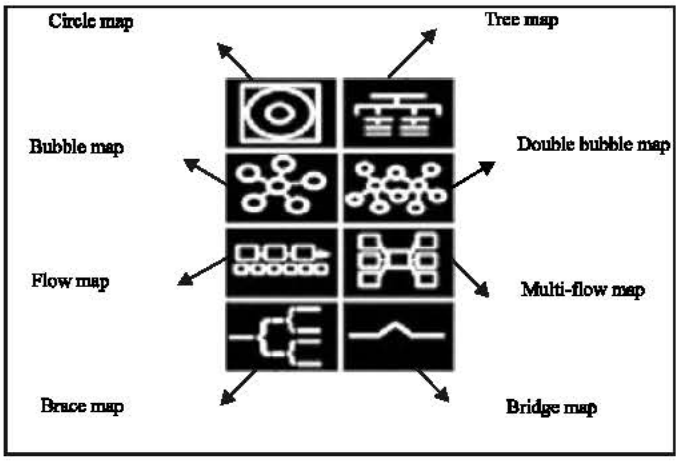


Fig. 4: Mental model and thinking maps

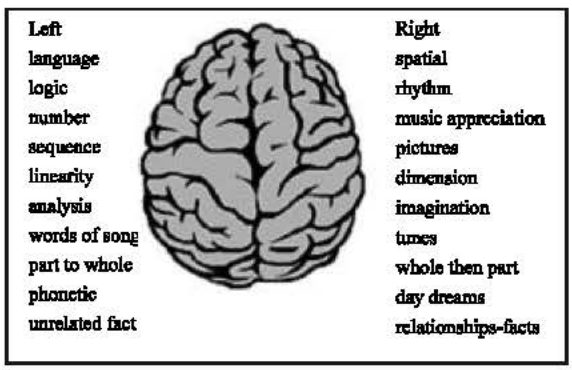


Fig. 5: Right and left learner

Gardner identified different styles of learning as seven distinct intelligences: logical/mathematical, interpersonal, intra-personal, musical, kinesthetic, linguistic and visual/spatial (Fig. 9). The capability of acquisition of knowledge of students depends upon their mode of learning i.e., type of intelligence.

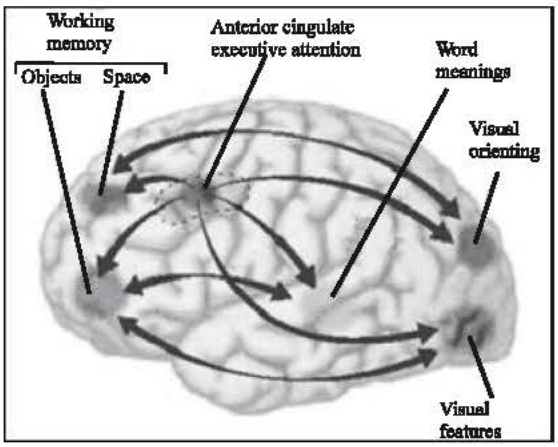


Fig. 6: Posner and Raichle model

Memory and aging

- Sensory memory remains stable over time Working memory slows down with age

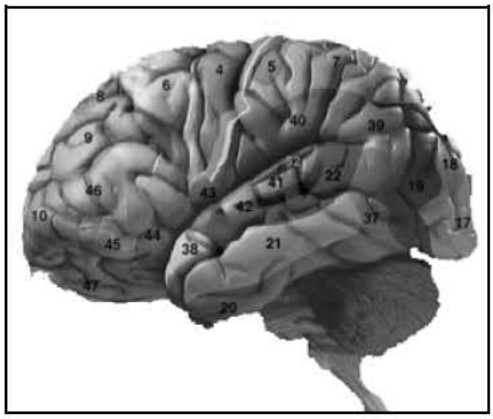


Fig. 7: Brodmann's map

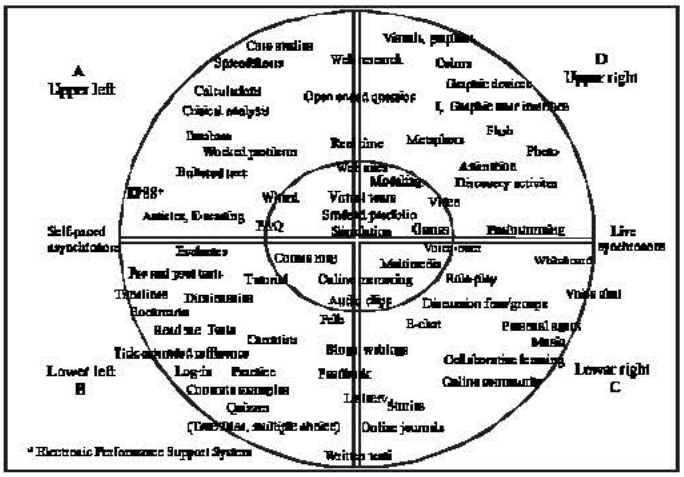


Fig. 8: Whole brain locator map for E-learning activities

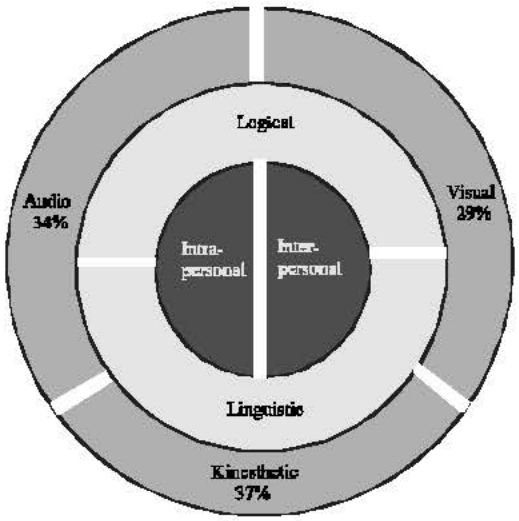


Fig. 9: Multiple intelligence

- Long-term memory slows down with age. More difficult to store and retrieve information
- Older adults have more difficulty for organizing new material and recalling old material.

Maximizing learning potential: Every learner has certain mental capabilities. If the intrinsic and extraneous cognitive load exceeds the learner's mental resources then learning will be decreased.

Rule 10: Target audience: It's difficult to develop the general-purpose E-learning software. Always try to develop it for specific user group. In case the E-learning software for wide audience is needed then developer should consider the principal of On Demand and Personalization. Use P2P (Peer to Peer) or Client-Server based Collaborative tools to satisfy the needs of Inter-Personal type of learners. To satisfy the needs of Kinesthetic-learner incorporate sufficient interactivity in the E-learning software.

Cause of confusion: It is difficult to retrieve the similar information or diagram from Long Term Memory.

Rule 11: Uniqueness: Use unique diagrams or multimedia technique without disturbing the consistency of the software for better retrieval from Long Term Memory.

User attention: User Attention is one of the very important factors for success of E-learning software.

Rule 12: User attention: Carefully use different multimedia technique for catching the attention of the student at specific point of the concept. In addition to the multimedia, the tricky small programs can help a lot.

Audio and video quality: Poor video quality can be digested but the poor audio quality cannot be tolerated. The poor audio quality creates irritation. The brain cannot store the information properly under such situation.

Rule 13: Codecs: Select proper audio and video Codecs for better audio-visual quality.

ROLE OF EPP IN MODIFIED SDLC MODEL

For simulating the teacher of programming language, the modified SDLC Model has been used. In the SDLC Model the EPP is involved in Initial Design Stage. But in the modified SDLC Model the EPP step continues from start to end and helps the project quality management.

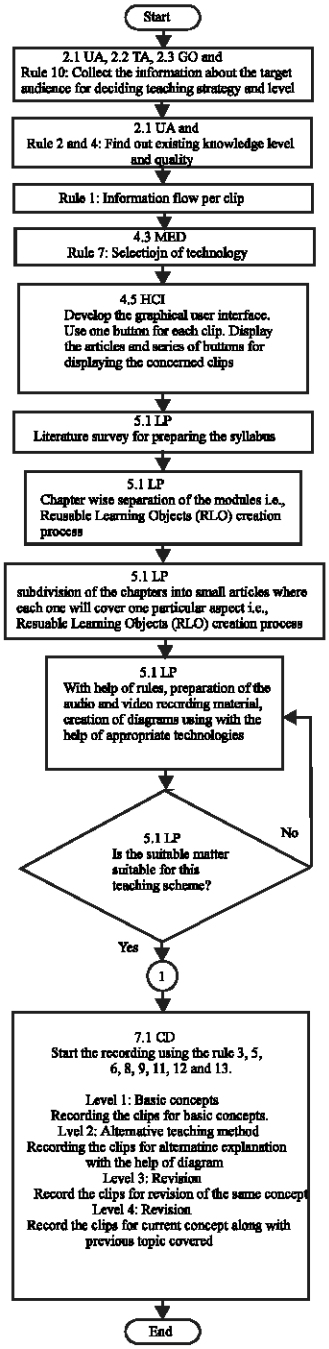


Fig. 10: Steps in SDLC and EPP up to CD step

Figure 10 shows the rules of EPP and steps of SDLC Model to develop the CD of Implementation Stage.

PROJECT QUALITY OPTIMIZATION IN BETA TESTING (BT)

The product developed up to CD step in SDLC Model can be further optimized in Beta Test (BT) using

following techniques

- Iterative techniques (Dharaskar, 2004a) and
- Personalization techniques and Student Model (Dharaskar, 2004b).

CASE STUDY

This modified SDLC Model has been applied for simulating the teacher of C language. Its 50 h audio-visual screen recordings. This CBT covers almost every aspect of the C language. Each concept has been taught with the help of recording of online program execution, diagrams, animations etc. In Direct Screen Recording (DSR) the ouline outputs, source code, various effects, integrated development environment of Turbo C, MS Visual C++, compilation process, debugging, help files, etc. can be watched along with the audio explanation. This technique simulates the perfect subject teacher. The students always feel the teacher presence as if he is teaching the subject directly using the personal computer. In development phase, more than 100 books on C language have been referred. Over 1000 kits have been distributed throughout India and thousands of students are getting extensive training on C language. It's a teacher less classroom. Special care has been taken for following steps of the SDLC Model.

Affordable methods and technologies: The audio-visual clips have been recorded using the Direct

Fig. 11: Graphical user interface

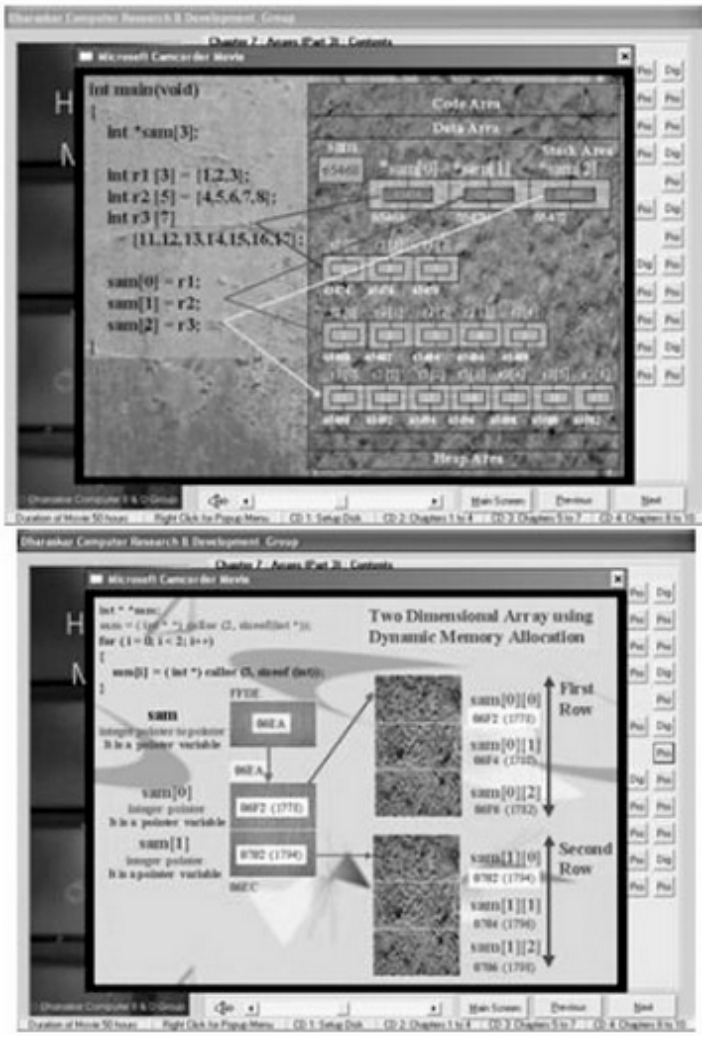


Fig. 12: Clips showing IDE and diagrams

Screen Recording (DSR) method. To do this job various recording tools were available like MS Camcorder, TechSmith's Camtasia Studio etc. Comparatively, the executables clips produced by MS Camcorder are very small and thus this tool has been preferred. Thus it it's possible to store total 50 h of audio-visual recordings (675 MB) on single CD.

Media selection (MED): Various complicated technical issues have been considered for faster and efficient audio-visual recording using the DSR (Dharaskar, 2003).

E-Pedagogy Plan (EPP): The EPP has been used throughout the project for improving the project quality.

Beta Testing (BT): To increase the apprehension level of the student, the teaching-learning optimization techniques have been used (Dharaskar, 2004a, b). These are iterative processes and applied over 300 students for getting optimized results. For automatic and flexible content management as well as for selecting the better teaching strategy, the student model technique has been used. Again in this second phase, testing has done with the help of more than 40 small groups of students of various disciplines like 10th standard, undergraduates, post graduate and teachers of various disciplines. The Fig. 11 and 12 show the screen shots of this software.

OBSERVATIONS AND EXPERIENCES OF BETA TESTING (BT)

There are many issues related to testing, feedback and evaluation process, which are considered in testing phase. 1). The students are unable to point out the exact lacuna of the clips or they hesitate to do so. It's the job of expert teacher cum developer to draw the correct

inference. 2). In testing phase some students may not pay proper attention. To identify such students, just insert few clips, which are very difficult to understand. If student is seriously learning then he should point out these clips. If he couldn't notice such clips then he is either extraordinary student or not learning seriously. 3). In the process of evaluation by expert teachers, don't rely on all the opinions. Listen to them and cautiously make the changes. The reason is, the teaching methods differ from person to person and the need is generalized acceptable method. 4). For testing, don't use the same group of students more than two times. In the first time everybody will watch the CBT seriously. But in the second time the interest will be reduced. 5). In one sitting don't show the movie for more than one hour. Technically, there should be a gap of five to ten minutes between every lecture of forty-five minutes or one hour. 6). The conflicting opinions of various groups of the students create confusion. Resolve them cautiously. 7). One modification may hamper number of recorded clips. In this C language CBT, around 300 hours of recording is discarded to finalize 50 h of clips.

It is found that in the beginning the students are not comfortable because of totally new teaching-learning technique. They are more familiar with blackboard teaching and learning from the books. After viewing around fifty clips they start appreciating the capabilities of new teaching tool. In the beginning they have taken the notes (i.e., programs and explanation) but afterward they simplify watch the movie. This happen because in the class room teaching the teacher can not teach same thing again and again but in CBT it is always possible. It is found that the students learn any difficult concept using this tool because of online teaching, appropriate selection of the C programs and animated diagrammatic explanations.

CONCLUSIONS

Along with the technology the E-learning has changed very rapidly. There is a need of software engineering based development methodology for developing E-learning softwares. The SDLC Model introduced over here has fulfilled these requirements.

Apart from software engineering the concepts like object oriented approach, Human Computer Interface, E-pedagogy etc. are needed to develop effective E-learning softwares. Thus there is a need of integrated approach. The SDLC Model presented here provides the required integrated approach.

For simulating the teacher of programming language, apart from SDLC Model, the special consideration for EPP is needed. The modified version of SDLC Model has provided the satisfactory solution to this problem. The rules created in EPP have helped a lot for increasing the teaching efficiency and effectiveness of the software.

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