Effective and personalized content delivery through the Butterfly Model

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***Abstract*— Content delivered in the wiki model has its own limitations. One being, learners with different learning styles have difficulty going through material that is not suited to their preferred learning style (audio, text, video etc.). This problem is particularly compounded when we have teachers who are not experts and cannot guide the students well. Another limitation is that it is difficult for a novice to navigate. Also normally the expectation from a good teacher is the ability to provide examples and walk through an interactive process of learning. Then again, we have the need to cater to students with differing abilities in learning based on their own background and interest. Thus content should be suitable to cater to learners who may be at a novice, intermediate or advanced level. We also need to have content that can be developed to cater to the learning levels of students in both urban and rural settings in India. Having worked with over 60 engineering colleges and having trained over 320 faculty members, we found that there is a serious need for one model that can address all these limitations. This has led to content development in the "Butterfly Model" with the "Learning by Doing" methodology at its foundation. This paper discusses in detail our studies and feedback received for four courses developed in this model. This model we feel will be applicable to a wide range of learners and also help in enhancing the quality of learning of the students.**

Keywords-content development, learning by doing, real-world application skills, personalization, learning styles

I. ABBREVIATIONS

LBD	Learning by Doing
CIT	Certificate in Information Technology
IIIT-H	International Institute of Information Technology, Hyderabad
MCIT	Ministry of Communications and Information Technology
MHRD	Ministry of Human Resources Development
NPTEL	National Program on Technology Enhanced Learning
MIT	Massachusetts Institute of Technology
OCW	Open course ware

II. INTRODUCTION

An explosion of educational institutes in India has caused a dearth of experienced faculty for teaching. The employability of graduating engineering students is low, owing perhaps to their weak training. To overcome this problem and to make the engineering graduates more "market ready", the Certificate in Information Technology (CIT) program was started as a joint initiative by the Ministry of Communications and Information Technology (MCIT), Government of India and IIIT-Hyderabad (IIIT-H). Through this program, faculty members of engineering colleges are trained who then are expected to train the students at their colleges. Through this program, we have worked with over 60 engineering colleges, trained their faculty and have begun implementing this program for the students through these trained faculty members at their respective colleges.

We have observed that a lot of content is available in the form of NPTEL [1], MIT's OCW [2] etc. However, we find that teachers are neither motivated nor able to use the content in these courses directly. Individuals too are not motivated enough to wade through semester worth of pages of text or series of video lectures. We believe that there is a need for course content to be in one place, be integrated with illustrations, and have a virtual lab environment which serves as a playground for trying different 'plays' as the player gets familiar with the game. Thus a good combination of just-in-time lectures which explain key concepts succinctly, in combination with illustrations that can serve as static and interactive examples, will help the learning process.

At first, we used a wiki based ICT model for content development and delivery in our teacher training programs and thereafter to be used by the students with the help of the trained teachers. Our experience and learning from this approach has had good results but also shown that personalization at the learner front needs to be emphasized more.

To address the foregoing, we developed a novel idea of designing course content – "The Butterfly Model" (refer Figure 1). The Butterfly model is an enhanced version of both Cronje's four-quadrant approach [3] and the LBD approach of content development [4]. It allows for more personalization and for more student involvement in the content. The most important benefit of having the LbD methodology as the basis is "Skill gain" as has been demonstrated earlier [5] [6].

With the support of the Ministry of Human Resource Development (MHRD), we investigated new methods of learning by developing and delivering content for various courses in information technology (Data Structures, Principles of Information Security, Data mining and Data warehousing and VLSI and Design for Testability) and measuring learning outcomes. The rest of the paper provides details about the Butterfly model and explains how this method of learning can be extended to benefit a wide range of students.

III. THE BUTTERFLY MODEL

The basis of this model has already been presented [7]. Most importantly our emphasis has been on the LbD methodology and in making the learners do "tasks" and showing work output.

We have identified and designed various components that would help the learner in the learning process. In this section, we will describe what each component signifies and how this model will provide more personalization for the learner.

THE COMPONENTS

Each of the components of the model will now be described in greater detail. Though there is no strict order in which these components should be accessed, we suggest the following order: learning objectives, implementation, concepts, illustration, playground, resources, analysis, imagination and insights.

A. Learning Objectives

Learning objectives are introduced at the start of the each section so that learners understand what they are trying to achieve and the level of the achievement. This allows learners to participate as active, independent learners as they are clearly told what they should be able to do at the end of the course.

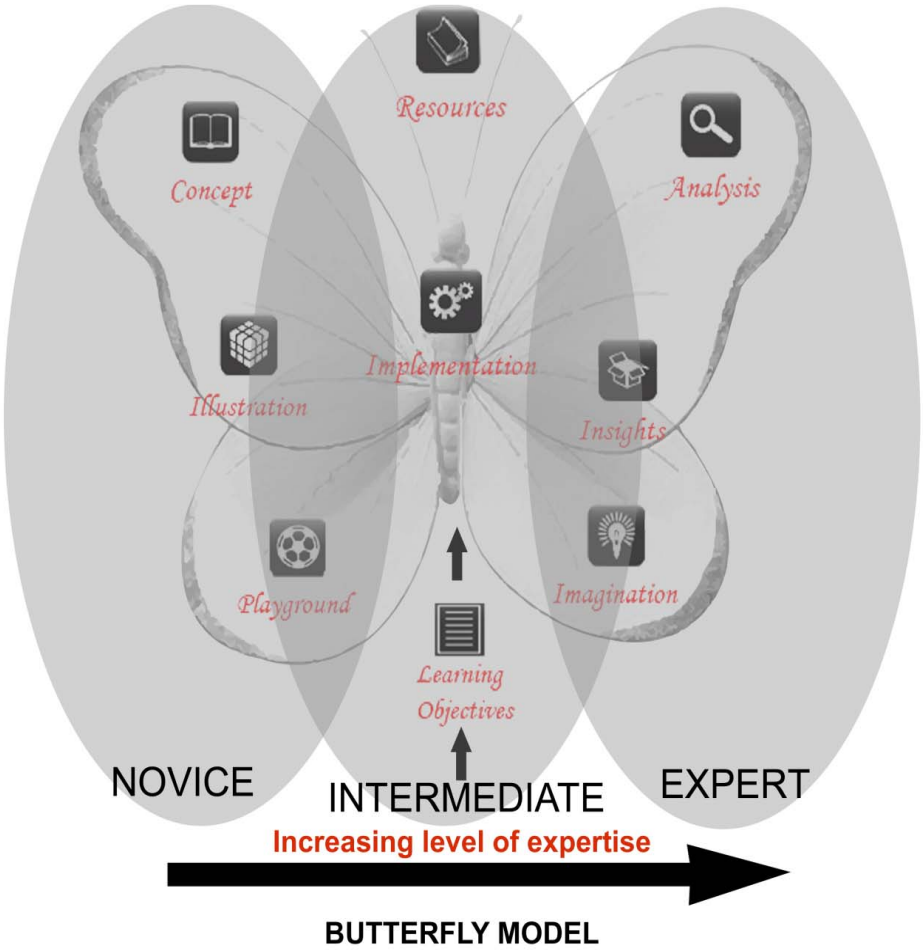

Figure 1. The Butterfly Model

We ensured that the learning objectives chosen by us touched on the higher order thinking skills mentioned in Bloom's taxonomy [8]. Moreover, the learning objectives are mapped to the assessments that we conduct during and at the end of the course. Such a mapping also makes both our assessment of student performance and student self-assessment easier as students can assess their own progress and concentrate on their weaker skills. This is especially important for professional students who are looking to gain specific skills and knowledge. Once the learning objectives are set, the students move on to the implementation part.

B. Implementation

Piaget [9] and other researchers have stressed on the many of the seemingly intuitive benefits of hands-on learning and have also documented a variety of unanticipated benefits. An often quoted Chinese proverb "I hear and I forget; I see and I remember; I do and I understand" succinctly puts their point across. Without hands-on learning students rely for the most part of their learning on memory and abstract thought, two methods which restrict learning in most students. By actually doing and experiencing, students develop their critical thinking skills as well as discover scientific concepts. This self discovery stays with students throughout their lifetime while memory fades. Moreover, hands on exercises force students to think by requiring interpretation of the observed events, rather than memorization of correct responses. Therefore, the justification for hands-on learning is that it allows students to build understanding that is functional and to develop the ability to inquire on their own, in other words, to become independent learners [10].

Given the fact that the employability level of our graduates is very low [11], our primary focus has been on improving their skills and thinking abilities. The implementation component involves tasks which when completed lead to prototypes of basic products in the area and emphasizes on the application skills of the learners. For example, in the Data structures course the learners are expected to build a web calculator using their knowledge of Stacks (refer Figure 2).

The next section i.e. concepts as the name suggests covers all the concepts in the module. This section actually gives the student enough knowledge about the module.

C. Concepts

Concepts refer to the theory related to the module which aids the learner in working on the tasks (i.e. implementation). These concepts are provided by the domain expert in the form of video lectures (also called spoken tutorials). All the concepts of a course when concatenated form a lecture-based course.

Learners may refer to the resources section for further information on the related concept.

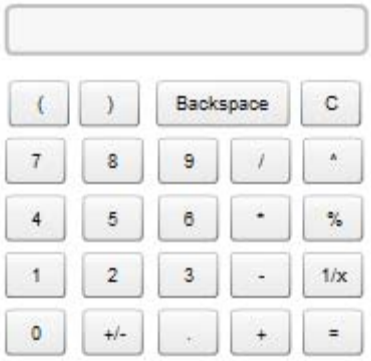

Figure 2. Implementation of a web calculator

D. Resources

These include additional material that will be useful for the student. These include presentations, videos, external links, and prescribed books for reference. Considering the different learning styles of the students we have designed multi-modal resources (covering text, audio, and video). These resources when concatenated form a collection of various multi-modal resources including the breakthrough papers in the area.

The next two sections pertain to "Illustrations" and "Playground" through animations and a virtual learning environment. The first of these, the "Illustration" section, comprises of explanation of the concepts via illustration of a concept generally through animation/simulation. The second, the "Playground" section, provides the user with a virtual lab to try out the "experiment". We will now discuss in detail about each section and also bring out the importance of using animations/simulations in the butterfly model.

E. Illustration

The importance of illustrations is well understood in learning [12]. Illustrations may be static, i.e., text book examples that elucidate the concept without learner interaction. In this section, the domain expert explains a particular concept through animations, which may be static or interactive illustrations. Figure 3 gives a screenshot of an animation employed for explaining the "Hierarchical Clustering" concept in the "Data mining and Data warehousing" course. Another example of illustrations used in the data structures wherein the domain expert explains concepts through animations is shown (refer Figure 4 for an example on merge sort).

The individual illustrations when concatenated form an e-workbook with solved examples.

The next section, playground, deals with interactive animations.

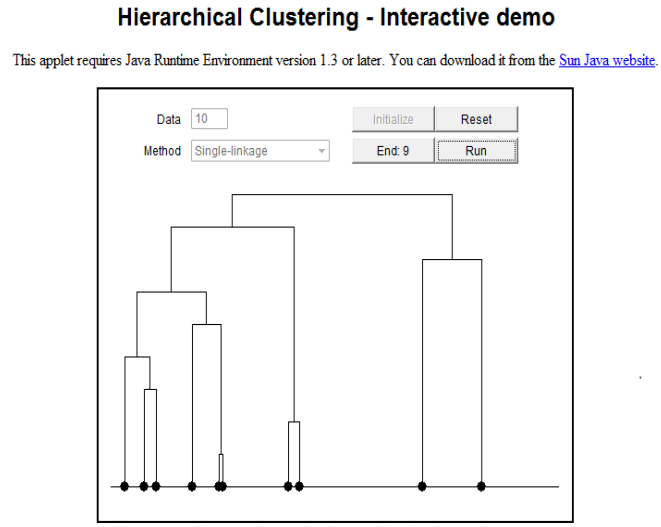

Figure 3. Illustration of Hierarchical Clustering

F. *Playground*

Agina [13] has widely discussed about the benefits of employing interactive animations in education. As these illustrations allow for the learner to try out possibilities through what-if examples, they help learning happen better and quicker. Learners have more interaction with the content and are thus more likely to assimilate the knowledge, skills and concepts involved. Because it is exciting, challenging, and fun to use, it encourages learners to return to the program again and again! More importantly, this approach appeals to different learning styles, allowing personalization possibilities to learning. Considering all these advantages of interactive animations, we have come with the playground component in the "Butterfly Model". Figure 5 shows an example of the "Mono-alphabetic cipher" employed in the "Modern Cryptography" course wherein the learner interacts with the system without any doubt/fear of breaking it. Thus feeling more empowered and learns by himself/herself.

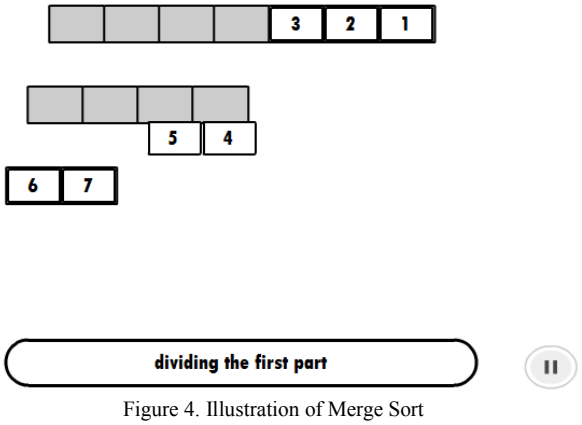

Figure 4. Illustration of Merge Sort

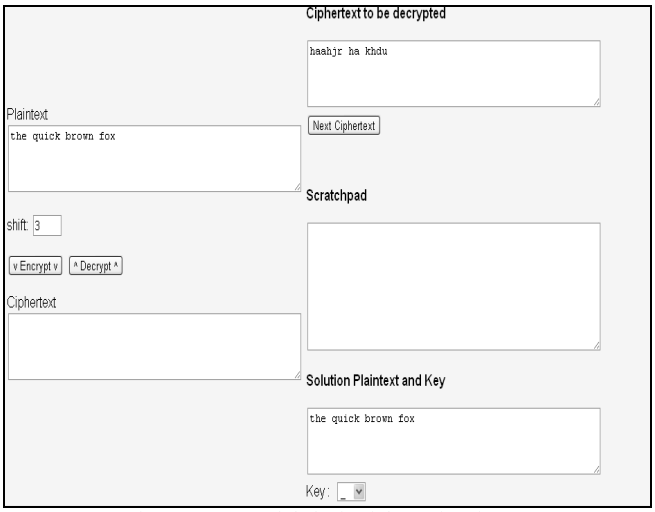

Figure 5. Mono-alphabetic cipher animation

Another playground example is provided above. This example deals with the "Caesar Cipher" concept covered in the "Modern Cryptography" course. The learner can key in different inputs and understand how Caesar cipher works.

Simply put, the collection of different "playground" sections forms a virtual lab for the course.

The next three components are designed keeping in mind the advanced (read research-oriented) learner. Primarily our focus over here is to make the learner think further and explore beyond the said.

G. *Analysis*

To be concise, this section forms detailed versions of the truths in the course (like mathematical proofs). The student is explained how the concept is reached at through the proofs.

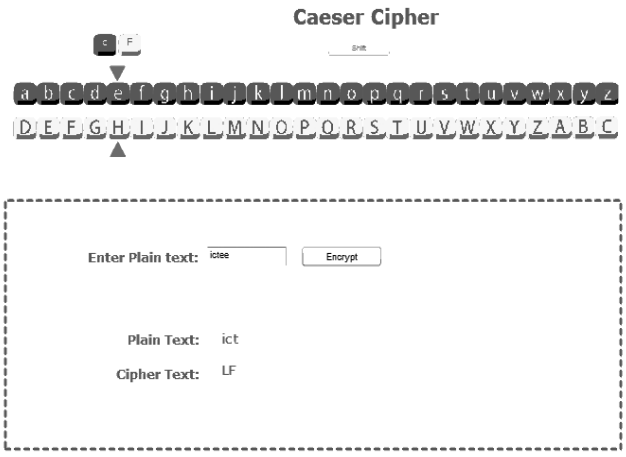

Figure 6: Caesar Cipher

H. *Insights*

Insights can be classified as historical insights which trace to the literature's evolution leading to the entire course. In

addition, questions posed here could help in learners getting altogether new insights.

I. Imagination

The imagination is about the research/idea "explosion" aftermath of the course/concept. This section leaves the student thinking on what's next and can be considered a precursor to the next module.

The content thus developed in this model, will cater to a wide range of students ranging from the novice to the advanced. A novice learner may start with the learning objectives, proceed to the implementation component, and navigate in the left section of the butterfly. An advanced learner may begin navigating in the right section of the butterfly and get more insights into the subject. An intermediate learner navigates in both the left and right sections of the butterfly and accesses components.

IV. PROCESS

There were a large number of people involved in the peer group for the development of course content in the pedagogical model that we have undertaken. In order to smoothen the working of this diverse peer group we have devised a process and structure along with roles and responsibilities which helped to ease the interactions among the peer group.

The peer group involved:

- Domain expert (i.e. the professors)
- Domain expert nominees (i.e. the research assistants of the professor)
- Animation experts
- Learning technology experts
- Reviewers (faculty members and students of engineering colleges)
- Coordinator (1 coordinator for each course)

This structure worked fairly well and we are continuing this for further course development as well. Based on past experience and on best practices, we designed a process for content development, delivery, review and testing. We conducted workshops for all members involved in the peer group and explained to them this process.

During the content development phase, we followed a wiki-based development model. Learning technology experts reviewed the content as it was being developed and checked for content consistency, completeness and correctness. Content was developed keeping in view the Bloom's taxonomy and specifically targeting the higher order thinking skills of the students. The content additionally had problems/tasks and quizzes that were designed to measure/enhance the students' higher order thinking skills.

During the content testing/review phase, we invited senior faculty members and students as reviewers for a 5 day workshop, wherein the content was presented to the reviewers. Feedback and review comments were collected on a daily basis from all reviewers and the necessary updates made.

V. RESULTS

We had conducted studies on content development and delivery in the Butterfly Model on two courses namely Principles of Information Security (PIS) and Data structures (DS) [7].

To highlight some key findings, 100% of the respondents for the PIS course and 94% of the respondents for the DS course felt that this model helped them learn better as emphasis was laid on application skills alongside knowledge gain (refer Figure 7). 100% of the respondents for PIS course and the 88% of the respondents for the DS course said they liked this model and would recommend their colleagues to take this course in this model (refer Figure 7). Most of the respondents felt that this model would cater to different learners' styles owing to the various components available.

These results have encouraged us to design two more courses in this model namely, Data mining and Data warehousing (DMDW) and Design for Testability (DFT). We conducted similar tests on the newly designed content and have collected feedback and user response from both students and faculty members [refer figure 8].

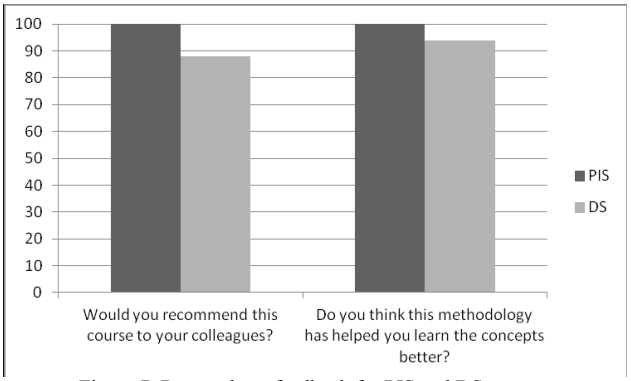

Figure 7: Respondents feedback for PIS and DS courses

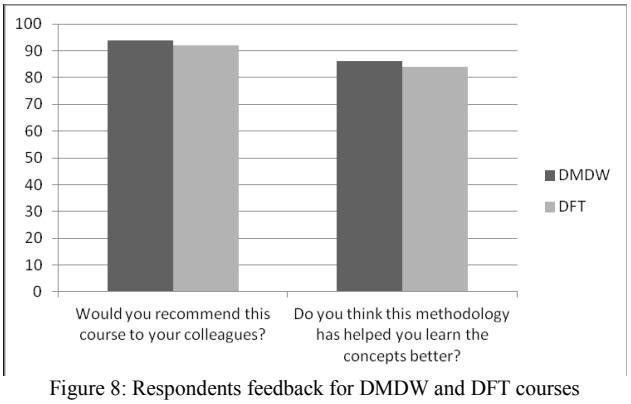

Figure 8: Respondents feedback for DMDW and DFT courses

VI. Future Work

Our future work would be design more courses in the Butterfly model and conduct similar studies. We also plan to make the content generation process easier and thus to design content authoring tools for this model. We also intend to host all this content on a portal for bigger reach. Additionally we plan to conduct training to the faculty members on this content to ensure scalability and use of the content.

Our biggest challenge would be to design an exhaustive question bank for the evaluation part of the learning process. We are developing strategies for testing with a variety of question types namely objective and subjective. Efforts are on to generate an exhaustive question bank for evaluating the learners.

These steps, we feel, will not only allow faster content development but also capacity building in terms of training teachers and allowing them to take it to the colleges and not having to spend large amounts of time in assessing the learners' work.

VII. Conclusion

Our preliminary results show that the Butterfly model introduced for content development and learning, enables a learner to overcome problems faced with earlier content, and actually helps learners learn concepts better through the various facets available that learners can choose to navigate through. The navigation is intuitive and easy for learners to understand. We are optimistic that content developed through this model will benefit the student community at large and the quality of education will truly be enhanced.

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