Butterfly Model: An innovative way to deliver and personalize content in the "Learning by Doing" methodology

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Abstract— **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 help overcome this problem, an innovative Certificate in Information Technology (CIT) program was started. Through this program, faculty members of engineering colleges are trained who then are expected to train the students at their colleges. We have worked with over 40 engineering colleges in Andhra Pradesh, trained their faculty and have begun implementing this program for the students through the faculty at their respective colleges. 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. 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 basis for this model and about our initial studies and feedback received for three courses developed in this model. The feedback for this model is encouraging and we expect to develop more courses in this model in the future. This model we feel will be applicable to a wide range of learners and also help in enhancing the quality of learning of the graduates.**

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

It has been widely realized that we continually graduate students who are not yet ready for the real-world. Bruner points out the quick rate of change in our world and says, "The principal emphasis in education should be placed on skills - skills in handling, in seeing, and imaging, and in symbolic operations" [1].

Our education system primarily measures retention levels (focus is on rote learning) while the real-world desires application skills (focus is on being able to deliver). 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).

We have 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. In this process, we observed that 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. Also, having worked with 40 engineering colleges and having trained over 260 faculty members in 4 batches (each of 2 months duration), we found that there is a serious need for one model that can address all these limitations as there is a severe dearth of faculty with the explosion of engineering colleges in the state of Andhra Pradesh.

We find that content is available in the form of NPTEL [2], MIT's OCW [3] 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.

To address the foregoing, we developed a novel idea of designing course content – "The Butterfly Model" (refer Figure 1). Several approaches to design and develop content have been advanced in the literature. For example, the four quadrant approach suggested by Cronje (2006) takes into consideration both the constructivist and objectivist approaches to learning [4]. The Learning by Doing (LbD) methodology is a constructionist approach to learning and promotes a learner-oriented environment [5].

The content development process in the LbD methodology and the methodology's inherent benefits have already been demonstrated [6] [7]. The most important of these benefits is increased skills level gain.

The Butterfly model is an enhanced version of both the four-quadrant approach and the LBD approach of content development. It allows for more personalization and for more student involvement in the content.

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 (e.g., Data Structures) 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 the model

Butterflies symbolize change. In ancient mythology, the butterfly was a symbol of wisdom and everlasting knowledge. Our model's blending of the different learning styles of the learners and their higher order thinking skills makes us believe that this model will result in a metamorphosis in the way students learn.

Since the basis of the Butterfly model is the learning by doing methodology the focus is on doing "tasks" and showing work output. We have identified and designed various components that would help the student in the learning process.

Mapping to the model

We have designed 9 components in this model. Each of these can be mapped to the butterfly anatomy.

Learning objectives: Prepare the butterfly for its flight by making it think "why it is flying and where it is flying" similar to the student thinking "why he/she is learning the course".

Implementation: It is known that the thorax or the body of the butterfly helps in its flight. Similarly, the implementation component has the tasks that the student works on and forms the main structure around which the rest of the flight is built.
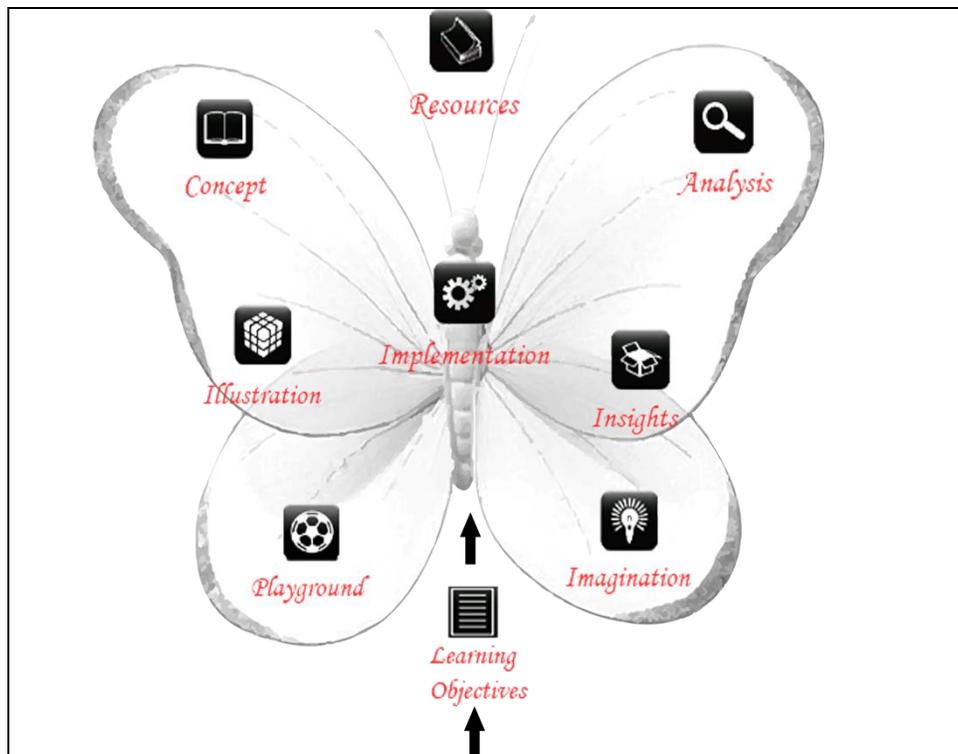

Figure 1. The Butterfly Model

Resources: These are available at the antennae of the butterfly and help in sensing the butterfly's direction, guiding it to its intended destination. Our model provides assistance that is tailored to the level of progress being made by the learner, thus guiding the learner toward the final destination. The key is that help is not thrown at the learner indiscriminately, but is provided on an as-needed basis. The hind- wings and the fore-wings help the butterfly in its flight and play a critical role.

In our model, Concepts & Analysis components act as fore-wings and **Playground & Imagination** act as hind-wings. At the intersection of these wings are **Illustration & Insights**.

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.

Thus, once a student completes a module in this model he/she will be able to fly comfortably and also let their imagination take flight.

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

In general, learning objectives are introduced at the start of the course so that learners understand what they are trying to achieve and the level of the achievement. This allows students to participate as active, independent learners as they are clearly told what they should be able to do at the end of the course. Thus, learning objectives put the focus on the learner and learning rather than the teacher and the teaching.

How will learning objectives help?

Taxonomies can be useful in getting ideas for the types of learning objectives to consider and in checking the completeness of a set of objectives. One example is Bloom's taxonomy [8], in which general concepts and specific skills are introduced in the beginning. The ability of students to recall information and understand its meaning is then verified. An explanation on how the concepts and skills are related to each other follows, which bridges the abstract with the concrete. Finally, the ability of students in applying the knowledge to real-life scenarios, breaking down the information into component parts, applying the knowledge in new domains, and judging the value of the information are assessed.

Given the fact that the employability level of our graduates is very low [9], our primary focus in this effort has been on improving their skills and thinking abilities. We ensured that the learning objectives chosen by us touched on the higher order thinking skills mentioned in Bloom's taxonomy.

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:

The implementation involves tasks which when completed lead to prototypes of basic products in the area. According to Piaget, "a sufficient experimental training was believed to have been provided as long as the student had been introduced to the results of past experiments or had been allowed to watch demonstration experiments conducted by his teacher, as though it were possible to sit in rows on a wharf and learn to swim merely by watching grown-up swimmers in the water. It is true that this form of instruction by lecture and demonstration has often been supplemented by laboratory work by the students, but the repetition of past experiments is still a long way from being the best way of exciting the spirit of invention, and even of training students in the necessity for checking for verification" [10].

Research has confirmed many of the seemingly intuitive benefits of hands-on learning and has 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 our 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 [11].

In this section, the emphasis is on application. 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

These refer to the reading material that the students refer to for doing the tasks. These concepts are provided by the domain expert in the form of video lectures (also called spoken tutorials). Thus, the individual concepts when

concatenated form a lecture-based course. Students can refer to the resources section for further information on the related concept.

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 resources in various formats (text, audio, and video). These resources when concatenated form a collection of various multi-modal resources including the breakthrough papers in the area.

Research has shown that learning is more when information is presented via computer animation systems than through traditional classroom lectures [13]. Using an interactive animation will solve the problem of the imagination-skill in education and training. Therefore, the ability to practice new concepts in a risk-free environment improves learners' skills and abilities.

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. However, an illustration that allows the learner to try out possibilities - interactive illustration through what-if examples, help learning happen better. Further, benefits of employing animations/simulations in education have been widely discussed. Agina [13] has explained the benefits of using animation in education and training namely skill and ability improvement, interactivity, and engagement. The main advantage of employing animations in education is to show the "non-possible" in real-life learning possible. Learners have more interaction with the content and are thus more likely to assimilate the knowledge, skills and concepts involved. More importantly, this approach appeals to different learning styles, allowing personalization possibilities to learning.

In this section, the instructor explains a particular concept through animations, which may be static or interactive illustrations. Figure 2 gives a screenshot of an animation employed for explaining the "Caesar Cipher" operation. There is a provision for the student to provide different inputs and test these inputs thus enabling students to get an immediate feedback from the animation system that will enhance their skills and abilities. We can say that all the individual illustrations when concatenated form an e-workbook with solved examples.

F. Playground

Interactive learning with live-action animation, simulation, video, audio, graphics, feedback, expert advice, and questions and answers keeps learners interested and reinforces skills. Because it is exciting, challenging, and fun to use, it encourages learners to return to the program again and again! Through continual practice, learning is absorbed and integrated into daily performance [13]. Moreover animations allow for flexible education and training and ultimately inspire learners to learn more.

Through interactive and what-if simulations, students take less time to learn complex things. This can be attributed to the fact that there is more student involvement in this process.

It is important to mention that computer animation also improves the skills and ability of instructors because they will be able to improve and enhance their way of teaching. During the process of the animation, instructors can open free-discussion among learners, which will positively affect the entire classroom. It is important to note that the learners' feedback could be useful to improve the animation/simulation system itself!

In figure 3 we show an animation of the "Mono-alphabetic cipher" functioning. The student needs to key in different inputs and test the system. The student can be working freely without any doubt/fear of breaking the system. Thus, the student is empowered to try out new things and learn by himself/herself.

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

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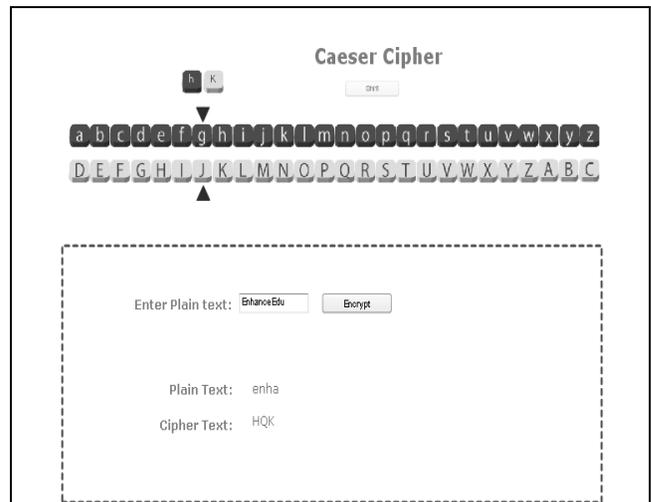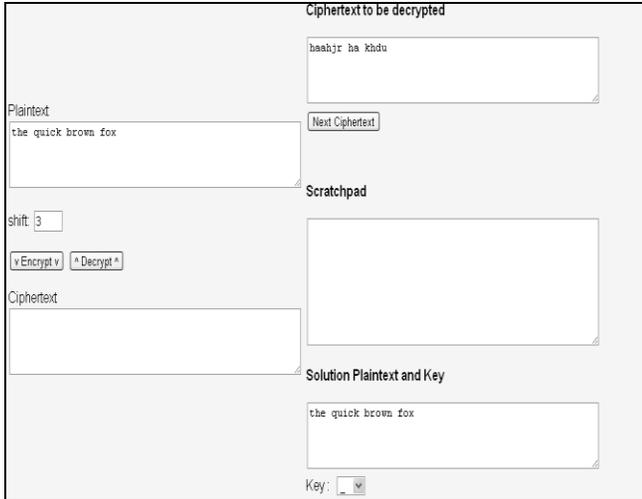

Figure 2. Caeser Cipher animation

Figure 3. Mono-alphabetic cipher animation

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.

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.

IV. RESULTS

We have done some preliminary tests on content developed in this model. We have taken feedback from both students and faculty members (30 respondents) and the initial findings are encouraging.

We had conducted these tests for two courses namely, Principles of Information Security (PIS) and Data structures (DS). The respondents ranged from the novice to the intermediate in these courses.

Interestingly, 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 4. 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 4. Most of the respondents felt that this

model would cater to different learners' styles owing to the various components available. Figures 5 and 6 depict the respondents' feedback for the different components in the model.

V. 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.
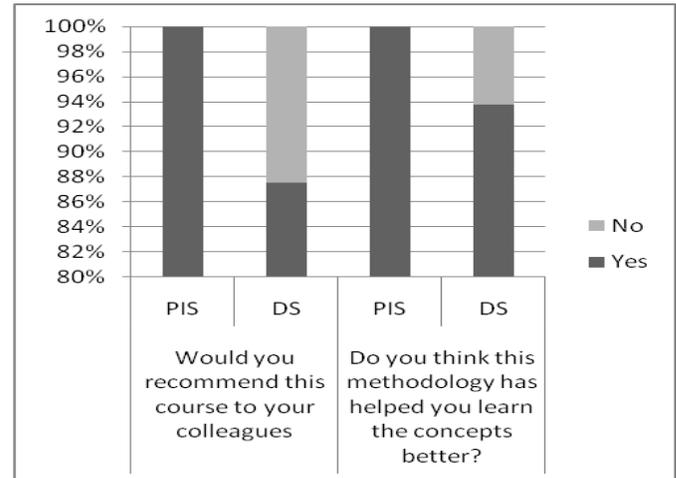

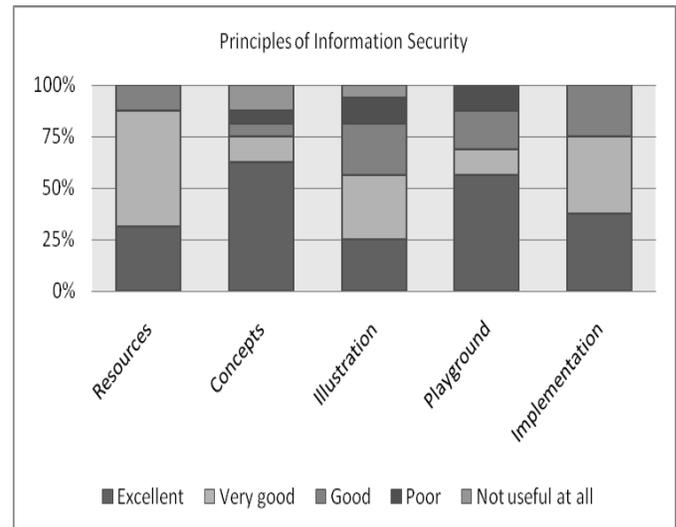Figure 4: Respondents feedback on the courses

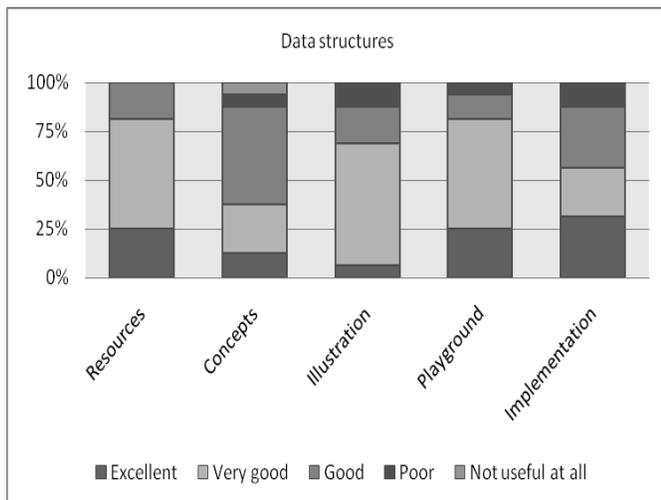Figure 5. Feedback for Principles of Information Security course

Figure 6. Feedback for DS course

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.

VI. 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.

REFERENCES

[1] Bruner, Jerome. In Search of Mind. New York: Harper Colophon, 1983, p. 183.

[2] http://nptel.iitm.ac.in/

[3] http://ocw.mit.edu/index.htm

[4] Paradigms regained - towards integrating objectivism and constructivism in instructional design and the learning sciences. Educational Technology Research and Development - Cronje J C (2006)

[5] Instructional-design Theories and Models: A new paradigm of instructional theory – Charles M. Reigeluth (Chapter 8: Learning by Doing Roger C Shank, Tamara R Berman and Kimberli A Macpherson, Institute of learning sciences at Northwestern University)

[6] Certificate in Information Technology (CIT): A program to enhance the quality of IT education in engineering colleges - Surya Kiran Reddy, Sandhya Kode (T4E 2010)

[7] Enhancing the learning experience by addressing the needs of the learner through customization and personalization in the learning by doing methodology - Surya Kiran Reddy, Sandhya Kode (ICALT 2010)

[8] Benjamin S. Bloom - *Taxonomy of educational objectives*.

[9] "Extending India"s leadership in the global IT and BPO industries" - NASSCOM-McKinsey Report published in 2005

[10] Piaget, J. (1985). The Equilibration of Cognitive Structures. Chicago: University of Chicago Press.

[11] Karen Worth, Education Development Center, Inc. (Developers of Insights: A 1), Newton, MA

[12] Designing Effective Instruction - Gary R. Morrison, Steven M. Ross, Jerrold E. Kemp, Howard Kalman (Chapter 8: Designing the Instructional Message)

[13] The advantages and disadvantages of the animation technology in education and training – Adel M. Agina 2002/2003