

Case Studies- Motivation and Drive for Curriculum Design

B S Nagabhushana¹, Rajeshwari Hegde²

¹Dept. of ECE, BMSCE, Bangalore

²Dept. of TCE, BMSCE, Bangalore

nagabhushanabs.ece@bmsce.ac.in

rajeshwari.hegde@gmail.com

Abstract: Higher Engineering education is moving towards Outcome Based Education (OBE) wherein the quality of the teaching-learning process is adjudged by the abilities of the outgoing students measured during the academic programme and also after the completion of the programme. In this manner, the assessment of the educational process is a bottom-up approach. However, curriculum development for the programmes is still a top-down approach. Moving forward, this orthogonality would impair OBE. This paper presents a methodology for curriculum development using bottom-up approach in-line with OBE. The methodology suggested is illustrated and discussed with the help of case study. The role of a teacher is redefined as a facilitator with curriculum development as his/her core functionality rather than being mundane with course delivery and assessment year after year.

Keywords: OBE, Curriculum development, case study

I. Introduction

Traditionally, provisioning Engineering education has been articulated with references from their non-engineering counterparts. In the recent past, there has been a realization on the need of technical education leveraging and aligning their output with the expectations of the industry who are the major consumers of the educational outputs. As such, the paradigm of “*Outcome Based Education (OBE)*” has come into being. The OBE assumes, in a way, a bottom-up approach in assigning its priority to assess the output of the educational system viz. the graduate Engineers in the context of technical education, in view of their capabilities being well aligned with the expectations of the associated industry. The educational system is assessed for having successfully implemented all processes to; ideally, ensure the building of such capabilities with the graduating Engineers.

Maturity assessment models for assessing technical education like the assessment model of National Board of Accreditation, INDIA has implemented checks and bounds on the processes being followed by the educational institutions. The OBE paradigm, in its present form, shall suffice the prevalent societal needs and the needs of the associated industry [1]. However, there are domains and technologies with lots of unknowns to both industry and academia. Such situations are not mirrored, explicitly in OBE with its present expanse. This paper is a contribution in this direction and is organized as follows: Section 2 presents the traditional curriculum design and its transition into the state-of-the-art curriculum design. Section 3 presents the prevalent challenges to curriculum design. Section 4 presents a mechanism that employ practical case studies and working backwards towards the curriculum design. Section 5 presents an illustration of the case study driven curriculum design taking the example of space science. Conclusions of the present work are present in Section 6.

2. Curriculum Design – State Of The Art

Curriculum design has been, rightly, viewed as an integral part of educational system and consists of framing of the content, delivery of the content and the assessment. Whereas the content delivery and assessment depends, solely, on the

B S Nagabhushana

Dept . of ECE, BMSCE, Bangalore, India

nagabhushanabs.ece@bmsce.ac.in

content itself, the selection of knowledge for content preparation has been quite complex and often disputed[2]. Traditionally, curriculum development has been perceived as a merely technical process that must produce 'results' strictly aligned with the demands of the economy, while its function has been to train the individuals to compete in the employment markets. Economy, trade, finance, communication and migration have developed on a global scale and many of the current and future challenges have spilled over national borders, fueling the growing debate on conflicting educational visions of the type of balance that must struck between local and universal identities, knowledge and values. National and international assessments have cornered on curriculum development as the main source of issues with respect to the acquisition of essential skills and knowledge along with significant gaps in their social distribution. Curriculum development is highly criticized because its basic principles have not changed but continue to favor the accumulation of facts, information and knowledge rather than fostering understanding of the use to be made of that knowledge.

A potential solution to overcome these problems is the gradual shift in emphasis from content and input to educational results, expressed as a set of competencies that pupils should develop and apply at the end of education. There are many proposals and frameworks of competencies that use a wide range of approaches, classifications and terminologies. Further, with the global problems on hand, these competency frameworks got refined into what are termed the "Graduate Attributes" and marked the beginning of OBE. The OBE advocates close alignment between the professional education and professional practice. As such, OBE driven models advocate specific processes within the framework of curriculum design that ensure good alignment between professional education and practice. In specific, the curriculum design is influenced by the following and other factors:

1. Industry participation in curriculum design and delivery
2. Research centres allowed to get started in nominal Engineering institutions as enablers to create Research ambience
3. Awarding autonomous and deemed university status to mature institutions leading to distributed wisdom which, effectively, have sufficient scope to drive the overall system
4. Campus recruitment on an extended scale as enablers to have closer interaction with industry
5. Continuous improvements initiated on account of changed outlook of the teaching fraternity after having exposed to advanced degrees, Faculty Development Programmes (FDPs), numerous technical workshops, Research grants, infrastructure grants, etc. on a continued basis.

Although the principle and objectives of OBE is widely appreciated, most of the Universities in developing countries

are not in a position to bring this transition, primarily, because of the inherent weakness of the affiliated institutions and the moral responsibility of the Universities, to harbor such institutions, being driven as a national commitment. However, in order not to lose out on the benefits of OBE, mature institutions are being encouraged by legislation to enjoy academic autonomy thus permitting such institutions to frame their curriculum based on OBE philosophy. Challenges being faced despite the introduction of OBE are discussed in the following section.

3. Curriculum design – Challenges

Firstly, although many institutions with academic autonomy are in a position to design curriculum in full compliance to OBE, the percentage of such institutions is alarmingly low. As such, the fundamental issue lies in the reachability of the OBE philosophy. Secondly, in view of the factors that influence curriculum design as listed in section II, it is clear that OBE is not as yet perceived with a global perspective but with a limited perspective of meeting the growing requirements of the associated industry in a dynamic manner. While the alignment of the curriculum design with the relevant industry appears to be in-place, it is to be noted that it is, probably, one of the dimensions of OBE. Even with this limited interpretation, the curriculum design is not in a position to visualize the long-range industry requirements which, sometimes, the industry themselves are not aware of.

While the OBE outreach and the limited interpretation of OBE have caused nominal advancements with respect to curriculum development, the sense of active learning is posing serious threat to effective curriculum design. Active learning focuses on the needs and expectations of learners as the main players who build and regulate their own learning. Active learning also advocates the fact that cognitive, ethical and emotional dimensions of learning are interrelated and cannot be arbitrarily dissociated. The prevalent curriculum design having not addressed these aspects, has led to unpredictable manifestations of learning crisis which cannot be explained.

After having failed to understand the influence of ethical and emotional dimensions on learning behavior, teachers are assuming multitudes of avenues to identify "slow learners" who really are not. Teachers spend and are expected to spend lot of time on such actions rather than having a relook at the curriculum itself viewing that as a probable potential cause of the learning crisis.

Similar to the way teachers seem to have mistaken the cause of learning crisis, the students also have mistaken on the roles of the teachers and hence no sharing of complete thoughts occur between the students and the teachers. Although proctoring of the students is in-place in many institutions, the perspectives are slightly different.

Yet another challenge to curriculum design in the back drop of OBE is that, the OBE employs bottom-up approach, whereas the curriculum design employs top-down approach. This orthogonality between OBE and curriculum design has to be resolved by reversing the curriculum design approach

since the OBE perspective is fully acknowledged and endorsed.

4. Case Study based Curriculum Design

Having convinced with the dire need to refine the motivation behind curriculum design and methodologies, both from the OBE and from the other perspectives, this section presents a technique to develop curriculum which would equip graduate engineers to face futuristic challenges. Also, the presented technique employs bottom-up approach in-line with the OBE philosophy. Thirdly, this technique, if practiced correctly, would navigate teachers from their conventional roles to the role of a facilitator who would practice developing curriculum as an independent activity. Curriculum development thus shall be driven by the need to learn and urge to learn and that the curriculum development shall not take place because a course or a programme is being offered by a University. The curriculum development needs to change from being an “information accumulation” exercise to a “utilitarian value of information”. Independent curriculum development shall be in a position to address the multiple dimensions of learning which, hitherto, have been neglected or at best compromised. The presented technique and similar such techniques are also expected to lessen the global learning crisis to a great extent. The core of the technique is explained in the following paragraph.

The prime input for curriculum development using this technique is any artefact that describes a case study. The domain of the case study shall be, invariably, niche to an extent that neither the teacher nor the students would ever have had any opportunity to be a part of such case study. This requirement holds in order to avoid unnecessary activities towards curriculum development on more obvious topics, reinventing the wheel [4]. Examples of such domains include space sciences, nuclear science, astronomy, aircraft design, to name a few. The artefacts could be documentary, specialized (often expensive) training, videos on public domain, webinars or even any ordinary document of some form. Following is a sequence of tasks which a teacher could execute on the artefact procured:

1. Experience the artefact multiple times as might be required to get a complete understanding of the case study
2. Map the constituents of the artefact to either an existing course of the programme or to a new course. If the artefact gets mapped to an existing course, the potential shall be to enhance the existing course curriculum. If the artefact gets mapped to a new course, the potential shall be to design a new course. However, the relevance of this new course shall have to be justified from the perspective of the overall programme of which the course is a part.
3. Execute a functional decomposition of the artefact and document the same. The grain size of the decomposed parts (say, functional entities) could be,

reasonably, large. It could be that the case study is trivial enough to be not a candidate for any sort of decomposition

4. Identify the following types of components in each of the functional entities, identified in step 2, above
 - a. Scientific concepts
 - b. Technologies
 - c. Evolutionary information
 - d. Challenges and limitations
 - e. Operational concepts
5. Arrange these components in the increasing order of their complexity
6. Map each component to one or more of the Bloom’s taxonomy of learning objectives
7. Divide the list of components into Units or Chapters
8. Check for continuity and dependencies Unit-wise and component wise
9. At this stage, the curriculum is ready. Title the course, suitably and Check for pre-requisite courses and position the designed course to maintain continuity within the academic programme.

5. Case Studies Driven Curriculum Design Illustration

The subject of this case study is related to space science and based on the analysis of a documentary of the public domain that explains orbital insertion process of the Indian Mars mission titled “Mangalyan”:

1. High level design aspects of the Mars Orbiter
2. Mission challenges
3. Mars Orbital Insertion
4. Space craft autonomy
5. Attitude and Orbit Control System (AOCS)
6. Orbit Determination techniques

An excerpt of the note with respect to MOI is provided in the following paragraph [4]:

“The mission of Mars Orbiter carried by Polar Satellite Launch Vehicle (PSLV) started on 5th Nov. 2013. On Sept. 24, 2014, the Mars Orbiter arrived at its destination after travelling a distance of 666million Kms. In an hyperbolic trajectory. From here, the orbiter shall be inserted into an elliptical orbit through an involved process termed Mars Orbital Insertion (MOI) which is a critical maneuver. This task was executed with a combined visibility of 70M Ground Antenna and the on-board Medium Gain Antenna. The MOI operation started with the changeover to MGA 3 hours prior to the liquid engine burn start. This was followed by the forward maneuver, 21 minutes prior to the liquid engine burn wherein the direction of the satellite is changed and reoriented pointing it to the desired thrust direction so that the space craft velocity can be reduced by the required amount. The orbiter encountered eclipse due to Mars 5 minutes 13 secs. Prior to the burn start and the solar panel were unable to generate power as the sun light is obstructed by Mars. During the eclipse period, the Orbiter was powered by the on-board 36AH Li ion battery. Still the Orbiter is in

the Line of Sight (LoS) of Earth and would receive data from it. The liquid engine burn started 5 Mins 13 Secs, after the onset of eclipse to lower the Orbiter's relative speed to the planet by 1109m/sec. and the velocity from 5.1Km/Sec. to 4.3Km/Sec. in relation to Mars. Nearly, 4 mins. 20 secs after the burn start, the Mars Occult starts. The Orbiter would go behind the planet. As a result, no signal from the satellite will reach earth for considerable amount of time. Nearly 28 mins after the burn start, the satellite will come on from behind the Mars and that is when the occult ends. It is during the liquid engine burn. sufficient thrusters are energized to set the orbiter into the planned orbit. After this activity, the reverse maneuver starts by which the Orbiter is once again reoriented pointing the HGA towards the earth. With the resumption of the HGA, the MOI is complete”.



Fig. 1 (a) and 1(b) (Courtesy: Doordarshan Delhi)



Fig. 1 (c) and 1(d) (Courtesy: Doordarshan Delhi)



Fig. 1 (e) and 1(f) (Courtesy: Doordarshan Delhi)

Figures 1(a) thro' 1(f) depict fundamental distinctions across the physical features of Earth with that of Mars. Starting from this cursory study, an in-depth study in this direction could lead to a detailed understanding of the constituents of the planet, possible explorations of the resources in the future and up to a speculation of possible human habitat that could be built on Mars.



Fig. 2(Courtesy: Doordarshan Delhi)



Figure 3. (Courtesy: Doordarshan Delhi)

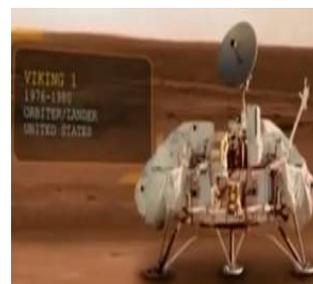


Fig. 4(a) and 4(b) (Courtesy: Doordarshan Delhi)





Fig. 5(a), 5(b), 5(c) and 5(d) (Courtesy: Doordarshan Delhi)



Fig. 6(a) and 6(b) (Courtesy: Doordarshan Delhi)



Fig. 7(a) and 7(b) (Courtesy: Doordarshan Delhi)

Figures 2 through 7 depict the brief explanations of the Mars explorations in terms of “Landers”, “Orbiters” and “Rovers” as mentioned. The first of the innovations is the “Flyby” (Figure 2) which possibly passed by the planet Mars. Figures 3 through 6 depict the various Landers, Orbiters and Lander/Orbiters which were built under varied space programmes, worldwide. Through these innovations mankind could land or revolve around Mars like a natural satellite. These missions could send thousands of photographs which could be analyzed from varied perspectives by space scientists. Figures 7(a) and 7(b) depict the recent innovations of Rovers which could land on Mars and navigate on its surface exploring the various geological aspects of Martian surface. These innovations not only provide sufficient excitement to budding Engineers but also provide technical directions for future programmes. In this age of information technology, huge amount of information is, readily, available for assimilation and further knowledge generation.

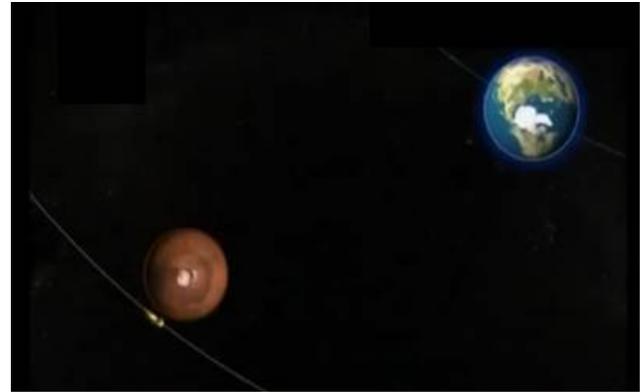


Fig. 8(Courtesy: Doordarshan Delhi)

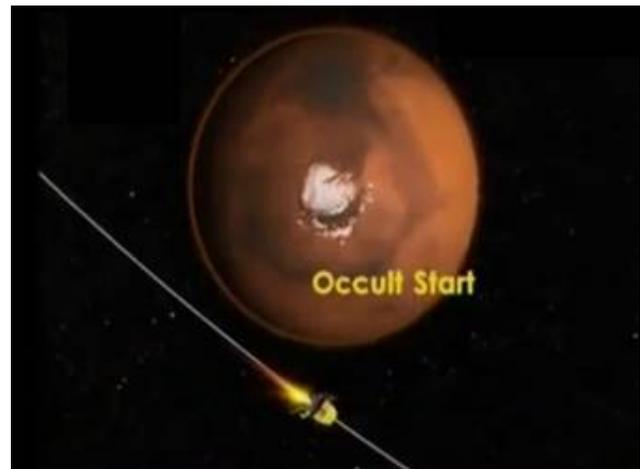


Fig. 9 (Courtesy: Doordarshan Delhi)



Fig. 10(Courtesy: Doordarshan Delhi)

Figure 8 through Figure 11 depict the varied stages of Mars Orbital Manouever (MOM). The documentary from Doordarshan Delhi explains all the stage of MOM which could be, sequentially, listed as follows:

- 1.Approach of the Orbiter in an hyperbolic orbit towards Mars

- 2.The Orbiter coming into the gravitational pull from the Mars planet
- 3.Orientation of the liquid propulsion engine into the direction of the negative velocity of the orbiter
- 4.Firing of the liquid engine to reduce the velocity of the Orbiter
- 5.Moving the Orbiter into the elliptical orbit around the Mars
- 6.Technologies built to address the Occult (Orbiter going behind the red planet)
- 7.Technologies built to address the eclipse during which the sunlight could not reach the Orbiter and the solar panels becoming inoperative. Figure 11 shows the operator panel that shows the icons representing the liquid engine and possibly the thrusters which, probably, were operated simultaneously to push the Orbiter into the preplanned orbit.

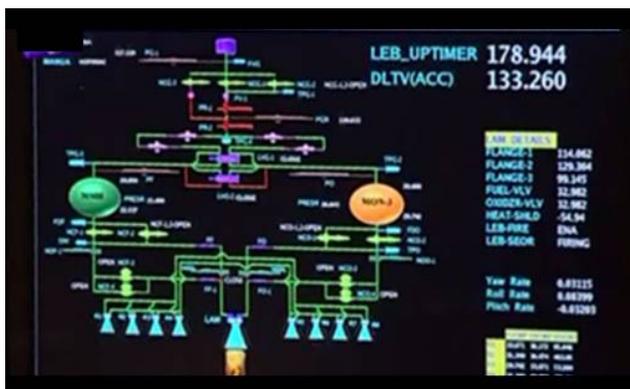


Fig. 11(Courtesy: Doordarshan Delhi)

With respect to the high level design and challenges, the simulation setup, challenges related to wide range of thermal environment, Payload design and power system design challenge are explained. With respect to the autonomy, the need of autonomy and the various design decisions and the implementation strategies conceptualized and followed are also explained. Similar technical explanations with regard to Orbit determination and its control are also provided. In this manner, the documentary is quite exhaustive and thought provoking for any interesting mind.

While the explanation about the space mission as provided above is incidental, the emphasis, in the context of this paper, is on its utility in carrying out curriculum development. Similar case studies exist in other domains such as nuclear reactor design, advanced communication networks, advanced robotics design and advanced mission critical aircraft design for defense. One commonality across these domains and case studies is the “System Approach” which is, severely, compromised while designing curriculum. On the other hand, most of the curriculum design delivers conceptual knowledge which, although generalized to equip the students for a gamut of professions, shows up as a big lacuna in terms of lack of system knowledge for the students in their careers. The importance and the need for curriculum design around such

case studies are briefly discussed in the following paragraphs:

Space programmes like Mangalyan which is briefly explained in the previous paragraphs and similar such programmes are, inherently, multidisciplinary and hence warrant a “system” based treatment. Continuing on the case study, although specialized, in depth, knowledge in space craft structural design, data communication subsystems, space ecosystem, telemetry, ground based simulation and many more subdomains are essential, the experts need to have an overall ownership of the complete mission which can only be got by gaining system knowledge. At the minimum, expert of a specific subdomain need to understand all other subdomains to the extent of his/her subsystem meeting the overall objective of the mission. Any further knowledge would, undoubtedly, increase the success of the overall mission. Such knowledge can only be accrued within the available time frame if there were to be an orientation in their graduate study towards the domain.

Programmes of the type indicated in the case study, owing to their complexity are of long duration. Nominal automotive programmes in the automotive industry would take about 3-4 years with many reusable components from their predecessor programmes. Similar deployment cycle in case of aircraft would consume 7-8 years. Design and deployment of satellites and launch vehicle from scratch would take much longer. Engineers within their nominal service span would, probably, take part in two or utmost three such programmes. With the increasing expertise and reusability of the designs across programmes, the cycle time is expected to come down. The emphasis in this connotation is that if there were to be a curriculum which specially addresses the domain requirements without any compromise on the continuity and synchronization amongst the courses that constitute an educational programme, the overall cycle time of mission critical programmes such as those of space sciences would slim down augmenting the overall growth.

As explained in the previous sections, the role of a teacher is being witnessed to shift from a nominal delivery and evaluation of curriculum to the role of a facilitator. An in-depth study of case studies, tracing them back to the required curriculum components, development of know-how of these components, lay-out of these components along with their schedule and delivery of such all-new domain oriented curriculum to interested students constitute the new role of the teacher as facilitator. Extending the case study presented, above, over a thorough understanding and further analysis of the documentary whose excerpts are provided above, a two or three credit system can be designed with the following Units of study:

- Unit 1: Fundamentals of satellite Engineering
- Unit 2: Space mission categories (Orbiter, Rovers and Landers) and their high level design
- Unit 3: Space mission challenges
- Unit 4: Orbit determination and control
- Unit 5: Space craft autonomy

While highlighting a possibility of framing a one semester course is of importance here, the details on establishment of pre-requisite knowledge is, cautiously, not a part of this paper owing to the volume of the work.

Lastly, mission critical programmes, invariably, are associated with multitude of global problems which need to be solved as early as possible. Some cases, the problem is to avoid an imminent problem while in others, it amounts to the question of survival of mankind on this earth. Amidst such situation, it is essential that all attempts need be provisioned to save time. As such, curriculum design for specialized domains mentioned above with an objective to take the students on a steep learning curve becomes the need of the hour.

6. Conclusion

Curriculum development has always been following a top-down approach. This paper has presented an idea of curriculum development using the bottom-up approach starting from a real-life discovery/mission with intent to build knowledge asset in the identified domain by tracing back from such real-life programmes back to the conventional curriculum framework. The paper also highlights the importance and the need of such, apparently, unconventional methodology for curriculum development. Authors have experimented with such methodology and have witnessed, reasonably, good success, so far. Authors visualize such methodology to play a significant role in addressing global problems. As such, the authors are of the opinion that a comprehensive framework shall need be developed and institutionalized so that the methodology suggested in this paper may be repeatedly used and adapted for various courses and programmes of the institution. Further, such framework shall accommodate suitable mechanisms to measure the quality of curriculum & its enhancement on a continued basis.

Acknowledgments

The authors are indebted to the Management, BMS college of Engineering for their encouragement and support in developing this knowledge and an attempt to share this knowledge among peers thro' this paper at ICTIEE 2016. The work reported in this paper is supported by our college through the Technical Education Quality Improvement Programme [TEQIP-II] of the MHRD, Government of India.

References

Dr. Richard Dales, Fiona Lamb and Dr. Emma Hurdle, Engineering graduates for industry, Faculty of Engineering and Computing – case study , February 2010.

Rajeshwari Hegde, Manjunath P S, Nagabushana B S, Teaching Wireless Communication using Modern Tools for OBE Accomplishment, pp 374-380, CL-IGIP 2014 Conference, 3rd-6th December 2014, Dubai.

B S Nagabhushana, Rajeshwari Hegde, “ Teaching-Learning Process for Industry Oriented Courses – A case study”, 3rd IEEE International Conference on MOOC's, Innovation and Technology in Education, Amritsar, October 2015

Mangalayan in Mars Orbit, September 2014 full live video, available at: www.youtube.com/watch?v=VZL_Vwy0JqI

B.S.Nagabhushana received his Bachelor of Engineering in Electronics from Bangalore University, M.Tech. in Industrial Electronics from Univ. of Mysore and Ph.D. from Indian Institute of Science (IISc), Bangalore. He is presently associated with the Department of Electronics and Communication Engineering of BMS College of Engineering, Bangalore, India. His Research interests include embedded systems with focus on automotive electronics



Rajeshwari Hegde received her Bachelor of Engineering in Electronics and Communication Engineering from National Institute of Engineering, Mysore , Master of Engineering in Electronics from BMS College of Engineering, Bangalore and PhD from Bangalore University. She is currently an Associate Professor in the Department of Telecommunication Engineering, BMS College of Engineering, Bangalore, India.

