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Curriculum Development of an Engineering PG Program at an Autonomous Institute – A Case Study

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Abstract: The evolution of the knowledge economy and the need for exploiting advancements in engineering sciences for commercial benefits have shifted the focus from undergraduate to postgraduate level education in engineering and technology. The number of students aspiring for post-graduation in engineering has seen a rise in recent past. There are about four thousand colleges in India which are offering PG programs in engineering and technology. The success of any educational program largely depends on the design and effective implementation of the curriculum. This work makes an effort to present the case study on curriculum development of a postgraduate Automobile engineering program at RIT. The requirements of a typical PG engineering program have been highlighted. The recently introduced framework of AICTE model curriculum for PG programs is introduced. The findings of analysis based on curriculum benchmarking are shared. The other two important dimensions of the curriculum development viz. outcomes-based education (OBE) and student placement perspective are presented. Finally, the salient features of the curriculum and structure are presented.

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1. Introduction and Literature review

The evolution of the knowledge economy and the need for exploiting advancements in engineering sciences for commercial benefits have shifted the focus from undergraduate to postgraduate level education in engineering and technology.

Engineering and technology are significantly contributing in various sectors like manufacturing, banking and finance, agriculture, automotive, pharmaceuticals, defence, service and many more that are important from a national development perspective. The number of students aspiring for post-graduation in engineering has seen a rise in recent past. There are about four thousand colleges in India which are offering PG programs in engineering and technology (www.aicteindia.org). The success of any educational program largely depends on the design and effective implementation of the curriculum. The curriculum is the formal mechanism through which intended educational aims are achieved (Heywood, 2005). Curriculum development for any educational program is one of the keys and fundamental academic processes and thus the challenges encountered, experiences, philosophies proposed and research findings of the process need to be documented to serve as guiding path for future endeavours.

Parashar and Parashar (Parashar and Parashar,

2012) have suggested the strategies for the development of education in line with modern trends in curriculum issues. Visscher-Voerman and Muller (Visscher-Voerman and Muller, 2017) have proposed Twente Education Model (TOM) which is a curriculum model implemented in the University of Twente and after three years of implementation the evaluation data were presented. Patil and Kumbhar) presented the journey of curriculum development of Automobile Engineering undergraduate program at an autonomous engineering institute (Patil and Kumbhar, 2018). Decision-making process according to the requirement of United States accreditation for redeveloping senior projects and capstone courses have been presented in (Buchanan and Mehrabian, 2016). Also, they discussed various issues related to curriculum development in engineering and technology education. Prasad (Prasad et al., 2018) presented the development of engineering curriculum based on educational theories.

Though some literature on curriculum development of engineering programs is available, the literature addressing curriculum development of postgraduate engineering programs seems scarce. This work makes an effort to present the case study on curriculum development of a postgraduate Automobile engineering program at RIT. The requirements of a typical PG engineering program have been highlighted. The recently introduced framework of AICTE model curriculum for PG programs is introduced. The findings of analysis based on curriculum benchmarking are shared. The other two important dimensions of the curriculum development viz. outcomes-based education (OBE) and student placement perspective are presented. Finally, the salient features of the curriculum and structure are presented. The curriculum structure of the program is appended for reference in the Appendix section.

2. Requirements and challenges of typical Engineering PG program

Typical engineering post-graduate programs in India are research intensive, two-year duration programs which aim at specialization in an engineering stream. The students are exposed to theory courses in the first year while they work on a research problem and submit their dissertations in the second year of the program. National Board of Accreditation (NBA) of All India Council for Technical Education (AICTE), the apex body for technical education in India has listed eleven Program Outcomes (POs) to be demonstrated by a typical postgraduate student at the time of obtaining the coveted degree. Any engineering postgraduate program must emphasize on following.

- Domain specialization
- Focus on research and independent learning
- Higher order learning: application /design / analysis /evaluation
- Creativity/innovative approach towards problem-solving

Though these aspects are embedded in the NBA prescribed POs, the major challenges are faced while ensuring integration of these outcomes during the curriculum development, addressing them during the course delivery and again ensuring that the evaluation framework is designed so that the evidence for outcomes achievement is recorded.

3. AICTE model curriculum for PG programs

AICTE has published 'Model Curriculum for Postgraduate Degree Courses in Engineering & Technology' for various streams in January 2018. Advanced study of specialization through core subjects, flexible and diverse program-specific electives, open electives to widen skills, enhanced engagement of industry in developing innovations and problem solutions; and focus on development of advanced knowledge and specific skills required for industrial development have been mentioned as distinct features of model PG curriculum in Engineering and Technology [1]. This model curriculum has incorporated various elements like core courses, program electives, open electives, seminar and mini-project, audit courses and dissertation to provide an engaging experience to the students of post-graduation. Though model curriculum for Automobile Engineering postgraduate program is not available, curricula for mechanical design engineering and mechanical thermal engineering specializations are available in the published document. These curricula and guidelines are referred during formulating the curriculum for PG Automobile Engineering program.

4. Curriculum benchmarking

The present curriculum of post-graduate Automobile Engineering program was benchmarked with curricula of similar programs being offered by other Indian reputed institutes/universities. As such, the present curriculum at RIT was compared with four reputed programs based on certain parameters. The details of this benchmarking exercise are presented in Table 1.

Table 1. Bench marking based on curricula structure

Sr. No.	Parameter	Curriculum			
		A	B	C	RIT
1	Total no. of credits	73	83	73	68
2	No. of theory courses	12	12	11	11
3	No. of laboratory courses	8	4	6	6
4	Credits for Mini-project, if any	4	NO	NO	2
5	Credits for seminars	0	2	2	2
6	Credits for dissertation work	16	26	24	26
7	No. of contact hours in FY	59	58	57	50
8	Declaration of course outcomes	YES	YES	YES	YES
9	Total no. of units	4 TO 6	8	4 TO 6	6
10	No. of opportunities for program electives	11	5	4	4
11	No. of opportunities for interdisciplinary electives, if any	NO	NO	NO	NO
12	Inclusion of course on technical communication	YES	NO	NO	YES
13	Inclusion of course on Mathematics/Computational methods	YES	NO	YES	YES
14	Inclusion on course on humanities	NO	NO	NO	NO
15	Opportunity for field training/internship	NO	NO	NO	YES
16	No. of days/weeks for an internship	NA	NA	NA	Two weeks

This comparison provided valuable insights for some important parameters like a number of opportunities for elective courses (program and interdisciplinary), availability of course on mathematics and so on. Following observations are made based on the curriculum benchmarking exercise.

- The number of credits and contact hours for the whole program varied from program to program. However, the number of credits in every case was found to be more than the number of credits prescribed by AICTE model curriculum i.e. 68 credits in total.
- The number of theory courses being offered was nearly the same. However, the number of laboratory courses varied from 4 to 8.
- The Mini-project element was found to be missing from two curricula as these were relying on more traditional 'Seminar' element.
- Though every program was offering opportunities for program electives, there does not seem to be an opportunity for interdisciplinary electives.
- The course on engineering mathematics was being offered by all programs except one.
- The course on technical communication was being offered by two programs only.
- The opportunity for field training/internship, though of small duration was not being offered except RIT.

The course instructors were requested to benchmark the course content of their respective courses and revise if necessary.

5. Other dimensions of curriculum development: OBE and student placements

Outcomes-based education and student placements are important perspectives to be considered during designing the curriculum of any engineering program. It is implied that OBE based curriculum shall enable the students to demonstrate adequate competency levels desired by the industry and hence result in student placements. The typical approach adopted at RIT for curriculum revision is illustrated with the help of Fig. 1.

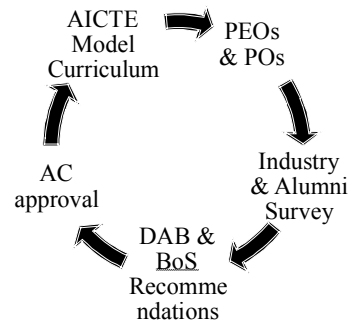

Fig. 1 General approach adopted for curriculum revision at RIT (Patil and Kumbhar, 2018).

Thus, the curriculum being revised was presented before the BoS (Board of Studies) members comprising representation from industry, academia and alumni. The inputs in the form of comments were especially useful for finalizing the course contents of the program and deciding the program electives of relevance. As seen in Fig. 1, the course structure was presented before the Academic Council (AC) for further revision and approval. The feedback from Training and Placement Officers (TPOs) was also requested during the process to ensure the mapping of particular industry requirements.

6. The curriculum of M. Tech. Automobile Engg. program at RIT

In keeping with the above-mentioned PG program requirements, AICTE model curriculum guidelines and industry expectations, the curriculum for a post-graduate program of Automobile Engineering at RIT was revised and being implemented for the academic year 2018-19. Appendix section presents the structure of this curriculum. The salient features of the curriculum are as follows:

Table 2. Comparison of curriculum credits

Semester	AICTE model curriculum credits	Revised curriculum credits
I	18	18
II	18	21
III	16	13
IV	16	16
Total	**68**	**68**

I. There are two slots for program electives per semester and four throughout the year. The students can opt for the elective course of their choice.

ii. As per the AICTE model curriculum, a course titled 'Advanced Mathematical Methods in Engineering' is incorporated which shall help build mathematical foundation required for advanced engineering domain courses.

iii. An audit course on technical communication is to be delivered for addressing oral and written technical communication issues of the students. This course shall help them present their research findings in verbal and written form in front of the scientific community.

iv. An audit course titled 'Industry internship' is planned in between first and second year with the objective to expose the students to industry environment, culture and professional practices.

v. A course titled, 'Innovation based Mini-Project on Automotive Element/Systems' is designed for encouraging innovation-based problem-solving skills among the graduates.

vi. 'Seminar' course though not a new, helps students develop the literature review and report writing skills.

vii. Research methodology and IPR' introduces the students to the process of research in general as well as research tools and methods so that they address the research problem systematically.

viii. The MOOC in the third semester is proposed with a view that students shall use a relevant online course so as to build theoretical background for the research problem or learn a research tool required for carrying out the research. It shall promote independent learning as well.

ix. The number of credits and contact hours for the program follow the AICTE model curriculum guidelines. Table 2 compares the revised curriculum with AICTE model curriculum.

7. Discussion

The curriculum under consideration offers a variety of choices to the students in terms of program elective courses. It makes to an effort to ensure a balanced mix of domain 'MUST' courses and choice-based courses. However, it is a difficult task to accommodate all domain-specific courses under 'MUST' category within the framework of a total of maximum five courses per semester and the choice of such courses is subject to diverse opinions and point of views across the section of stakeholders. This becomes especially true since a course on mathematics and research methodology needs to be accommodated in the structure and rightly so when looking at the relevance of these course for postgraduate engineering student's requirements. The program electives offer a good opportunity to introduce modern relevant courses in the curriculum. However, the faculty expertise and lack of supporting infrastructure like laboratory equipment, software limit the potential of these courses to be actually delivered in the classroom. In many institutions, the postgraduate and undergraduate program is usually shared by the faculty members. The limited number of

faculty members eligible for postgraduate teaching and their occupancy with undergraduate program puts the constraint on a logical grouping of courses across the semesters. Though the present curriculum offers choices in the form of program electives, it does not offer the opportunity for interdisciplinary learning through institute electives. Earlier versions of the curriculum at RIT though offered such opportunities. The curriculum under consideration makes an effort to meet the requirements as mentioned in section 2 and stands well in comparison with benchmarked curricula. It derives relevant and important inputs from the industry and academic experts through the structured process. However along with the design of the curriculum, its effective delivery and implementation is the key to attaining the desired outcomes.

8. Concluding remarks

An effort of curriculum development of the post-graduate program in Automobile Engineering at an autonomous institute is presented in this work. The present curriculum is benchmarked with the curriculum of similar programs offered by institutes of repute. It is ensured that the curriculum adheres to the framework of AICTE's model curriculum for Mechanical engineering programs. The revisions are made based on feedback from the stakeholders in the form of BoS and AC members. The major features of the program curriculum are listed. It is argued that the program curriculum designed shall deliver the program outcomes and offer students a rewarding research experience. The process described in this work could be adopted for similar post-graduate program curriculum revisions in the future.

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Appendix
First Year M. Tech. (Automobile) (2018-19)
Semester I

Course Code	Course	Teaching Scheme				Evaluation Scheme					
							Theory Marks			Practical Marks	
		L	T	P	Credits	Scheme	Max.	Min. % for Passing		Max.	Min. % for Passing
AUT1013	Automotive Engine Design	3	-	-	3	ISE	20	40	40	--	--
						UT1	15			--	--
						UT2	15			--	--
						ESE	50	40		--	--
AUT1023	Finite Element Methods	3	-	-	3	ISE	20	40	40	--	--
						UT1	15			--	--
						UT2	15			--	--
						ESE	50	40		--	--
PE-I	Program Elective - I	3	-	-	3	ISE	20	40	40	--	--
						UT1	15			--	--
						UT2	15			--	--
						ESE	50	40		--	--
PE-II	Program Elective – II	3	-	-	3	ISE	20	40	40	--	--
						UT1	15			--	--
						UT2	15			--	--
						ESE	50	40		--	--
AUT1133	Automotive Engineering Laboratory - I	-	-	2	1	ISE	--	--	--	50	50
						ESE	--	--	--	50	50
AUT1143	Finite Element Analysis Laboratory	-	-	4	2	ISE	--	--	--	50	50
						ESE	--	--	--	50	50
AUT1153	Engine Testing and Emission Laboratory	-	-	2	1	ISE	--	--	--	100	50
AUT1163	Innovation Based Mini-Project on Automotive Element/Systems	-	-	4	2	ISE	--	--	--	100	50
	Total	12	-	12	18						

Total Credits: 18, Total Contact Hours/Week: 24
ISE = In Semester Evaluation, UT1 = Unit Test-I, UT2 = Unit Test-II, ESE = End Semester Examination

First Year M. Tech. (Automobile) (2018-19)
Semester II

Course Code	Course	Teaching Scheme				Evaluation Scheme					
		L	T	P	Credits	Scheme	Theory Marks			Practical Marks	
							Max	Min % for Passing		Max	Min % for Passing
AUT2013	Vehicle Dynamics	3	-	-	3	ISE	20	40	40	--	--
						UT1	15			--	--
						UT2	15			--	--
						ESE	50	40		--	--
AUT2023	Automotive Drivetrain Design	3	-	-	3	ISE	20	40	40	--	--
						UT1	15			--	--
						UT2	15			--	--
						ESE	50	40		--	--
SHP513	Advanced Mathematical Methods in Engineering	3	-	-	3	ISE	20	40	40	--	--
						UT1	15			--	--
						UT2	15			--	--
						ESE	50	40		--	--
PE-III	Program Elective – III	3	-	-	3	ISE	20	40	40	--	--
						UT1	15			--	--
						UT2	15			--	--
						ESE	50	40		--	--
PE-IV	Program Elective – IV	3	-	-	3	ISE	20	40	40	--	--
						UT1	15			--	--
						UT2	15			--	--
						ESE	50	40		--	--
AUT2133	Research Methodology & IPR	1	1	-	2	ISE	25	40	40	--	--
						ESE	50	40		--	--
AUT2143	Vehicle Testing and Simulation Laboratory	-	-	2	1	ISE	--	--	--	50	50
						ESE	--	--	--	50	50
AUT2153	Automotive Engineering Laboratory – II	-	-	2	1	ISE	--	--	--	100	50
SHP551	Technical Communication	2	-	-	Audit	ISE	--	--	--	50	50
AUT2163	Research Literature Review	-	-	4	2	ISE	--	--	--	100	50
	Total	18	1	8	21						

Total Credits: 21, Total Contact Hours/Week: 27
ISE = In Semester Evaluation, UT1 = Unit Test-I, UT2 = Unit Test-II, ESE = End Semester Examination

Second Year M. Tech. (Automobile) (2018-19)
Semester III

Course Code	Course	Teaching Scheme				Evaluation Scheme				
		L	T	P	Credits	Scheme	Theory (Marks) %		Practical (Marks) %	
							Max	Min % for Passing	Max	Min % for Passing
AUT3013	Industry Internship	-	-	2	Audit	ISE	-	-	P/NP	
AUT3023	MOOC Course	-	-	-	3	ISE	50	40	--	--
AUT3033	Dissertation Phase-I	-	-	8	4	ISE	--	--	100	50
AUT3043	Dissertation Phase-II	-	-	12	6	ISE	--	--	100	50
						ESE	--	--	100	50
Total		-	-	22	13					

ISE = In Semester Evaluation, UT1 = Unit Test-I, UT2 = Unit Test-II, ESE = End Semester Examination

Total Credits: 13, Total Contact Hours/Week: 22

Second Year M. Tech. (Automobile) (2018-19)
Semester IV

Course Code	Course	Teaching Scheme				Evaluation Scheme				
		L	T	P	Credits	Scheme	Theory (Marks) %		Practical (Marks) %	
							Max	Min % for Passing	Max	Min % for Passing
AUT4013	Dissertation Phase-III	-	-	12	6	ISE	--	--	100	50
AUT4023	Dissertation Phase-IV	-	-	20	10	ISE	--	--	100	50
						ESE	--	--	100	50
Total		-	-	32	16					

ISE = In Semester Evaluation, UT1 = Unit Test-I, UT2 = Unit Test-II, ESE = End Semester Examination

·Total Credits: 16, Total Contact Hours/Week: 32