Principles of Elective Design with Industry-Institute Collaboration

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Abstract: Along with core courses, an education program is usually designed with discretionary elective courses for professional advancement. It is naturally inherent that most electives' course contents need periodic apprise to persevere to the state-of-art. The pace at which industries adapt to new technologies is considerably rapid as compared to the teaching and learning that happens at the university. However, an elective design needs an equal role and support to be played by the industry and the institute. This paper proposes the design principles for an elective course, which envelopes from curriculum structure to evaluation methodologies. The principles are outlined to cover the design aspects, selection methodologies for the content and course materials, syllabus division to units, course learning outcomes, teaching pedagogy, industry principles, evaluation methodologies, and course learning attainment. Each principle is presented with an objective and deliberation. The intended principles were applied to the design and delivery of an elective – Semantic Web. The course, which was offered with an industry-institute collaboration, was opted by 125 students in the sixth semester. The paper further presents each of the principles as applied and delivered for the semantic web course. The course attainment with respect to course learning outcomes, student elective opt ratio, and the feedback obtained stand in favor of the proposed model. The principles can be applied to design the elective for enhanced learning experiences and make students industry-ready, which is one of the major objectives for introducing the electives.

Keywords: design, elective, industry, learning outcomes, principles

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1. Introduction

A degree program curriculum customarily has a theory, practical, and project mode of delivery attained through a variety of practices. Contemporary advancements in teaching and learning pedagogy have also introduced variants like tutorials, studio mode classes, project-based learning, etc. Each of the newly introduced segment targets to achieve a blooms level of application, analysis, and beyond. In regards, programs have designed elective courses to instill and enhance skillsets for professional growth. Electives also contribute to personal development (Altunbay, 2018).

Electives are usually offered for various reasons. Along with professional development, it also contributes to numerous other factors. Electives help in understanding a course depth-wise and also go with the breadth horizon to understand interdisciplinary acquaintances. While some electives help one to specialize in a domain of interest, others might help to explore a new area of study. They instill confidence in students by growing their interest in a specific domain. Electives help students to gain a profound perspective contributing to the growth of professional welfares and abilities.

Once students complete all the core courses mandated by the program, they are presented with a set of electives they could opt for. Every university has its own set of objectives for an elective design and offer. From operational, co-curricular strength to performance, they are targeted to discrete fragments. Students are empowered and feel ownership when they opt for a particular course. Electives bring out the state-of-art, open up a fun world, and help students grow.

Having known the importance of electives, universities have a greater responsibility for designing and delivering them effectively. While the core course syllabus remains the same for a few years, electives usually see frequent changes and updates. Especially in the field of engineering, with continuous apprises, elective syllabus demand a recurrent change.

The design of an elective has its own challenges. While the institutes focus majorly on the theory and their principles, industries need the applications and practical know-how. With swift advancements in technology, students need to be elucidated with underlying pedigrees and life cycles where they can adapt the learnings to any forthcoming technological developments. This can be achieved and lead to its success only when an elective is designed in collaboration with institutes and industries. The right principles need to be laid out for the operative realization of the courses.

This paper proposes a design principle model for elective design and delivery. Section 2 presents the literature survey. Section 3 presents the principle model. Section 4 presents a

case study of applying the model to a course Semantic Web and also presents the results and discussion. Section 5 presents the conclusion.

2. Literature Survey

Elective courses are targeted to enhance curricular and co-curricular capabilities directly or indirectly, leading to professional and personal developments (Jie, 2005). Elective courses to enhance retention beyond university have been comprehended, seeking towards learning and academic success (Higbee et. al., 2002). Ample research and study have been carried out on elective considerations; however, several open challenges still need addressing.

Electives have been analyzed with respect to relationships among social-contextual factors, individual differences, and intrinsic motivation. The relationship model has also been validated on different data samples (Ferrer-Caja and Weiss, 2000). The impact of course evaluation has been studied with respect to the training method employed, the trainer, and the student background (Darby, 2006). The choice of electives and their implications have been studied (Ding and Christina, 2012).

On the other end, even students are equally confused about the choice of elective courses. Recommendation systems have been designed to suggest electives to students (Bhumichitr et. al., 2017). Collaborative recommendation systems have been built to recommend the right courses to the students (Ray and Sharma, 2011). Models have also been developed to recommend courses using a hybrid multi-criteria with genetic optimization methods (Esteban et. al., 2020). Fuzzy logic systems have been designed to recommend electives (Adak et. al., 2016). The schedule of electives has been experimented using association rules via optimization algorithms (Susan and Bhutani, 2018). The factors that students consider to register for an elective have been studied as well (Amin et. al., 2009).

Not only the design and delivery, but there are also several other factors that play a role in the course effectiveness evaluation. For elective courses and course selections, real-life curriculum-based timetabling has been investigated (Müller and Rudová, 2016). Student opinions of elective courses in the changing education have been analyzed (Ulusoy et. al, 2012). Leadership elective courses have been offered where the senior students teach the juniors (Patterson, 2013). Interdisciplinary elective courses have been offered to enhance cross-domain knowledge and applications (Versypt, 2019).

Industry institute partnerships for engineering education have been studied and dates back to decades earlier (Tener, 1996). Educational strategies for industrial design have been studied with respect to the graduation project course (Evyapan et. al., 2005). Strategies have been devised to infuse global perspectives and industrial collaboration in engineering education (Jackson et. al., 2010). Industry institute collaborative domain-specific theme-based projects have been offered and evaluated (Patil et. al., 2020). Though there are industry collaborations in many aspects, there is no time-honored model for elective design yet.

With all the mentioned experiments and challenges at hand, the area calls for the right principles to achieve the sought after. Proper planning, feedback, and delivery is the need of the hour.

3. The Principle Design Model

This section details out our proposed model with the design goals, the foundational components of the course design, and the principles derived from the components.

A. Design Goals

The purpose of designing this model is threefold and are listed below:

- To realize the importance of industry collaboration for an elective design
- To design state-of-art electives
- To provide the guiding principles for an elective design

B. Foundational Components

In order to derive the design principles, it is essential to identify the components that are an intricate part of the system and course design. The components identified can be seen in figure 1 below.
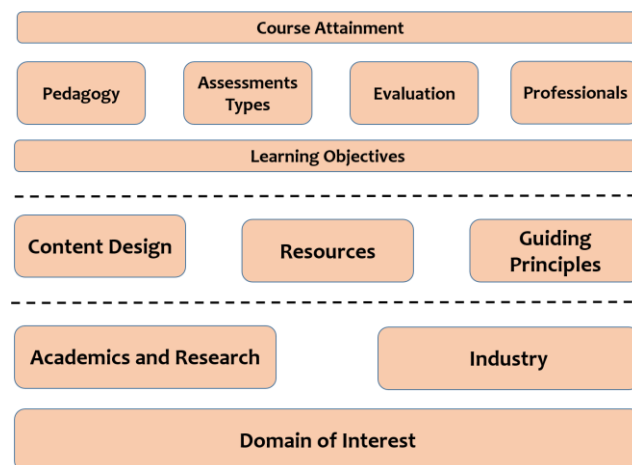

Fig. 1 Course system components

The components can be divided into three layers. In layer 1 is the academic and industry contribution to the domain of interest. In layer 2 are curriculum design, the resources available for curriculum design, and the guiding principles for the design. Layer 3 covers the learning objectives for the course attainment. Layer 3 has an additional component called 'Professionals'. Professionals component is a non-evaluation component that gives the holistic perspective of the course with respect to specialized skills.

C. Elective Design Principles

Following are the laid out principles for the elective design, which were crafted and concluded after six meetings of three hours each. The panel included members from academics and industry. Several course case studies were considered in crafting the principles. The key components can be seen below in figure 2.
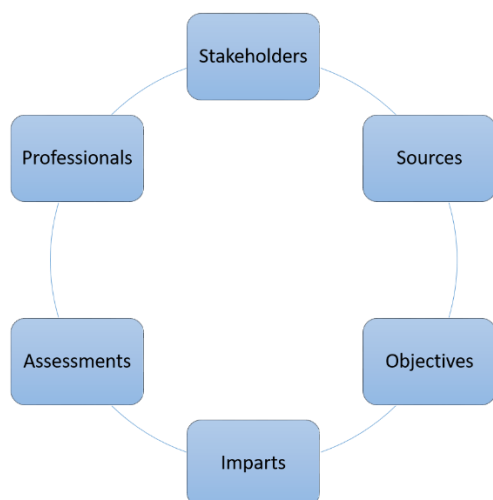

Fig. 2 Key components of principle design

1) *Principle One – all stakeholders are equal:* If there are three stakeholders contributing to the syllabus design, then all of them play an equal role. If not equal, then they are not the stakeholders. A syllabus has to be a proper balance of each individual component. Each stakeholder has a specific role-play, typically coming either from industry or academics. Examples include theoretician, researcher, application developer, associate engineer, etc.

2) *Principle Two – sources are beyond the books:* Textbooks are not the only means of reference. There are industry case studies, research papers, applications, and many others that can be looked for. There are always more resources than we actually see and know of. The compartmentalization of the syllabus also plays a major role. A syllabus designed must never be cent percent theory, nor cent percent applications.

3) *Principle Three – objectives are atomic:* course learning objectives must be written by keeping in mind the pedagogy, assessment, and attainment. They must not be sentences that drift with dangling and weasel words. Every objective must aim to reach a learning taxonomy.

4) *Principle Four – impart abstractions:* a course should not only explain a concept but explain the guiding principles for the future scope. Delivery methods and modes have to be appropriately decided based on the course content and relevance.

5) *Principle Five – assessments for inclusive learning:* written exams and quizzes are not the only ways of assessment. Every elective must adapt to the effective measure of evaluation than the one employed for the

traditional courses. An elective might require an on-filed evaluation and another a project-based learning. Also, it is not necessary that every component of the course needs to be assessed and considered for the evaluation.

6) *Principle Six – the professional paradigm:* an elective must connect and comprehend professional growth. After completion of the course, the student must carry the required course attitude and culture.

4. Semantic Web - Case Study
The School of Computer Science and Engineering of KLE Technological University has introduced elective subjects in the Engineering curriculum from the sixth semester onwards. These elective subjects are categorized into domains as web-based engineering, system engineering, data engineering, and network engineering. The electives in each domain are revised every academic year with the inputs given from the Board of Studies to keep the syllabus up-to-date with the industry standards and expectations. The students have the option of choosing their interested domain. This choice of the domain gives students the freedom to explore the area of interest. It does not restrict the learnability of students to a specific subject.

An elective 'Semantic Web' was designed in collaboration with KLE Technological University and Knit Arena Software Research and Services Private Limited. The elective was offered for sixth-semester students under the data engineering category for three credits. The course had 40 hours of the syllabus to be delivered. The elective was opted by 125 students and relatively graded. This section walks through from the course design to course attainment as per the discussed principles in section 3.

A. Objective
The household discussion in the community is that the semantic web is dead. But in reality, the fact is that after machine learning and artificial intelligence took over, it gave a new perception to the web. The current conceptual understanding is obsolete, but the web certainly requires semantics. It needs to now tailor according to the platform set by learning and intelligence

The objective of designing this elective was to bring out the principles of the semantic web, discuss on what failed and then inspire to build models for the contemporaneous web demands. The course aimed to impart the principles required to build a better web for tomorrow. The stakeholders identified were semantic web researchers, instructors from web technology courses, and developers working on semantic web applications.

B. Curriculum Design and Delivery
The curriculum was designed jointly by the institute and industry. There were two in-person meetings and more online discussions carried out for the purpose. Resources like textbooks, research papers, case studies, start-ups on the domain, applications, etc., were considered. Even

technologies that are obsolete and are considered a failure were made part of the syllabus. In consideration of the academic delivery structure, the course was divided into three units.

Unit I was designed to cover the semantic web principles, tools, and techniques. The unit aimed to provide the literature survey. Unit II was designed to cover the state-of-art needs and challenges deliberated by industry. The syllabus also included research papers and societal challenges. Unit III covered the applications and shed light on future models that are needed to realize a meaningful semantic web.

C. Course Learning Outcomes

The Course Learning Outcomes (CLO's) designed for the course are listed in Table 1.

Table 1. CLO's for the Course

CLO id	CLO
CLO1	Examine and analyze data and its properties for the semantic web
CLO2	Explain the need to understand data, express and use it for the semantic web
CLO3	Investigate and explain the tools and models to work with semantic data
CLO4	Compare and analyze the semantic web principles with state-of-art tools, techniques, and principles
CLO5	Realize models for the semantic web.

Each of the above CLO's was mapped to program learning outcomes. For each CLO, in order to measure the attainment, a threshold and target were set. The threshold was set for each CLO depending on the complexity and level of assessment. The target indicates the percentage of students, and it is a common number set across all the CLO's. Table 2 presents the target and threshold for each CLO. As an example, the numbers can be interpreted as 75% of students must score 65% or more marks allotted for CLO5.

Table 2. CLO Threshold and Target

CLO id	Threshold	Target
CLO1	70%	75%
CLO2	60%	75%
CLO3	60%	75%
CLO4	65%	75%
CLO5	65%	75%

The assessment was premeditated to be evaluated on the following basis: if the set target is achieved as per table 2, a number of 3 is scored. If it is 10% less than the set, a number of 2 is scored. If 55% of students score the set threshold, then a number 1 is scored. Anything lesser is scored to 0.

D. Delivery Modes

The delivery of the syllabus employed several methods. Powerpoint presentations were used for limited concepts and as a mode to present and discuss the case studies. There were classes that were conducted in studio mode and involved brainstorming, discussion, and critique of the learned concepts.

Industry lectures were scheduled and delivered especially to cover unit II. Paper reading sessions were organized where students in groups read papers, summarized, and critiqued. Students in teams browsed over web applications and prepared a report building new models to adhere to the semantic web principles. There were also sessions conducted discussing social semantics and their effect on technology design. The course takeaway session addressed how the current architecture can be changed to meet contemporary needs (this was designed to attain the professionals principle).

E. Assessments

Assessments were designed based on curriculum design and outcomes to be achieved. A total of 100 marks was split, as mentioned in Table 3 below. Mapping to CLOs is not mentioned in the table as each component had mapping to more than one CLO with respective rubrics.

Table 3. Assessment Parameters and Marks

Sl. No.	Assessment Type	Marks
1	Minor Exam 1	30
2	Open Book Exam	15
3	Coursera Course	05
4	Portfolio Assignment	20
5	End Semester Exam	30
	Total	100

Minor exam 1 was a written exam that covered the Unit I syllabus. As the syllabus covered literature and theory principles, a written exam was conducted. An open book exam was conducted for Unit II as the syllabus had industry contents and delivery. The open book exam was divided into two sessions on the same day. Students had an option to answer one question out of two in both sessions, and each session was of 2.5 hours. Students were asked to complete the course from Coursera 'Web of Data' offered by EIT Digital to get a global perspective on the subject matter. The course had a portfolio assignment which was carried out in teams of 3-4 by taking a real-world problem and addressing the semantic issues of the domain for the modern web. The course also had an end semester examination to provide a holistic theory and application evaluation. However, the end semester exam concentrated on Unit II and Unit III only.

F. Attainment

The overall attainment of all CLO's for the course can be seen in Table 4. The calculation details are as briefed in section 4C.

Table 4. Course CLO Attainment

CLO id	Attainment Score
CLO1	3.00
CLO2	2.36
CLO3	2.11
CLO4	2.29
CLO5	1.87

CLO5 had the least attainment, which was because of the portfolio assignment. As students did the portfolio assessment for the first time, they expressed the need for more clarity in the process. This was a learning for students and the faculty team. The overall course results were satisfactory.

The overall grading of the class can be seen below in Figure 3. Majority of the class was in the range of S to B grades.
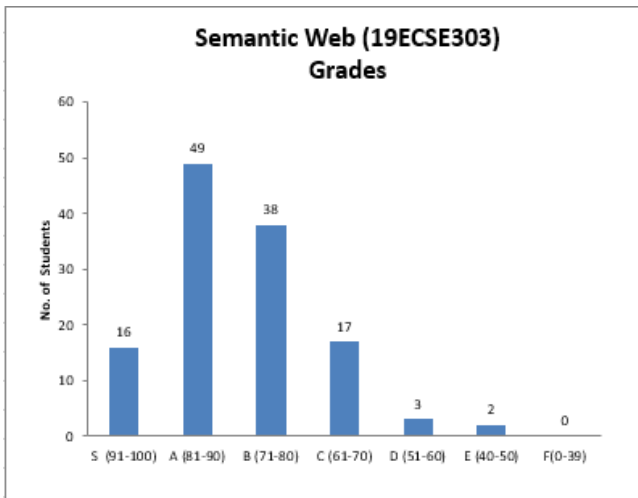
Fig. 3 Overall course grades

G. Closure

A feedback sheet was circulated to students to measure the course effectiveness, and this section presents the results of the feedback. The form data was submitted by 82 students. Students had to rate each question with one of the below mentioned options:

- highly ineffective (1)
- ineffective (2)
- neutral (3)
- effective (4) and
- highly effective (5)

The questions and their respective graphs are presented in the order ahead.

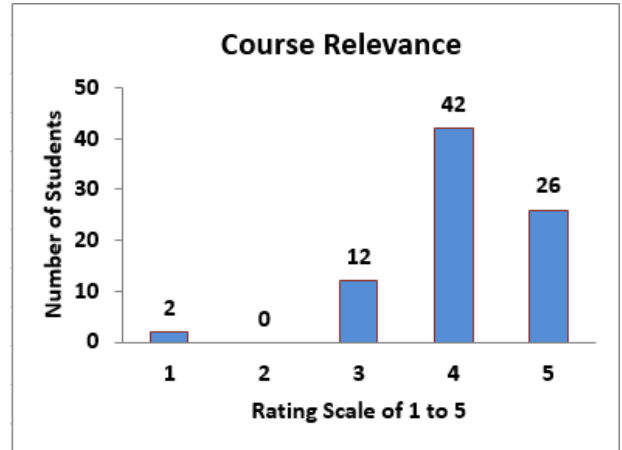Question 1: How relevant/effective did you find the course syllabus?

Fig. 4 Feedback on course relevance

Question 2: How effective was the portfolio assignment?
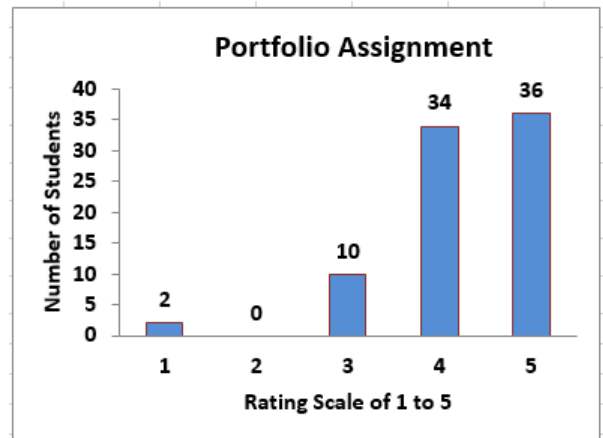

Fig. 5 Feedback on portfolio assignment
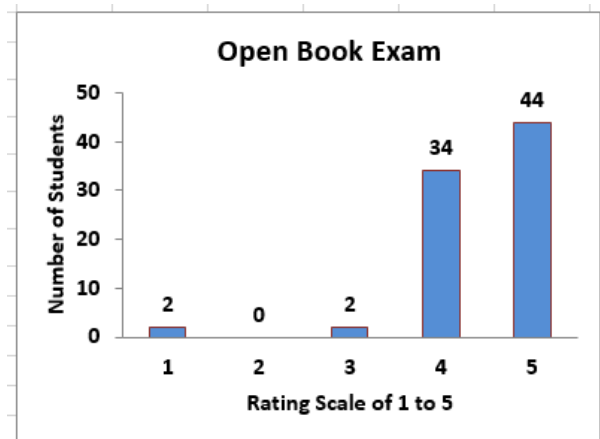
Question 3: Your opinion on open book exam

Fig. 6 Feedback on open book exam

Question 4: The syllabus was not completely based on textbooks but also incorporated industry case studies and published papers. Your opinion.
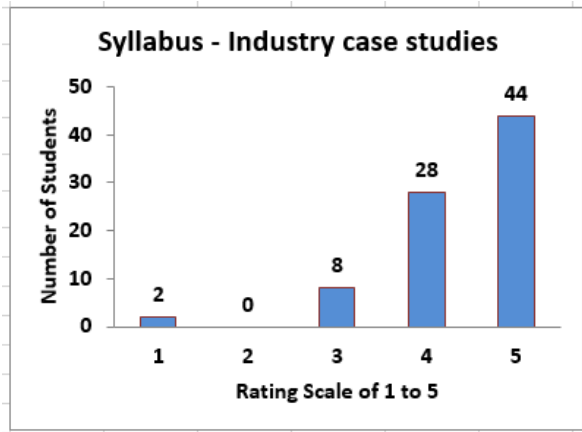
Fig. 7 Feedback on resources

Question 5: Overall course feedback

Fig. 8 Overall course feedback

Question 6: Would you recommend this course to your juniors? (Where 1 was definitely no and 5 was definitely yes)
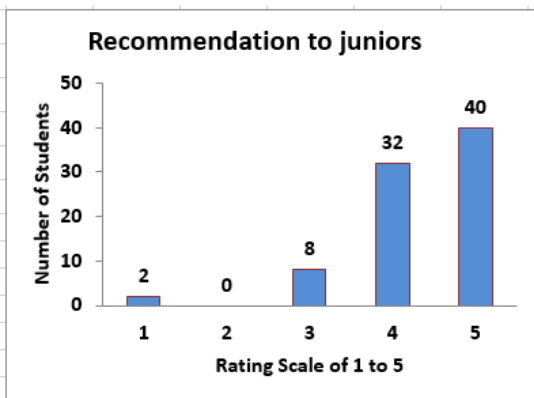

Fig. 9 Course recommendation to juniors

The feedback statistics are self-explanatory, and course delivery was satisfactory with respect to the course attainment and the feedback. Additional text feedback was also collected, where many students requested more industry interaction and case studies. Another significant fact was that the course had the highest registrations as compared to other electives offered during the semester. The feedback obtained for question 6 is an assurance for the trend to continue in the future.

5. Conclusion

Electives play a major role in professional growth and development. This paper presented a principle model for the design and delivery of an elective. The six principles guide through for elective courses design from curriculum to attainment. Elective courses need stakeholders support, and industry collaboration is an essential aid. Be it a small scale or large scale, start-up, or a well-established, an elective designed with conglomerate can promise a better delivery. The partnership not only means in syllabus design but also extends for delivery and assessments. The model proposed promises to be an effective strategy to meet the state-of-art challenges and evolving solicitations.

The principles need validation from different courses and a structured format to guide through and be applicable to other domains. The future scope of this work would involve building a template for each principle with an extendable work log.

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