TEAL2.O ANALYSIS MODEL

Improving Access to Science and Technology Higher Education in Resource-Poor Institutions through an Open Platform for Technology Enabled Active Learning Environment

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INTRODUCTION

This document provides the first technical representation of the TEAL2.O solution. It focuses on clarifying the business model and logic of TEAL2.O and on stipulating the software requirements.

The intended audience for this document comprises the developer teams. The document should be used in conjunction with the TEAL2.O Software Design Document.

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SCOPE OF THE SOLUTION
What Should the System Do?

TEAL2.O should be developed as a comprehensive learning environment allowing for the design and delivery of courses and other forms of training in the area of Science and Technology. The TEAL2.O environment will have features similar to Learning Managements Systems such as Moodle or Canvas, and to online course platforms such as edX or Coursera. However, it will extend its capabilities beyond the functionality available in these systems.

In contrast, TEAL2.O should enable customizability and collaborative development at all stages of the education design and delivery process – at the stage of developing programs, at the stage of developing courses and content, and during the learning process. This will make learning more relevant to institutional requirements and individual learners' needs and capabilities. It will enable effective feedback collection and assessment of learning efficiency. All of these features will be wrapped in an inbuilt evaluation and quality assurance process that will rank programmes, courses, content, teachers, and students based on peer reviews and interaction with the content.

The solution should be a designed as a cloud-based, open-access collaborative teaching & learning platform. It should be open for use by any institution of higher learning. Cloud reliance does not imply the solution is going to be tailored to a specific environment public/private cloud. Instead, TEAL2.O will fully rely on open source, avoiding any undesirable vendor lock-in phenomena.

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GOALS
Business Logic

The TEAL2.O environment should offer:

☐ Access to MOOCs and other digital learning content developed around the globe

☐ Modularity and full customizability, allowing institutions and faculty to design programs and develop teaching content that suit local needs and constraints, including those of underrepresented learners

☐ Autonomous assessment and quality assurance

☐ Integration of open source hardware and software into the learning process to maximize learners' exposure to technology and provide access to virtual labs and experimentation

☐ Enhanced opportunities for collaborative learning and teaching, allowing institutions to pool available expertise and support quality

☐ Learner-cantered education, flexible learning pathways and co-creation on the part of learners

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NON-FUNCTIONAL REQUIREMENTS

☐ **Product Requirements**

Security, performance and usability

The main concerns when developing the TEAL2.O product requirements were **security, performance and usability**. Maximizing quality in this regard was of paramount concern and it dictated all technological choices.

User feedback was taken into account. User feedback and concerns mostly indicated general apprehension towards new and complex systems that would entail a steep learning curve. The situation is compounded by the Covid-19 pandemic which pushed all educational activities into online mode. The TEAL2.O platform was initially envisaged as a platform *supporting* Science and Technology education and thus mostly targeted at technology-savvy and enthusiastic users. In the new situation, the platform is viewed by users and target institutions as a form of *replacement* of classroom learning. As a result, the size and diversity of the user community has grown exponentially. This community now encompasses also users that are less comfortable with habit-breaking tech solutions. It could be expected that within 1-2 years the situation would normalize but there are strong indicators that there will be no full return to the pre-Covid status quo. Rather, online-based course design and delivery will remain a strong alternative to traditional modes of education and will be increasingly integrated into university development plans, in effect creating a truly *blended* course design and delivery process. For the TEAL2.O to be able to serve its new purpose, we need to address the main user concerns – namely an aversion to radically new and complex learning environments – and to avoid creating a backbone, and consequently a learning environment, that requires a long investment of time and effort on the part of both lecturers and students.

This basic non-functional requirement has prompted the team to look for ways to develop the backbone in full conformity with, and within the broader technological framework, of existing Learning Management Systems (LMS) that are widely used and already accepted by users. This would allow us to preserve the habitual user interface that users are already comfortable with, while adding new functionalities and features. The approach would also facilitate the process of involving users in co-creating and further developing the TEAL2.O network through the development of new functionalities and content. The chances of co-creation increase exponentially as familiarity with the framework increases.

At the same time, TEAL2.O is more than a traditional LMS. In addition to creating content, online classrooms and courses, it will also facilitate active collaborative teaching and learning – a feature that is novel compared to any of the existing LMSs. It will incorporate outcome-based education by evaluating progress by measuring the attainment of the outcomes, as well as rank content and processes based on actual student engagement and student attainment of the expected outcomes. There exists no platform that accommodates all of these requirements. TEAL2.O will develop such features. However, the basic elements of the backbone should be grounded in existing LMS frameworks.

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The currently available open LMS development platforms that users have grown accustomed to and largely comfortable with are:

- Moodle
- Totara
- Canvas
- Open EdeX

Our survey of the capabilities of the above open source platforms indicated that Totara is the one that contains the highest number of required features of TEAL2.O. Of course, major features – such as mapping activities/assessments/content to LOs, collaborative learning content creation, enabling collaborative learning and customization of learning content, ranking of learning content based on attainment of LOs, and quality assurance – are missing in it. But it looked like a good starting point. Initially, therefore, we considered modelling the TEAL2.O platform on Totara. Unfortunately, however, further investigation showed that even though Totara is Moodle-based and open-source, the source code is only available to Totara partners or direct subscribers. Integration with a source that is not freely accessible to potential user institutions will derail the usability and accessibility of the TEAL2.O platform. Since Totara is itself based on Moodle, the next best available option for us was to base TEAL2.O on – and integrate it with – Moodle.

Moodle is a free and open-source learning management system written in PHP. It is the world's most popular LMS, with over 160 million current users and over 100 thousand active sites. With an equally large variety of use-cases across those sites, the Moodle LMS is the go-to for anybody looking to run a general/ traditional e-Learning program. Moodle delivers a powerful set of learner-centric tools and collaborative learning environments that empower both teaching and learning. Because of its flexibility and scalability, Moodle has been adapted for use across education, business, non-profit, government, and many other community systems of all sizes. Moodle is freely available for all users. It can be self-hosted. Moodle will be accepted by educators and learners as it will be easy to use. Apart from being fairly familiar already, it boasts a simple and flexible user interface and well-documented resources. It is web-based and features a mobile-compatible interface, making it accessible from anywhere in the world across different web browsers or devices. It has been translated into more than 120 languages and is designed to comply with open and accessibility standards. Because Moodle is *the* big open-source player in the LMS space, it is supported by a massive and active community with tons of plugins and options to customize it to the required specifications. It also benefits from a lot of online documentation for help with development, support issues or questions.

All in all, the features of the TEAL1.O backbone can be developed by adopting a Moodle-based structure. This will guarantee wider user acceptance, fairly good usability, full accessibility and a great degree of security. Integration of the many TEAL2.O elements can be achieved by developing them as plugins to the fully Moodle-based and Moodle-compatible skeleton.

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This technology choice will impose key non-functional requirements – namely **using PHP as the Programming language for Development, and building on Moodle source code.**

Infrastructure

✓ Medium-term infrastructure support

It is recommended to keep the TEAL2.O infrastructure that is used across development, testing and integrated deployment consistent across all participants, across all regions and across all institutions. The TEAL2.O project proposal envisages purchase of on-premises support infrastructure including the following hardware components:

Description	Number of Units	Where	Specifications
Development Servers	3	VIT	Processor: 3.0GHz, 8-Core Intel Xeon E5 with 25MB L3 cache and Turbo Boost up to 3.9GHz Software: Mac Server software Memory: 16GB (four 4GB) of 1866MHz DDR3 ECC memory Storage:256GB PCI e-based SSD Graphics: Dual AMD Fire Pro D700 graphics processors with 6GB of GDDR5 VRAM each Display Support: Three dual-cable 5K display, Six thunderbolt display Connections: USB3-4, Thunderbolt 2- 6, Dual Gigabit Ethernet, HDMI .4Ultra HD Input: Wired Keyboard, Wired Mouse End Point Protector (device control, file tracing, device logging, USB lockdown, DLP) Operating System: Mac OS Sierra
Storage Servers	3	UoP, UoM, IITA	Eight-core Intel Xeon processor. (Xeon Silver 4110), 64GB system memory, RAID 0/1/5/6/10 with controller support up to 8GB cache, Hybrid storage supporting SLC, MLC & TLC flash, Storage Pool should be configured with not less than 5TB usable capacity in RAID 5 using with 1.2TB 10K SAS HDDs. (Hot spare drives are Mandatory). R/W ratio – 70/30 Block Size – 8K, support Async replication and related licenses should be included can replicate 32 volumes per system, HTML5 Web GUI, CLI & REST, support integration with commonly used virtualization and data archival solutions (VMware,vSphere (ESXi) vCenter; SRM, Microsoft Hyper-V)

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Backup Servers	1	AIT

The indicated infrastructure should be taken into account during the development process in order to avoid hardware conflicts. This on-premises support infrastructure should be able to meet the requirements of the TEAL2.O platform for around 10 years starting from the moment when the platform is deployed.

Longer-term solutions may also include using the services of a public cloud provider. It is not expected that a switch to a public service provider would impose any constraints on the technological solution and so it will not affect the development process. The choice of long-term support infrastructure can be made in the course of exploitation, toward the end of the 10-year period.

- ✓ Long-term support infrastructure options

Why choose a Public Cloud Provider?

In the long run, priorities may shift and it may become more reasonable to not spend valuable time in maintaining support infrastructure as such efforts do not provide any value towards expanding the TEAL2.O network. It may also be recommended not to spend valuable time in setting up application servers, databases and keeping the software and operating system updated as again none of these activities contribute towards expanding the TEAL2.O network. If priorities are so re-aligned, it may be recommended to just focus on functional code and leave all non-functional aspects to an external provider of support infrastructure.

Based on the comparison provided below, the following long-term infrastructure options exist: Public cloud IaaS (Infrastructure as a Service), PaaS (Platform as a Service), SaaS (Software as a Service) and FaaS (Function as a Service).

Which Cloud Provider to Use?

There are several factors to be considered before deciding on a preferred Cloud Provider:

1. Completeness of the vision of Cloud Patterns
2. Ability to execute and keep up with the latest trends
3. Provision of complete coverage of services during development and beyond
4. Provision of quick starts, patterns and solutions out of the box

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5. Provision of consistent management of Cloud resources regardless of whether the resources are deployed via portal, command line or SDK
6. Provision of a lightweight contained environment construct that can be used to manage separate budgets across teams, separate components and role-based access for each component
7. Provision of a consolidated hybrid environment where Cloud and on-premise components can be easily integrated, should we chose to go in that direction.

As of the current status-quo, out of all Cloud Providers, obviously AWS, Microsoft Azure and Google Cloud are the market leaders. In terms of (1) and (2) above AWS and Microsoft Azure leads well ahead of Google Cloud according to Garners Report as IaaS Provider. Both AWS and Azure provide (3) and (4) in a comparably matured way, so these requirements are not significant when choosing between AWS and Azure. For (5), (6) and (7), Microsoft Azure leads the way and AWS is still catching up. In (5) for example, ARM (Azure Resource Manager) is architected well to suit all type of deployment, whereas AWS's Cloudformation only works if the initial deployment is done via Cloudformation; thus, for new users of AWS this creates steep learning curve. In (6), Azure Subscriptions and Azure Resource Group provide a lightweight construct to manage separate budgets and separate contained environments, while the AWS account provides the same but comes with the overhead of managing multiple accounts. In (7), Microsoft born on-premise and now focusing on moving to Cloud, the ecosystem in Azure caters for most of the on-premise scenarios and even provides the capabilities and services to host applications and databases on-premise and expose them securely into Azure environments. AWS on the other hand is born in Cloud and is hence focusing only on migration from on-premise to Cloud rather than on running Hybrid solutions.

On the basis of these considerations, the more reasonable choice would be Microsoft Azure – with an account for the entire project/platform, a subscription for each partner so that it can manage its budgets and a resource group for each component in the component test environment. However, since we are discussing a long-term solution and technological options are quick to change, a similar analysis needs to be made around the 6-7 year mark after the deployment of the TEAL2.O platform.

☐ Organizational requirements

Tools for development

Developer teams are required to use the following development tools:

Git

Installing Git on your computer and setting up can be found here. It will be used for version control.

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Apache + PHP

Based on your system, you can install Apache2 and PHP.

- Debian: LAMP
- OS X: Mountain Lion Server
- Windows: Apache2 + PHP
- PHP Extensions and libraries
- Enable SSL for Apache (Transitioning to HTTPS)

More information: Installation

Database

Based on you system, setup MySQL Database for Moodle.

Moodle

Manual installation: Quick guide

✓ Moodle Development Kit (MDK)

Only for Linux and MacOS (not available for Windows).

- Setup
- Sample to create some instances

```
mdk create --install --engine mysqli --run mindev users makecourse -n stable_master-mysql
```

✓ Docker

Docker containers provide significant advantages in software development. Docker is an open source platform which is designed to be lightweight and simple. A Docker container is a standardized unit of software used to deploy applications. The containers allow a developer to wrap up an application with all essential parts, i.e. libraries, dependencies, and ship it all out as one package. By doing this, the developer can be assured that the application will run on any machine, regardless of any customized settings. Containers also work in isolation from each other allowing a range of tasks to occur independently.

✓ IDE

You can setup any of the following IDE and use it for development:

- Sublime
- PhpStorm - Setting_up_PhpStorm for Moodle development.

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- Eclipse
- Netbeans
- ViM
  - ✓ Detailed Moodle Setup

More details about Moodle development environment setup can be found HERE.

There is a YouTube channel that shows clips with guides and tips for the Moodle setup.

Support and Collaboration Tools

In a distributed environment, the building of a significantly large platform requires a lot of collaboration and consistent feedback exchange among participants. In the environment needed to create TEAL2.O work is distributed across several regions and several institutions within each region. This setup requires active collaboration during the design and implementation processes. This will create more engagement among all parties and we will get the best out of all developers, while also applying the latest trends, best practices and technology choices that will contribute to the overall quality of the project and will increase the motivation of the participants.

The types of collaborative tools that will be employed in the TEAL2.O development process are:

Documentation and General Task Allocation

Cloud-based Atlassian confluence will be used as it is easy to sign up and it is using matured Wiki-style documentation with concurrent editing enabled. It is Cloud-based, so no maintenance is required.

Software Development Task allocation

The work packages, composed of features, large-sized stories to small stories and individual tasks, all these can be allocated to an individual in any team, so they can be tracked. The **cloud-based Atlassian JIRA** provides clear decomposition from a large domain model to small tasks and can still maintain the hierarchy of all items.

Delivery Methodology

In an uncertain situation, it is recommended to start small and iterate through rather than trying to design everything upfront. It is also absolutely important for all stakeholders to be kept informed of the development of the platform and all tracking towards their final vision.

Therefore, the developer teams will use **Agile, especially Scrum, methodology, with two-week Sprint across all teams, with Sprint start and end dates aligned.** It is also proposed to include the design and refinement work in the Sprint n - 1 and integration and testing work in Sprint n + 1 for the work that is happening in Sprint n.

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Source Control

All source code needs to be maintained in a collection of repositories, so that it is accessible by all participants and everyone gets to contribute towards high-quality code and best coding practices.

It is also important that all code commits are reviewed by at least another person so there is less chance of human error and so that coding consistency is maintained throughout the platform.

We will keep at least two branches of source code. One branch will be used for the stable version and the other one will be for the daily build. The stable version will be maintained by a person after the review of the current version at the end of sprint or per period.

Therefore, the developer teams will use **Git-based Project for the entire platform and repositories for each domain/component/feature.**

Continuous Integration and Continuous Deployment (CICD)

All developed code needs to be continuously integrated with the application server and database and deployed in an environment that is the same as the final environment. This provides early insight into any software bugs and required changes and reduces the risk of deviation from the ultimate vision.

Therefore, the developer teams will use **cloud-based CICD tooling.** It does not require any management other than setting up your own pipelines.

Development Environment

A development environment needs to be dedicated to each component development team so they can continuously develop and test their code without interfering with other teams' development activities.

Therefore, the developer teams will use **cloud-based contained environment for each component development team, as well as managed roles and groups that are respectively associated with each component and team.** This will give flexibility for a team to be involved in one or many components.

Component Test Environment

The component test environments are needed to make sure any component can be deployed and tested in the same way as it is developed, and to make sure that there are no environment-related issues present before it gets promoted to next level for an end-to-end testing.

Therefore, the developer teams will use **cloud-based contained environment per each component across the platform**, so this is always kept functional and updated during the development process.

Integrated Environment

This is the final environment where all components expected to be integrated and all the completed components of the entire platform are always kept functional. It is expected that this environment

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will act as a gluing environment over the component environments unless a copy of component environments is required for different types of testing such as user acceptance, partnership testing, performance testing, etc.

Therefore, the developer teams will use **cloud-based contained environment with specific roles assigned for each type of activity and these roles may or may not be assumed by the developers who developed the component.** It is expected that most often a nominated group of people will manage this (instead of the original developers) so it is considered from the user point of view.

☐ External constraints

The main external constraint for the development teams is the need to comply with Moodle standards and documentation. This is absolutely necessary as the idea is to develop all features as Moodle plugins. This will improve their usability and user acceptance. Developer teams will be required to comply with these constraints (consult section "Moodle Integration" in the TEAL2.O Software Design Model).

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☐ Method for representing standards for the specification of Program Objectives (POs) in Alignment with Accreditation accords - Washington Accord/Sydney Accord/Seoul Accord

About program specifications, program objectives and learning outcomes

A program specification contains the aims, objectives or learning outcomes, program content, learning and teaching methods, process and criteria for assessment, usually with indicative reading or other reference material as well as identifying the modules or subunits of the program, setting out core and optional elements, precursors and levels.

Program specifications should make explicit the intended outcomes in terms of knowledge, understanding, skills and other attributes. They should help students to understand the teaching and learning methods that enable the outcomes to be achieved; the assessment methods that enable achievement to be demonstrated; and the relationship of the program and its study elements to the qualifications framework and to any subsequent professional qualification or career path.

Program specifications must give detail information about the program of study and typically include:

- Educational aims of the program
- Intended learning outcomes
- Program structure and requirements
- Support for students and their learning
- Criteria for admission
- Methods for evaluation and enhancing the quality and standards of teaching and learning
- Regulation of assessment
- Indicators of quality and standards
- List of mandatory and option modules
- Capabilities (skills) map

Institutions of higher education (HE) should develop, for each program they offer, a ‘program specification’ which identifies potential stopping-off points and gives the intended outcomes of the program in terms of:

- knowledge and understanding that a student will be expected to have upon completion
- key skills: communication, numeracy, use of information technology and learning how to learn;
- cognitive skills, such as an understanding of methodologies or ability in critical analysis;
- subject specific skills – such as laboratory skills.

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Objective

A very general statement about the larger goals of the course or program. Program learning goals and objectives describe what students will learn, what skills they develop, what experiences they will have (or likely have) as a result of completing the requirements for the degree program.

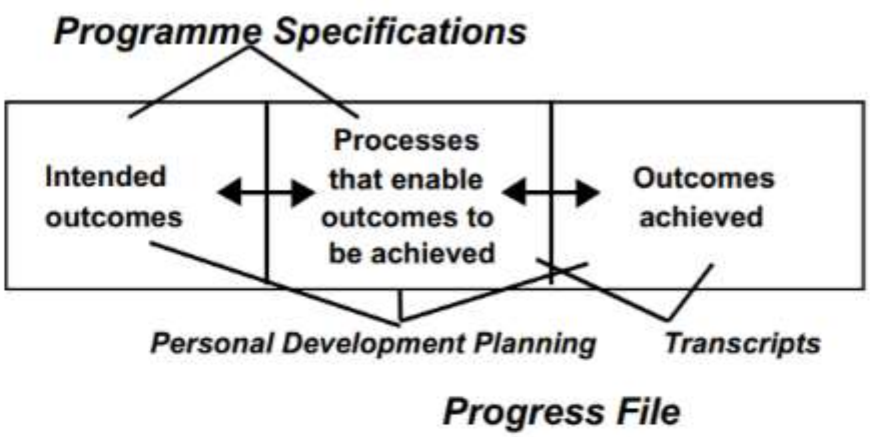
Outcome

A very specific statement that describes exactly what a student will be able to do in some measurable way. A competency may have several specific learning outcomes so a course typically contains more outcomes than competencies.

Competency

A general statement detailing the desired knowledge and skills of student graduating from our course or program.

Objectives are intended results of learning process activities. Outcomes are achieved and measurable results of what was learned.



The program specifications should include clearly the learning outcomes [4].

Standards for the specification of Program Objectives (POs) in different accreditation accords

The standards and guidelines for engineering programs in higher education are generally given by the International Engineering Alliance (IEA). IEA is an umbrella organization for six multilateral agreements which establish and enforce amongst their members internationally benchmarked standards for engineering education and what is termed “entry level” competence to practice engineering. The Alliance, which currently has lead engineering organizations from 23 nations as members (including five G8 and 11 G20 nations), is expanding steadily with China being the latest to apply.

The IEA covers the Washington, Sydney and Dublin Accords.

These accords recognize that the members of the European Network for Accreditation of Engineering Education (ENAEE) operate similar accreditation processes to similar standards within Europe, and its authorized members provide the Eur-ACE label to accredited programs. There is a formal mechanism between the IEA and ENAEE to maximize mutual understanding and potential benefits of the two organizations.

- https://www.ieagreements.org/about-us/key-documents/

The IEA's core activities are:

- Consistent improvement of standards and mobility
- Defining standards of education and professional competence
- Assessment of education accreditation and evaluation of competence
- Participation in activities that are driven from the engineering profession.

The Washington Accord

- https://en.wikipedia.org/wiki/Washington_Accord

The Washington Accord is an international accreditation agreement for undergraduate professional engineering academic degrees between the bodies responsible for accreditation in its signatory countries and regions. It was established in 1989. Its full signatories are Australia, Canada, China, CostaRica, HongKong, India, Ireland, Japan, Korea, Malaysia, New Zealand, Pakistan, Peru, Philippines, Russia, Singapore, South Africa, Sri Lanka, Taiwan, Turkey, the United Kingdom and the United States.

Usually, the Washington accord deals with the professional engineer qualification.

The Washington Accord Knowledge Profile has eight elements

WK1	A systematic, theory-based understanding of the natural sciences applicable to the discipline.
WK2	Conceptually-based mathematics, numerical analysis, statistics and formal aspects of computer and information science to support analysis and modelling applicable to the discipline.
WK3	A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline.
WK4	Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline.

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WK5	Knowledge that supports engineering design in a practice area.
WK6	Knowledge of engineering practice (technology) in the practice areas in the engineering discipline.
WK7	Comprehension of the role of engineering in society and identified issues in engineering practice in the discipline: ethics and the professional responsibility of an engineer to public safety; and the impacts of engineering activity – economic, social, cultural, environmental and sustainability.
WK8	Engagement with selected knowledge in the research literature of the discipline.

The Washington Accord Graduate Attribute Profile has 12 elements, supported by the knowledge profile:

Engineering knowledge	WA1: Apply knowledge of mathematics, natural science, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to the solution of complex engineering problems.
Problem analysis	WA2: Identify, formulate, research literature and analyses complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences (WK1 to WK4).
Design/development of solutions	WA3: Design solutions for complex engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health, and safety, cultural, societal and environmental considerations (WK5).
Investigation	WA4: Conduct investigations of complex problems using research-based knowledge (WK8) and research methods including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions.
Modern tool usage	WA5: Create, select and apply appropriate techniques, resources and modern engineering and IT tools, including prediction and modelling, to complex engineering problems, with an understanding of the limitations (WK6).
The engineer and society	WA6: Apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice and solutions to complex engineering problems (WK7).
Environment and sustainability	WA7: Understand and evaluate the sustainability and impact of professional engineering work in the solution of complex engineering problems in societal and environmental contexts (WK7).
Ethics	WA8: Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice (WK7).

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Individual and teamwork	WA9: Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings.
Communication	WA10: Communicate effectively on complex engineering activities with the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations and give and receive clear instructions.
Project management and finance	WA11: Demonstrate knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work as a member and leader in a team, to manage projects and in multidisciplinary environments.
Life-long learning	WA12: Recognize the need for, and have the preparation and ability to engage in, independent and life-long learning in the broadest context of technological change.

The Sydney Accord

- https://en.wikipedia.org/wiki/Sydney_Accord

The Sydney Accord covers engineering technologist qualifications.

The Sydney Accord was signed in June 2001, by seven founding signatories representing; Australia, Canada, Hong Kong, Ireland, New Zealand, United Kingdom and South Africa.

As with the other Accords, the signatories are committed to development and recognition of good practice in engineering education. The Sydney Accord is specifically focused on academic programs dealing with engineering technology.

Currently there are eleven signatories that make up the Sydney Accord. There are also two organisations that hold provisional signatory status.

Signatories of the Sydney Accord

- Australia - (Engineers Australia, 2001)
- Canada - (Canadian Council of Technicians and Technologists, 2001)
- Taiwan - (Institute of Engineering Education Taiwan, 2014)
- Hong Kong - (The Hong Kong Institution of Engineers, 2001)
- Ireland - (Engineers Ireland, 2001)
- Korea - (Accreditation Board for Engineering Education of Korea, 2013)
- Malaysia - (Board of Engineers Malaysia, 2018)
- New Zealand - (Institution of Professional Engineers New Zealand, 2001)
- South Africa - (Engineering Council of South Africa, 2001)
- United Kingdom - (Engineering Council UK, 2001)
- United States - (ABET, 2009)
- Sri Lanka - (The Institution of Engineers Sri Lanka)

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The Seoul Accord

- https://en.wikipedia.org/wiki/Seoul_Accord

The Seoul Accord is a multi-lateral agreement among agencies responsible for accreditation or recognition of tertiary-level computing and IT-related qualifications.

Signatories: Australia, Canada, Hong Kong, Korea, Japan, United Kingdom, Taiwan, USA, Sri Lanka, New Zeeland, Ireland, Malaysia, Mexico.

The Seoul Accord graduate attributes for Computing Professional, comparative to other two qualifications, are:

	Differentiating Characteristic	… for Seoul Accord (Computing Professional) Graduate	… for Computing Technologist Graduate	… for Computing Technician Graduate
Academic Education	Educational depth and breadth	Completion of an accredited program of study designed to prepare graduates as computing professionals	Completion of a program of study typically of shorter duration than for professional preparation	Completion of a program of study typically of shorter duration than for technologist preparation
Knowledge for Solving Computing Problems	Breadth and depth of education and type of knowledge, both theoretical and practical	Apply knowledge of computing fundamentals, knowledge of a computing specialization, and mathematics, science, and domain knowledge appropriate for the computing specialization to the abstraction and conceptualization of computing models from defined problems and requirements	Apply knowledge of computing fundamentals, knowledge of a computing specialization, and mathematics, science, and domain knowledge appropriate for the computing specialization to defined and applied computing procedures, processes, systems, or methodologies	Apply knowledge of computing fundamentals, knowledge of a computing specialization, and mathematics, science, and domain knowledge appropriate for the computing specialization to a wide variety of practical procedures and practices
Problem Analysis	Complexity of analysis	Identify, formulate, research literature, and solve complex computing problems reaching substantiated	Identify, formulate, research literature, and solve broadly-defined computing problems reaching	Identify and solve well-defined computing problems reaching substantiated conclusions using

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		conclusions using fundamental principles of mathematics, computing sciences, and relevant domain disciplines	substantiated conclusions using analytical tools appropriate to the discipline or area of specialization	codified methods of analysis specific to the field of activity
Design/ Development of Solutions	Breadth and uniqueness of computing problems, i.e., the extent to which problems are original and to which solutions have previously been identified or codified	Design and evaluate solutions for complex computing problems, and design and evaluate systems, components, or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations	Design solutions for broadly-defined computing technology problems, and contribute to the design of systems, components, or processes to meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations	Design solutions for well-defined computing problems, and assist with the design of systems, components, or processes to meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations
Modern Tool Usage	Level and appropriateness of the tool to the type of activities performed	Create, select, adapt and apply appropriate techniques, resources, and modern computing tools to complex computing activities, with an understanding of the limitations	Select and apply appropriate techniques, resources, and modern computing tools to broadly-defined computing activities, with an understanding of the limitations	Apply appropriate techniques, resources, and modern computing tools to well-defined computing activities, with an awareness of the limitations
Individual and Team Work	Role in, and diversity of, the team	Function effectively as an individual and as a member or leader in diverse teams and in multi-disciplinary settings	Function effectively as an individual and as a member or leader in diverse technical teams	Function effectively as an individual and as a member in diverse technical teams
Communication	Level of communication according to type of activities performed	Communicate effectively with the computing community and with society at large about complex computing activities by being able to	Communicate effectively with the computing community and with society at large about broadly-defined computing activities by being able	Communicate effectively with the computing community and with society at large about well-defined computing activities by being able

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		comprehend and write effective reports, design documentation, make effective presentations, and give and understand clear instructions	to comprehend and write effective reports, design documentation, make effective presentations, and give and understand clear instructions	to comprehend the work of others, document one's own work, and give and understand clear instructions
Computing Professionalism and Society	No differentiation in this characteristic except level of practice	Understand and assess societal, health, safety, legal, and cultural issues within local and global contexts, and the consequential responsibilities relevant to professional computing practice	Understand and assess societal, health, safety, legal, and cultural issues within local and global contexts, and the consequential responsibilities relevant to computing technologist practice	Understand and assess societal, health, safety, legal, and cultural issues within local and global contexts, and the consequential responsibilities relevant to computing technician practice
Ethics	No differentiation in this characteristic except level of practice	Understand and commit to professional ethics, responsibilities, and norms of professional computing practice	Understand and commit to professional ethics, responsibilities, and norms of computing technologist practice	Understand and commit to professional ethics, responsibilities, and norms of computing technician practice
Life-long Learning	No differentiation in this characteristic except level of practice	Recognize the need, and have the ability, to engage in independent learning for continual development as a computing professional	Recognize the need, and have the ability, to engage in independent learning for continual development as a computing technologist	Recognize the need, and have the ability, to engage in independent learning for continual development as a computing technician

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The ENAEE – European Network for Accreditation of Engineering Education

- https://www.enaee.eu/eur-ace-system/

Under ENAEE, in 2014 a Mutual Agreement was signed for the recognition of engineering degree programs.

The framework "comprises three cycles (including, within national contexts, the possibility of intermediate qualifications), generic descriptors for each cycle based on learning outcomes, and credit ranges in the first and second cycles".

The overall result of the application of the EQF is a range of Bachelor and Master Degree programs in engineering now offered in European Higher Education Institutions. These are described here in terms of the European Credit Transfer System as follows:

a) Fulltime Bachelor degree programs in engineering are now of 180, 210 or 240 ECTS credits.

b) Fulltime Master degree programs in engineering are of 60, 90 or 120 ECTS credits.

As established by the "Recommendation of the European Parliament and of the Council" of 23 April 2008, the descriptor for the first cycle in the Framework for Qualifications of the European Higher Education Area (Bologna process) corresponds to the learning outcomes for the EQF, level 6. The descriptor for the second cycle in the Framework for Qualifications of the European Higher Education Area corresponds to the learning outcomes for the EQF, level 7.

The Program Outcomes are described here separately for both Bachelor and Master Degree programs with reference to the following eight learning areas:

• Knowledge and understanding;

• Engineering Analysis;

• Engineering Design; • Investigations;

• Engineering Practice;

• Making Judgements;

• Communication and Team-working;

• Lifelong Learning.

Conclusions

Graduate attributes and professional competencies are mutually agreed by all accords – Washington, Sydney and Dublin, under the umbrella of IEA. The European Network for Accreditation of Engineering Education (ENAEE) operates with similar standards within Europe.

- http://www.ieagreements.org.

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The Seoul accord deals with the tertiary-level computing and IT-related qualifications, so it is independent from the above accords.

Typical engineering activity requires several roles including those of the (professional) engineer, engineering technologist and engineering technician, recognized as professional registration categories in many jurisdictions. Each qualification has common standards with the others and different requirements for the competencies.

Differentiating Characteristic	Professional Engineer	Engineering Technologist	Engineering Technician
Comprehend and apply universal knowledge: Breadth and depth of education and type of knowledge	EC1: Comprehend and apply advanced knowledge of the widely-applied principles underpinning good practice	TC1: Comprehend and apply the knowledge embodied in widely accepted and applied procedures, processes, systems or methodologies	NC1: Comprehend and apply knowledge embodied in standardized practices
Comprehend and apply local knowledge: Type of local knowledge	EC2: Comprehend and apply advanced knowledge of the widely-applied principles underpinning good practice specific to the jurisdiction in which he/she practices.	TC2: Comprehend and apply the knowledge embodied procedures, processes, systems or methodologies that is specific to the jurisdiction in which he/she practices.	NC2: Comprehend and apply knowledge embodied in standardized practices specific to the jurisdiction in which he/she practices.
Problem analysis: Complexity of analysis	EC3: Define, investigate and analyze complex problems	TC3: Identify, clarify, and analyze broadly-defined problems	NC3: Identify, state and analyze well-defined problems
Design and development of solutions: Nature of the problem and uniqueness of the solution	EC4: Design or develop solutions to complex problems	TC4: Design or develop solutions to broadly-defined problems	NC4: Design or develop solutions to well-defined problems
Evaluation: Type of activity	EC5: Evaluate the outcomes and impacts of complex activities	TC4: Evaluate the outcomes and impacts of broadly defined activities	NC5: Evaluate the outcomes and impacts of well-defined activities
Protection of society: Types of activity and responsibility to public	EC6: recognize the reasonably foreseeable social, cultural and environmental effects of complex activities generally, and have regard to the need for	TC6: Recognize the reasonably foreseeable social, cultural and environmental effects of broadly-defined activities generally, and have regard to the need for	NC6: Recognize the reasonably foreseeable social, cultural and environmental effects of well-defined activities generally, and have regard to the need for

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	sustainability; recognize that the protection of society is the highest priority	sustainability; take responsibility in all these activities to avoid putting the public at risk.	sustainability; use engineering technical expertise to prevent dangers to the public.
Legal and regulatory: No differentiation in this characteristic	EC7: Meet all legal and regulatory requirements and protect public health and safety in the course of his or her activities	TC7: Meet all legal and regulatory requirements and protect public health and safety in the course of his or her activities	NC7: Meet all legal and regulatory requirements and protect public health and safety in the course of his or her activities
Ethics: No differentiation in this characteristic	EC8: Conduct his or her activities ethically	TC8: Conduct his or her activities ethically	NC8: Conduct his or her activities ethically
Manage engineering activities: Types of activity	EC9: Manage part or all of one or more complex activities	TC9: Manage part or all of one or more broadly-defined activities	NC9: Manage part or all of one or more well-defined activities
Communication: No differentiation in this characteristic	EC10: Communicate clearly with others in the course of his or her activities	TC10: Communicate clearly with others in the course of his or her activities	NC10: Communicate clearly with others in the course of his or her activities
Lifelong learning: Preparation for and depth of continuing learning.	EC11: Undertake CPD activities sufficient to maintain and extend his or her competence	TC11: Undertake CPD activities sufficient to maintain and extend his or her competence	NC11: Undertake CPD activities sufficient to maintain and extend his or her competence
Judgement: Level of developed knowledge, and ability and judgement in relation to type of activity	EC11: Recognize complexity and assess alternatives in light of competing requirements and incomplete knowledge. Exercise sound judgement in the course of his or her complex activities	TC12: Choose appropriate technologies to deal with broadly defined problems. Exercise sound judgement in the course of his or her broadly-defined activities.	NC12: Choose and apply appropriate technical expertise. Exercise sound judgement in the course of his or her well-defined activities
Responsibility for decisions: Type of activity for which responsibility is taken	EC12: Be responsible for making decisions on part or all of complex activities.	TC13: Be responsible for making decisions on part or all of one or more broadly defined activities.	NC13: Be responsible for making decisions on part or all of all of one or more well-defined activities.

In the terms of the learning areas which set up the guidelines for POs of each program specification, a comparative analysis is given in the following table.

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	The Washington Accord program	The Sydney Accord program	The ENAEE European guidelines
Engineering knowledge	WA1: Apply knowledge of mathematics, natural science, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to the solution of complex engineering problems.	SA1: Apply knowledge of mathematics, natural science, engineering fundamentals and an engineering specialization as specified in SK1 to SK4 respectively to defined and applied engineering procedures, processes, systems or methodologies.	EN1: knowledge and understanding of the mathematics and other basic sciences underlying their engineering specialisation
Problem analysis	WA2: Identify, formulate, research literature and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.	SA2: Identify, formulate, research literature and analyse broadly-defined engineering problems reaching substantiated conclusions using analytical tools appropriate to the discipline or area of specialisation.	EN2: identify, formulate and solve engineering problems in their field of study; analyse complex engineering products, processes and systems in their field of study; to select and apply relevant methods from established analytical, computational and experimental methods; correctly interpret the outcomes of such analyses
Design / development of solutions	WA3: Design solutions for complex engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.	SA3: Design solutions for broadly- defined engineering technology problems and contribute to the design of systems, components or processes to meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.	EN3: develop and design complex products (devices, artefacts, etc.), processes and systems in their field of study to meet established requirements, that can include an awareness of non-technical – societal, health and safety, environmental, economic and industrial – considerations; to select and apply relevant design methodologies
Investigations	WA4: Conduct investigations of complex problems using research-based knowledge and	SA4: Conduct investigations of broadly-defined problems; locate, search and select relevant data from codes,	EN4: consult and critically use scientific databases and other appropriate sources of information, carry out

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	research methods including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions.	data bases and literature, design and conduct experiments to provide valid conclusions.	simulation and analysis in order to pursue detailed investigations and research of technical, consult and apply codes of practice and safety regulations in their field of study; • laboratory/workshop skills to design and conduct experimental investigations, interpret data and draw conclusions in their field of study
Modern tool usage / practice	WA5: Create, select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering problems, with an understanding of the limitations.	SA5: Select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to broadly-defined engineering problems, with an understanding of the limitations. (SK6)	EN5: understanding of applicable techniques and methods of analysis, design and investigation and of their limitations in their field of study; • practical skills for solving complex problems, realising complex engineering designs and conducting investigations in their field of study; • ability to apply norms of engineering practice in their field of study
Communication, individual and team work	WA6: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions. Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary	SA6: Communicate effectively on broadly-defined engineering activities with the engineering community and with society at large, by being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions Function effectively as an individual, and as a member or leader in diverse teams	EN6: communicate effectively information, ideas, problems and solutions with engineering community and society at large; • function effectively in a national and international context, as an individual and as a member of a team and to cooperate effectively with engineers and non-engineers.

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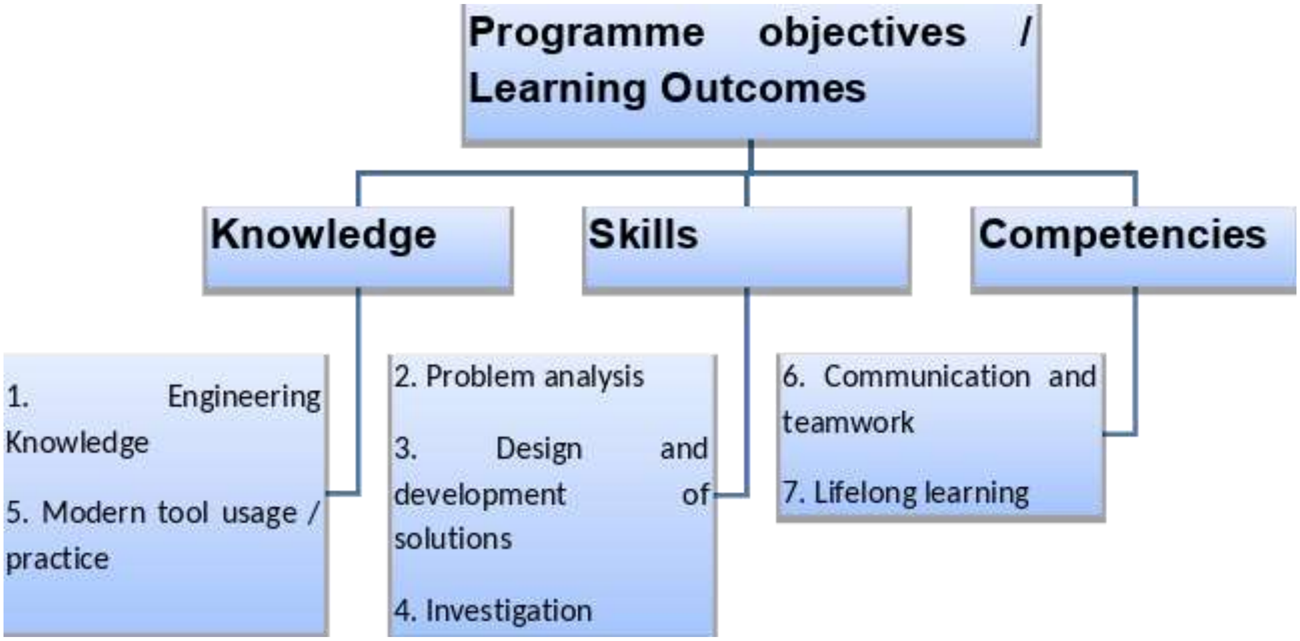
	settings		
Lifelong learning	WA7: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.	SA7: Recognize the need for, and have the ability to engage in independent and life-long learning in specialist technologies	EN7: recognise the need for and to engage in independent life-long learning; follow developments in science and technology.

The program objectives (POs) should be classified in three categories and further subdivided in the 7/8 learning areas, as presented in the following scheme.



PO/LO

Learning outcomes (LOs) have been defined as a statement of what a learner is expected to know, understand, or be able to do at the end of a learning process.

At a basic level the learning outcomes may require learners to be able to define, recall, list, describe, apply, explain or discuss. For a more advanced program the learners may be expected to be able to formulate, analyse, appraise, evaluate, estimate, develop or construct. The verb will usually be followed by words indicating on what or with what the learner is acting and the nature or context of

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the performance required as evidence that the learning was achieved. These additional words also indicate the level of learning achieved.

The EQF classifies learning outcomes into knowledge (facts, principles and concepts), skills (cognitive and practical) and competences (such as ability to take responsibility and show autonomy). In some settings the EQF categories are subdivided further. For example, competence is divided into personal and social competences and in another case: context, role, learning to learn and insight.

LOs must be SMART [5]

References

[1] https://europa.eu/europass/ro/european-qualifications-framework-series
[2] https://www.qualityresearchinternational.com/glossary/programspecification.htm
[3] Allen, Mary J. Assessing Academic Programs in Higher Education. Boston: Anker Publishing Company, 2004.
[4] Jackson, N., Program specification and its role in promoting an outcomes model of learning. Active Learning in Higher Education, 2000, DOI: 10.1177/1469787400001002004.
[5] Valerie L, A Short Primer for Writing Course Learning Outcomes, Seneca, Teaching&Learning, 2015
[6] https://www.ieagreements.org/about-us/key-documents/
[7] https://en.wikipedia.org/wiki/Seoul_Accord
[8] https://en.wikipedia.org/wiki/Sydney_Accord
[9] https://en.wikipedia.org/wiki/Washington_Accord
[10] https://www.enaee.eu/eur-ace-system/

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☐ Method for representing and mapping competencies

Taxonomy based

Blooms/SOLO

Bloom's Taxonomy is a set of taxonomies in three domains of learning, namely the cognitive, affective and psychomotor [1, 2]. The Cognitive Domain in Bloom's Taxonomy consists of 6 cognitive levels of complexity: Knowledge, Comprehension, Application, Analysis, Synthesis and Evaluation. The first three levels are generally referred to as lower levels of thinking and the last three are referred to as higher levels of thinking [1].

The learning processes corresponding to each level can be briefly summarized as:

1. Knowledge - an ability to recall and remember information;
2. Comprehension – an ability to understand and explain concepts;
3. Application – an ability to use information in a new setting;
4. Analysis – an ability to analyse and distinguish parts;
5. Synthesis – an ability put things together and develop a new product; and
6. Evaluation – an ability to judge and justify a decision or point of view.

Bloom's Taxonomy revised in 2000 and the metacognitive knowledge dimension was added. The nouns changed to verbs with the last two cognitive processes switched in the order.

- Remember
- Understand
- Apply
- Analyse
- Evaluate
- Create

Due to its relation to the cognitive abilities, Bloom's Taxonomy can be applied in any discipline. Multiple studies have attempted to integrate and apply Bloom's Taxonomy to the curriculum design to enhance engineering courses or evaluate students' learning [1, 2]. In many cases Bloom's Taxonomy is applied to the development of course learning outcomes. The CDIO Initiative, for example, which is implemented by more than 100 engineering schools worldwide, implements Bloom's Taxonomy for the curriculum and learning outcome development [3].

Bloom's Taxonomy provides a common language to compare and discuss two different subject areas. It helps understand how these areas overlap or can deliver conceptual and practical knowledge concurrently [3]. It also helps to assess the cognitive aspects of the design activities. This makes the taxonomy a good tool for the development of a transdisciplinary design curriculum with emphasis on cognitive development.

Since engineering design education is mostly based on teaching students the basics of engineering and then combining this knowledge in design projects at later stages, a successful synthesis of knowledge

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from first-year to last year courses is essential and can be achieved through application of Bloom's Taxonomy as a common language or unifying foundation. In our case we aim to develop a first-year engineering design course that incorporates Bloom's taxonomy and knowledge from other engineering disciplines in order to be applicable to all departments' curriculums and facilitate students' success in engineering design throughout the later years of their undergraduate studies.

SOLO

A much less known taxonomy of assessing student learning is SOLO, which was created by John Biggs and Kevin Collis in 1982. According to Biggs, "SOLO, which stands for the Structure of the Observed Learning Outcome, is a means of classifying learning outcomes in terms of their complexity, enabling us to assess students' work in terms of its quality not of how many bits of this and of that they got right."

According to Biggs and Collis (1982), there are five stages of "ascending structural complexity." Those five stages are:

- Prestructural - incompetence (they miss the point).
- Unistructural - one relevant aspect
- Multistructural - several relevant and independent aspects
- Relational - integrated into a structure
- Extended Abstract - generalized to new domain

One of the positives sides to SOLO is that it makes it easier for teachers to identify the levels, and therefore help guide students through the learning process.

John Hattie is a proponent of SOLO Taxonomy, and has broken it down to an easier way for students to understand which gives them the ability to assess their own learning. Hattie suggests that teachers can use:

- No Idea - equivalent to the prestructural level.
- One Idea - equivalent to the unistructural level
- Many Ideas - equivalent to the multistructural level
- Relate - equivalent to the relational level
- Extend - equivalent to the extended abstract

These advantages concern not only item construction and scoring, but incorporate features of the process of evaluation that pay attention to how students learn, and how teachers devise instructional procedures to help students use progressively more complex cognitive processes. Both teachers and students often progress from surface to deeper constructs and this is mirrored in the levels of the SOLO taxonomy.

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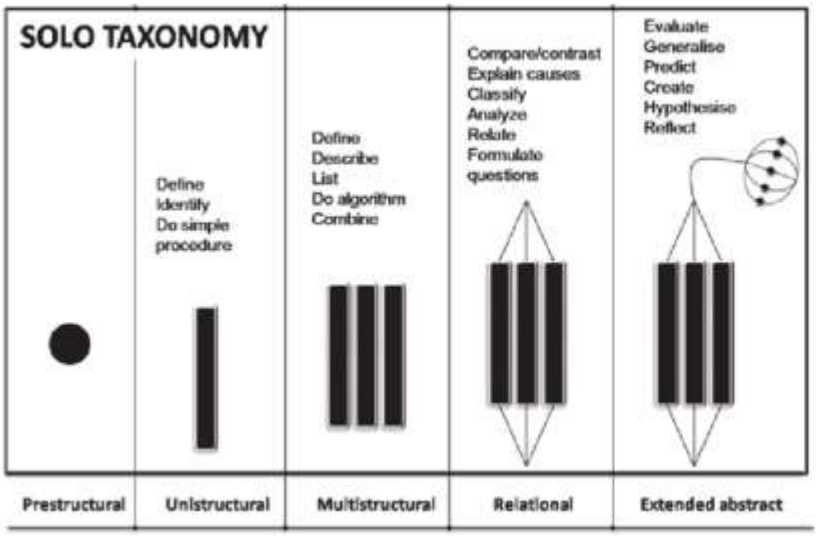
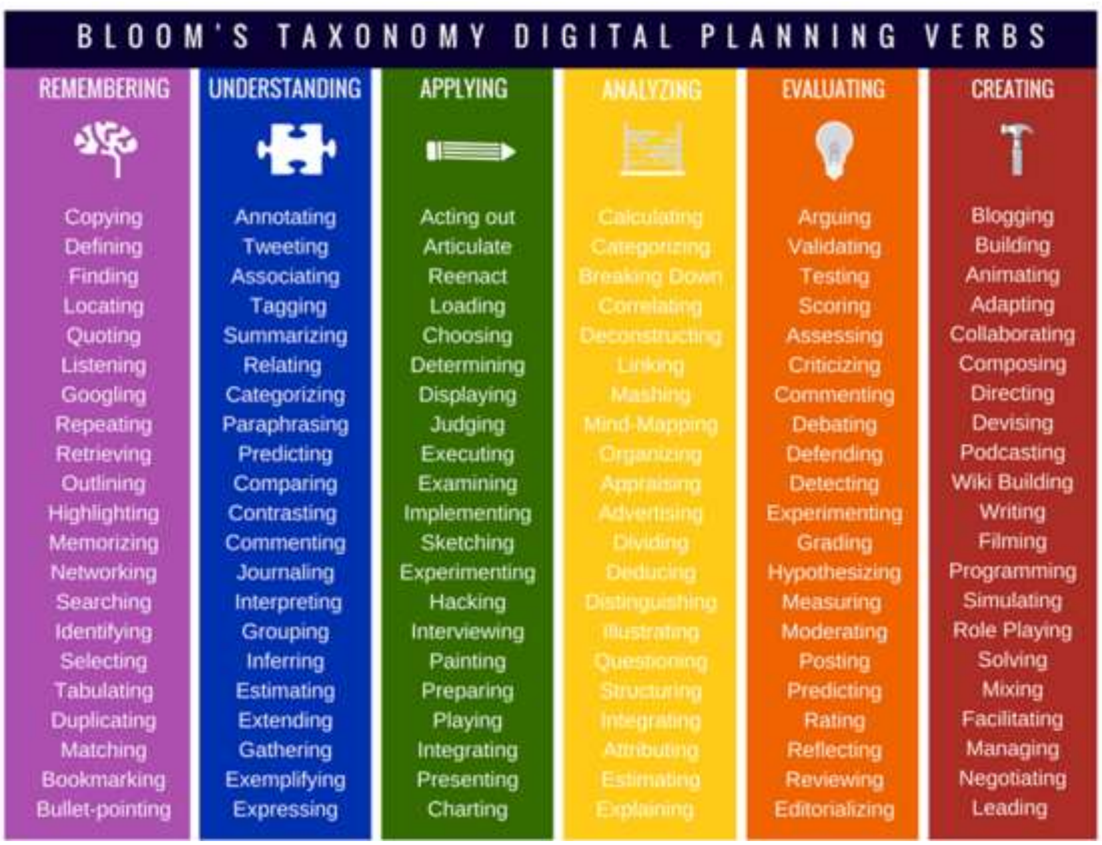


Solo taxonomy [2, 3]



Bloom's taxonomy [3]

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There are several verbs which can be used to define learning outcomes for the different levels of Bloom's and Solo taxonomy (see the figures above). These refer to the behaviour/performance.

Unlike the experience of some with the Bloom taxonomy, it is relatively easy to identify and categorize the SOLO levels.

Similarly, teachers could be encouraged to use the 'plus one' principle when choosing appropriate learning material for students. That is, the teacher can aim to move the student one level higher in the taxonomy by appropriate choice of learning material and instructional sequencing.

Based on technical competencies

- Specification of the breadth and depth of the expected competency
- Mapping depth and breadth of competencies to Program Objectives

In the field of education, concept maps are used as both a learning tool and an evaluation tool to assess student learning. The concept map can be used to:

- Foster meaningful learning by helping create connections between what students already know and new knowledge they acquire
- Organize knowledge around a subject for quick analysis
- Assess students' understanding to see where their knowledge needs improvement
- Conduct effective brainstorming around a topic
- Present complex concepts in an easily digestible way
- Organize instructional material for courses or curricula
- Can be used as a basis for discussion among students
- Help identify valid and invalid ideas held by students
- Help promote creative and critical thinking among students
- Can be used as an alternative to traditional note-taking and writing assignments.

As an example, the relation between capacity, skills and competence can be describe in the table below.

Capacity / Skills / Competence in Industry 4.0 [4-7]

Capacity / Skills / Competence	Purpose
Advanced simulation and modelling of virtual plants [4]	Evaluate a large amount of data from different sources, optimize production, and make real-time decisions. Deploy machine data and functionality in the 'cloud' to facilitate data-driven services to monitor and control

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	production processes. Optimize industrial systems with simulation (virtual plant). The real-time nature of the inputs and outputs of Industry 4.0 makes real-time simulation and plant virtualization indispensable in plant operations.
Interface between humans and machines [4]	Program and act with robots, which must be present throughout Industry 4.0.
Augmented reality system [4]	Generate productivity gains.
3D printing [4]	Manufacturing parts in one step.
Computational engineering [4]	Understand programming logic to contribute to the process improvement.
Real-time inventory and logistics system [4]	Identify and monitor parts and products in the production chain.
Learning factory [5]	Enable practice-oriented learning in an environment close to industrial reality.
Interrelations among electrical, mechanical, and computer components [5] Statistical methods and data analysis techniques [5]	Develop innovative strategies, products, and processes to solve problems of quality.
Process knowledge [6],[7]	Analyse the causes of error and execute quality control of the output products.
Efficiency in decision-making [5]	Solve complex problems more efficiently and in a short time.
Analytical skills [5]	Analyse a large amount of data.
Be able to learn in an autonomous way in order to deal with unknown situations and contexts, updating yourself in relation to advances in science and technology (permanent updating) [6]	Constantly empower (update). Be willing to constantly change / upgrade technology.
Collaboration at a distance [7]	Acting as a member of a team that meets

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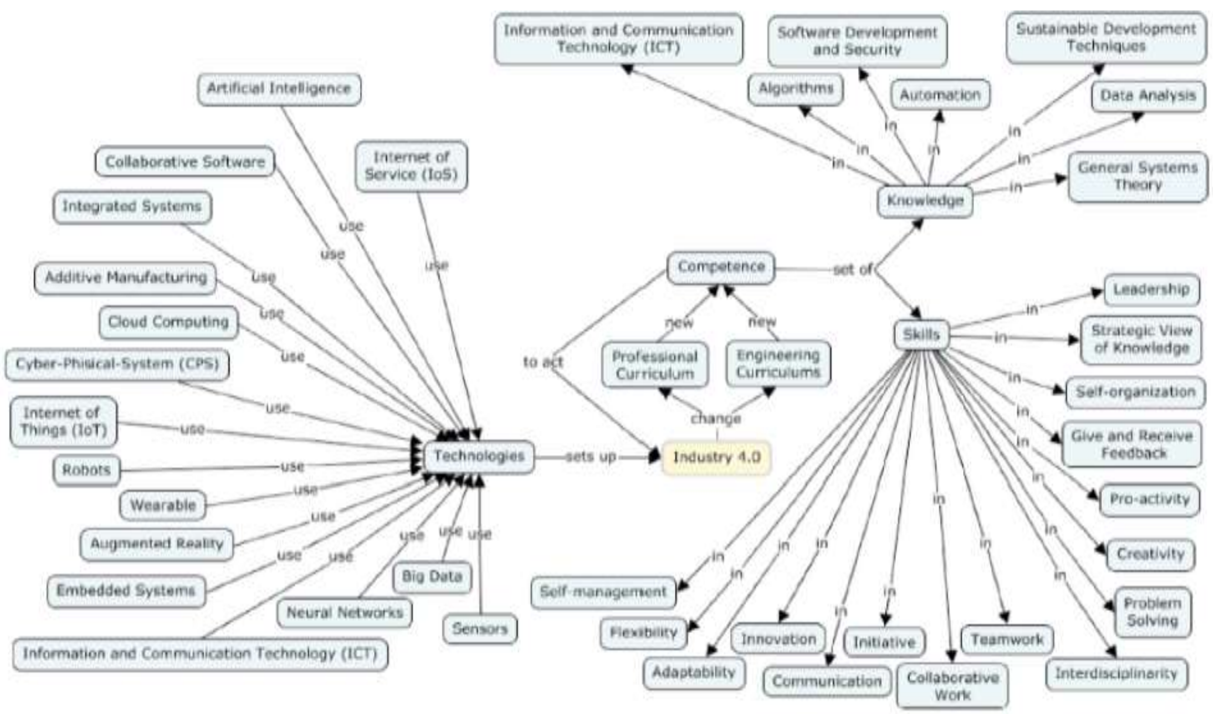
	virtually
Transdisciplinarity [7]	Fully understand at least one discipline, but ability to deal in a language with a wider range of disciplines.

The results of the literature review are highlighted by the set of competencies (knowledge and skills) that must be developed in professional education to accompany the new industrial revolution, as well as the importance of integrating efforts by companies, governments and universities.



Conceptual map [8]

The conceptual map [8] shows that the main competencies needed include skills: (leadership, strategic vision of knowledge, self-organization, giving and receiving feedback, pro-activity, creativity, problem solving, interdisciplinarity, teamwork, collaborative work, initiative, communication, innovation, adaptability, flexibility and self-management) and knowledge of contemporary fields (information and communication technology, algorithms, automation, software development and security, data analysis, general systems theory and sustainable development theory).

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References

[1] Alyona Sharunova, Mehwish Butt, Ahmed Jawad Qureshi, Transdisciplinary Design Education for Engineering Undergraduates: Mapping of Bloom's Taxonomy Cognitive Domain Across Design Stages, Procedia CIRP, Volume 70, 2018, Pages 313-318, ISSN 2212-8271, https://doi.org/10.1016/j.procir.2018.02.042

[2] https://cft.vanderbilt.edu/wp-content/uploads/sites/59/BloomsTaxonomy-mary-forehand.pdf

[3] https://www.edweek.org/education/opinion-whats-our-best-taxonomy-blooms-or-solo/2014/02

[4] https://creately.com/blog/diagrams/ultimate-concept-map-tutorial/

[4] Karre, H., Hammer, M., Kleindienst, M. & Ramsauer, C. 2017. Transition towards an Industry 4.0 state of the LeanLab at Graz University of Technology. Procedia Manufacturing, 9, pp. 206–213.

[5] Sackey, S.M. & Bester, A. 2016. Industrial engineering curriculum in Industry 4.0 in a South African context. South African Journal of Industrial Engineering, 27(4), pp. 101-114.

[6] Erol, S., Jäger, A., Hold, P., Ott, K. & Sihn, W. 2016. Tangible Industry 4.0: A scenario-based approach to learning for the future of production. Procedia CIRP, 54, pp. 13–18.

[7] Abele, E., Metternich, J., Tisch, M., Chryssolouris, G., Sihn, W., Elmaraghy, H., Hummel, V. & Ranz, F. 2015. Learning factories for research, education, and training. Procedia CIRP, 32, pp. 1-6.

[8] Mahlmann Kipper, L., Iepsen, S. et al, Scientific mapping to identify competencies required by industry 4.0, Technology in Society, Volume 64, 2021, 101454, ISSN 0160-791X, https://doi.org/10.1016/j.techsoc.2020.101454.

[9] Benesova, A. & Tupa, J. 2017. Requirements for education and qualification of people in Industry 4.0. Procedia Manufacturing, 11, pp. 2195–2202.

☐ Method for representing course structures

- Technical core/Nontechnical core/Technical electives/Nontechnical electives/Other
- Credit structures

Based on the information from different sources and universities [1-8], to describe a course from a study programme are needed some general data which comes from the curricula and specific data of the course which have to be specified in each particular case, according to the study programme objectives.

The specific data could be categorised as follows:

- Data about the course identification (name, status, evaluation convenor, etc.);

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- Total estimated time and number of credits (lecture, seminar, laboratory, project, individual study etc.);
- Prerequisites (if applicable) curriculum-related and competences-related;
- Facilities required for course development and for seminar/ laboratory/ project development;
- Intended learning outcomes of the course (ILOs)/ Specific competences (professional competences and transversal competences);
- Course objectives (general and specific course objectives)
- Topics to be covered/Contents (for lecture/seminar/laboratory/project including teaching-learning methods);
- Evaluation (lecture/seminar/ laboratory/ project);
- Date when the course is certified/ approved by Department/Faculty board.

A possible block scheme of a course structure which contains all the fields categories are presented below.

<table>
<tr><td>

1. Data about the course identification

- Name of course;
- Study year;
- Semester;
- Name of faculty member responsible for the course/ Course convenor;
- Course status (content);

Depending on the educational system.

For example, in Romania are the following options:

- for the Bachelor level: FC (fundamental course) / DC (course in the study domain)/ SC (speciality course)/ CC (complementary course);

- for the Master level: PC (proficiency course)/ SC (synthesis course)/ AC (advanced course);

- Course status (attendance type);
- Usually are selected one of the following options: - CPC (compulsory course)/ EC (elective course)/ NCPC (non-compulsory course);
- Evaluation type (Exam, Colloquium)

</td></tr>
<tr><td>

2. Total estimated time and number of credits

- Number of hours (total/week), out of which: lecture, seminar, laboratory and project;
- Study of textbooks, course support, bibliography and notes (total):
- Additional documentation in libraries, specialized electronic platforms, and field research (total):
- Preparation of seminars/ laboratories/ projects, homework, papers,

</td></tr>
</table>

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portfolios, and essays (total); ▪ Tutorial(total); ▪ Examinations(total); ▪ Other activities(total); ▪ Total number of hours (all activities); ▪ Number of credits (total and per lecture, seminar, laboratory and project).
3. Prerequisites (if applicable) List of courses or other requirements (skills/competences) that are prerequisites enrolling in the course ▪ Curriculum-related; ▪ Competences-related.
4. Facilities required ▪ For course development; ▪ For seminar/ laboratory/ project development.

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5. Intended learning outcomes of the course (ILOs)/Specific competences
ILOs depend on level of qualification awarded ▪ Competences ▪ Professional competences ▪ Transversal competences
6. Course objectives (resulting from the ILOs/specific competences to be acquired) ▪ General objective ▪ Specific objectives
7. Topics to be covered/Contents ▪ Lecture /teaching methods/no. of hours /bibliography ▪ Seminar / laboratory / project /teaching-learning methods/ no. of hours/ bibliography
8. Evaluation ▪ Exam/Colloquium ▪ Course/Seminar/ laboratory/ project For each is specified: evaluation criteria, evaluation methods and percentage of the final grade.
9. Approvals ▪ Dates when the course is certified/approved by Department/Faculty board.

References

[1] *** USING LEARNING OUTCOMES European Qualifications Framework Series: Note 4, Publications Office of the European Union, 2011, https://www.cedefop.europa.eu/files/Using_learning_outcomes.pdf

[2] *** Internal documents from Transilvania University of Brasov, 2020.

[3] *** Course outline template. University of Calgary - https://www.ucalgary.ca/CTED/LS/outlines/course_outline_template.docx

[4] *** Course Syllabus Template California State University University of Maryland, https://www.csuci.edu/ati/im/faculty/documents/sample-syllabus.doc

[5] *** Syllabus Guidance & Template. University of Maryland. https://tltc.umd.edu/syllabus

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[6] *** Course Outline Template. The University of Hong Kong. https://ar.cetl.hku.hk/pdf/HKU%20CourseOutlineTemplateV1.1.doc
[7] *** Handbook - University of Peradeniya. https://med.pdn.ac.lk/Handbook%202017_18.pdf
[8] *** Syllabus. University of Delhi. http://www.du.ac.in/du/uploads/Syllabus2016/B.E_MechEng.pdf

☐ Method for autonomous mapping of course Learning Outcomes (LOs) to POs

While there is no right or wrong way to handle the mapping process, we understood that each of the approaches below might have strengths and weaknesses of their own. The five levels of mapping learning outcomes are as follow [1]:

- PO-Course mapping
- CO-PO mapping
- Assessments - CO mapping
- Syllabus - CO mapping
- Questions - CO mapping

Level 1: PO-COURSE MAPPING

In this first step, the Learning Outcome is mapped with Program outcomes. Program Outcomes which were earlier referred to as Graduate Attributes specify what we expect from a graduate in his/her 4 years of graduation. In line with Bloom's Taxonomy, this level of mapping lets the Instructor set up threshold value alongside the program learning.

Level 2: CO - PO MAPPING

Aligning program level outcomes with course-level outcomes is the second level of mapping. This level of outcomes mapping focuses on student learning and it allows faculty to create a visual map of a program. It also explores how students are meeting program-level outcomes at the course level.

Level 3: ASSESSMENTS - CO MAPPING

This level of mapping facilitates the alignment of various Assessments with the Courses Outcomes. It represents what students know and will be able to do as a result of the course (at the course level). This level specifies what ways will be used to assess the outcome and what the total student performance on the assessment was (as well as whether the student achieved the desired percentage levels). Lastly, it might specify what the instructor learned from assessing students and how this has altered his/her way of teaching?

Level 4: SYLLABUS - CO MAPPING

This is the main mapping level. It shows how the entire syllabus will be mapped with the Courses in the given course time.

Level 5: QUESTIONS - CO MAPPING

At this level, inquiry learning can be mapped with the courses.

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These five levels of mapping articulate how the curriculum and learning goals match together. As a next step, gathering evidence of student learning follows, which involves determining assessment methods and identifying the measures.

Mapping learning outcomes can have benefits. Here is a list of them.

- It identifies how the required courses add to the achievement of program outcomes
- Expands the student achievement in achieving program outcomes
- Works on reflection by revealing gaps in the curriculum and propagates remedial classes
- The course instructors become fully aware of other courses in which students achieve similar outcomes and can plan their syllabi accordingly. This reinforces outcomes, helps skill/knowledge development, and avoids overlap
- Helps to determine the course prerequisites and program requirements based on how the outcomes fit together
- It shows the logic and overall design of a program and captures the relevance of its courses

[1] https://www.creatrixcampus.com/blog/10-benefits-using-curriculum-mapping-system

☐ Method for Classifying programs - Field/Subject area/PG/UG

Generally, the classification of study programs targets two aspects: the content and organization of the programs on one hand [1,2,3], and ranking the programs in terms of quality, performance and quality management [4,5] on the other hand.

According to [1, 2], two main criteria are used to classify a program. They take into account the field of studies (A), and the level of education (B).

A. Classification of programs based on study field

According to the cited sources, 11 main fields are defined:

00 – Generic programs and qualifications

01 – Education

02 – Arts and humanities

03 – Social sciences, journalism and information

04 – Business, administration and law

05 – Natural sciences, mathematics and statistics

06 – Information and Communication Technologies

07 – Engineering, manufacturing and construction

08 – Agriculture, forestry, fisheries and veterinary

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09 – Health and welfare

10 – Services

Each field is itself divided to several sub-fields, to describe more accurately narrower study areas [3]

B. Classification of programs based on the level of education

Nine education levels are defined:

ISCED 0: Early childhood education ('less than primary' for educational attainment)

ISCED 1: Primary education

ISCED 2: Lower secondary education

ISCED 3: Upper secondary education

ISCED 4: Post-secondary non-tertiary education

ISCED 5: Short-cycle tertiary education

ISCED 6: Bachelor's or equivalent level

ISCED 7: Master's or equivalent level

ISCED 8: Doctoral or equivalent level

They are grouped in three categories: Low education (levels 0-2), Medium education (levels 3-4), and Higher education (level 5-8). Since significant differences can be found between the education systems of different countries, some so-called proxies for the student have to be specified for each study level, to allow comparison of the programs. These proxies include: the age of students, the duration of studies, the minimum entrance requirements, type of documents (diplomas) issued upon successful completion of studies, type/level of studies the graduate are eligible for, the extent to which the program is oriented to a specific occupation or trade.

Some other criteria can be used to classify education programs, but they are not formalized in ISCED Classification. They are only mentioned to emphasize particular features of the programs: Institutional and structural programs. The criterion takes into account the type of institution that provides education services: school-based programs, enterprise-based programs, and mixed school/enterprise-based programs. This classification covers more dimensions, as follows: service provider, mode of service provision, type of participants, and mode of participation.

In terms of higher education, specific criteria can be applied to classify the programs:

- attendance: full time, part time, distance learning,
- duration of studies: 2, 3, 4, 5 6 years (or 4,6,8,10,12 semesters);

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- number of credits: 120, 180, …. Since usually 30 ECTS are allocated per semester, this criterion might not be relevant for programs organized in semesters. However, if a program has another structure in terms of academic year, ECTS can still be a useful criterion.

Within TEAL 2.O, for data handling purpose, an *Identity Card* might be defined for each program. This should have the following specific fields, one field for a classification criterion:

- program title / acronym;
- country;
- university;
- study field (00 ... 10);
- level of education (5 ... 8);
- attendance (1-full time, 2 – part time, 3 distance learning);
- duration of studies (2 ...6);

If a code is associated to each criterion, a unique ID could be bound to each program defined within the project. This might be useful for data handling and classification of the programs within the database. For an easy management of the IDs, some rules should be followed in assigning the codes to each criterion, as shown in Table 5.1

Table 5.1

#	Criterion/field	Type of field	(Max) length	Possible values	Remarks
1	Acronym	C	5		Depends on the full name of the program
	Country	C	2	IN – India SL – Sri Lanka IT – Italy No – Norway Ro – Romania ……..	
	University that delivers the course	N	2	01, 02, 03 ….	To be assigned to each university in the country which use TEAL 2.O
	Study field, according to ISCED	N	2	00, 01, 02, …10	
	Level of education,	N	2	05,06,07,08	

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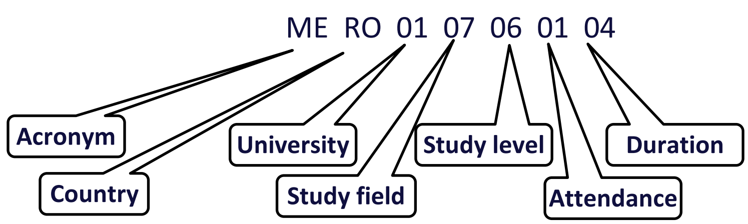
	according to ISCED				
	Attendance	N	2	01 – fulltime 02 – part-time 03 - distance	
	Duration	N	2	02, 03, 04, 05, 06	

According to the data in table above, the IDs for two programs in UTBV are:

Program: Manufacturing Engineering, Romania, UTBV, Engineering …., Bachelor's, Full attendance, 4 years. ID; MERO0107060104



The structure of Program ID

Program Advanced Manufacturing Processes Engineering, Romania, UTBV, Engineering …., Master's, Full attendance, 2 years, ID AMPERO0107070102

Some other criteria of program classification could target the level of recognition of diplomas (national or international), and if within TEAL 2.O, the program has equivalent(s) among the partner universities.

References

[1] International Standard Classification of Education (ISCED) https://ec.europa.eu/eurostat/statistics-explained/index.php/International_Standard_Classification_of_Education_(ISCED)#ISCED_1997_.28fields.29_and_ISCED-F_2013

[2] https://ec.europa.eu/eurostat/statistics-explained/index.php/International_Standard_Classification_of_Education_(ISCED)#ISCED_1997_.28fields.29_and_ISCED-F_2013

[3] https://unesdoc.unesco.org/ark:/48223/pf0000235049

Co-funded by the Erasmus+ Programme of the European Union

This project has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

[4] Dosbergs, D, Borzovs, J, Concept Classification for Study Programs Quality Evaluation, CSEDU 2010: PROCEEDINGS OF THE 2ND INTERNATIONAL CONFERENCE ON COMPUTER SUPPORTED EDUCATION, VOL 2

[5] Aleca, OE, Mihai, F, Dumitru, V, Best Practices in Academic Management. Study Programs Classification Model, AMFITEATRU ECONOMIC, volume: 18 Issue: 42 Pages: 462-473, Published: May 2016

☐ Standards and guidelines for the specification of benchmarking statements

Making the educational objectives/outcomes operational is crucial since these are a certification standard in most countries, offer a fundament for selecting appropriate teaching strategies, help the students focus on what is expected form them, offer support for proper evaluation; offer criteria for determining how efficient the whole educational process is.

There are 2 methods to define learning objectives/outcomes: Robert Mager's Performance-Based Learning Objectives and Gilbert de Landsheere's 5 step method [1,2]. These can be used to define general, broad and lesson specific objectives/outcomes.

Mager's approach - Performance-Based Learning Objectives - may be better suited for general and broad objectives.

According to Mager, a learning objective should include the following three components:

- Performance
- Conditions (under which the learner must perform)
- Criteria (by which the performance is evaluated by another; or, in other words, how well the learner must perform)

The Performance defines the Learning Objective "what the learner will be able to perform as a result of some learning experience." Example: Be able to write a news article. The Conditions of a Learning Objective should „state the conditions, if any, in which the learner must complete the performance." It is not always needed to add conditions; they should be used to make things clearer and remove ambiguity.

The conditions will tell the leaner things like the following:

- What can I use while doing the performance?
- What will be denied to me?
- In which conditions will the performance have to occur?

The Criteria of a Learning Objective

Finally, the third part of a Mager performance-based learning objective is the criterion or criteria: "Having described what you want your students to do, you can increase the communication power of an objective by telling them HOW WELL you want them to be able to do it."

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Here are some examples:

- Identify four out of five product defects on a moving manufacturing line.
- Close ten boxes in a minute.

It may not always be practical to include criteria in a learning objective.

According to Gilbert de Landsheere, a learning objective should include the following five components:

- Who is going to produce the desired behaviour?
- What observable behaviour will be reached?
- What will be the product of this behaviour (the performance)?
- The behaviour has to happen under what conditions?
- How to we decide that the product is satisfactory (criteria)?

Example: The students / will be able to build / a radio device / by choosing the parts according to a blueprint / and the device will be able to receive at least 5 radio stations. It can be noticed that, while being quite similar to the 3 components method, this method further details the performance (who, what behavior, what product).

Teachers currently record the LOs in educational engineering projects and didactic strategies in the form of sentences. It is up to the teachers to formulate the LOs and they do it correctly as much as their pedagogical training allows. There is a tendency to compromise the strictness of formulation as the scope of application increases.

General Learning Outcomes

Graduates with the exemplifying qualifications, irrespective of registration category or qualification level, must satisfy the following criteria:

Knowledge and understanding	They must be able to demonstrate their knowledge and understanding of essential facts, concepts, theories and principles of their engineering discipline, and its underpinnings in science and mathematics. They must have an appreciation of the wider multidisciplinary engineering context and its underlying principles. They must appreciate the social, environmental, ethical, economic and commercial considerations affecting the exercise of their engineering judgement.
Intellectual abilities	They must be able to apply appropriate quantitative science and engineering tools to the analysis of problems.

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	They must be able to demonstrate creative and innovative ability in the synthesis of solutions and in formulating designs. They must be able to comprehend the broad picture and thus work with an appropriate level of detail.
Practical skills	They must possess practical engineering skills acquired through, for example, work carried out in laboratories and workshops; in industry through supervised work experience; in individual and group project work; in design work; and in the development and use of computer software in design, analysis and control. Evidence of group working and of participation in a major project is expected. However, individual professional bodies may require particular approaches to this requirement.
General transferable skills	They must have developed transferable skills that will be of value in a wide range of situations. These include problem solving, communication, and working with others, as well as the effective use of general IT [information technology] facilities and information retrieval skills. They also include planning self-learning and improving performance, as the foundation for lifelong learning/CPD [continuing professional development].

Specific Learning Outcomes in Engineering

Graduates from accredited programmes must achieve the following five learning outcomes, defined by broad areas of learning. As set out here, the outcomes apply to accredited programmes at Bachelor (Honours) level leading to CEng registration.

The weighting given to these different broad areas of learning will vary according to the nature and aims of each programme and other requirements of the relevant engineering institution:

- Knowledge and understanding of scientific principles and methodology necessary to underpin their education in their engineering discipline, to enable appreciation of its scientific and engineering context, and to support their understanding of historical, current, and future developments and technologies;
- Knowledge and understanding of mathematical principles necessary to underpin their education in their engineering discipline and to enable them to apply mathematical methods, tools and notations proficiently in the analysis and solution of engineering problems;
- Ability to apply and integrate knowledge and understanding of other engineering disciplines to support study of their own engineering discipline.

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Engineering Analysis	▪ Understanding of engineering principles and the ability to apply them to analyze key engineering processes; ▪ Ability to identify, classify and describe the performance of systems and components through the use of analytical methods and modelling techniques; ▪ Ability to apply quantitative methods and computer software relevant to their engineering discipline, in order to solve engineering problems; ▪ Understanding of and ability to apply a systems approach to engineering problems.
Design	▪ Investigate and define a problem and identify constraints including environmental and sustainability limitations, health and safety and risk assessment issues; ▪ Understand customer and user needs and the importance of considerations such as aesthetics; ▪ Identify and manage cost drivers; ▪ Use creativity to establish innovative solutions; ▪ Ensure fitness for purpose for all aspects of the problem including production, operation, maintenance and disposal; ▪ Manage the design process and evaluate outcomes.
Economic, social, and environmental context	• Knowledge and understanding of commercial and economic context of engineering processes; • Knowledge of management techniques which may be used to achieve engineering objectives within that context; • Understanding of the requirement for engineering activities to promote sustainable development; • Awareness of the framework of relevant legal requirements governing engineering activities, including personnel, health, safety, and risk (including environmental risk) issues; • Understanding of the need for a high level of professional and

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	ethical conduct in engineering.
Engineering Practice	• Knowledge of characteristics of particular materials, equipment, processes, or products; • Workshop and laboratory skills; • Understanding of contexts in which engineering knowledge can be applied (e.g. operations and management, technology development, etc.); • Understanding use of technical literature and other information sources; • Awareness of nature of intellectual property and contractual issues; • Understanding of appropriate codes of practice and industry standards; • Awareness of quality issues; • Ability to work with technical uncertainty.

Below we present a UML diagram describing an LO (using the 3-step method from above) as an individual object and its connections to others.

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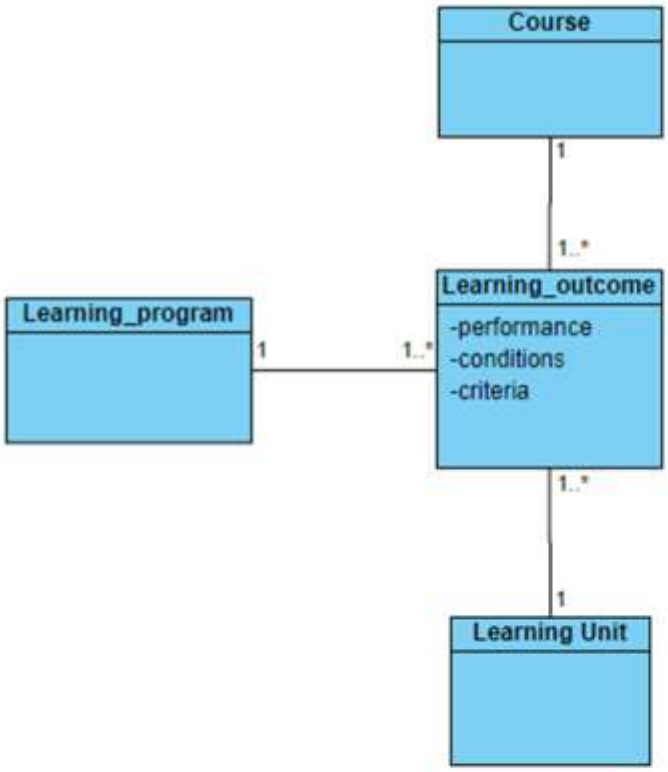

UML structure

Although we can use UML diagrams to describe the LO as an individual object and its connections to others, there are attributes of the object that are not clearly describable. What we can include as a limited option input (select) are the verbs which connect the objective to the Bloom's and SOLO taxonomy (these are related only to the performance). The conditions and the criteria are very diverse.

Therefore, it is more flexible and easier to include the LOs as sentences. The teachers are used to doing it this way anyway. A text input should do fine for this.

However, next to the text input, we should include a link which can open a pop-up or a new page where application at operational level is well explained (how the teacher should do it), including the pedagogical aspects mentioned above.

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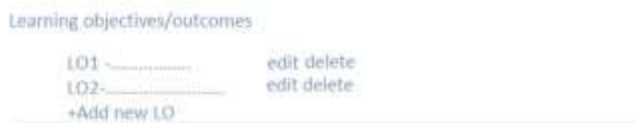
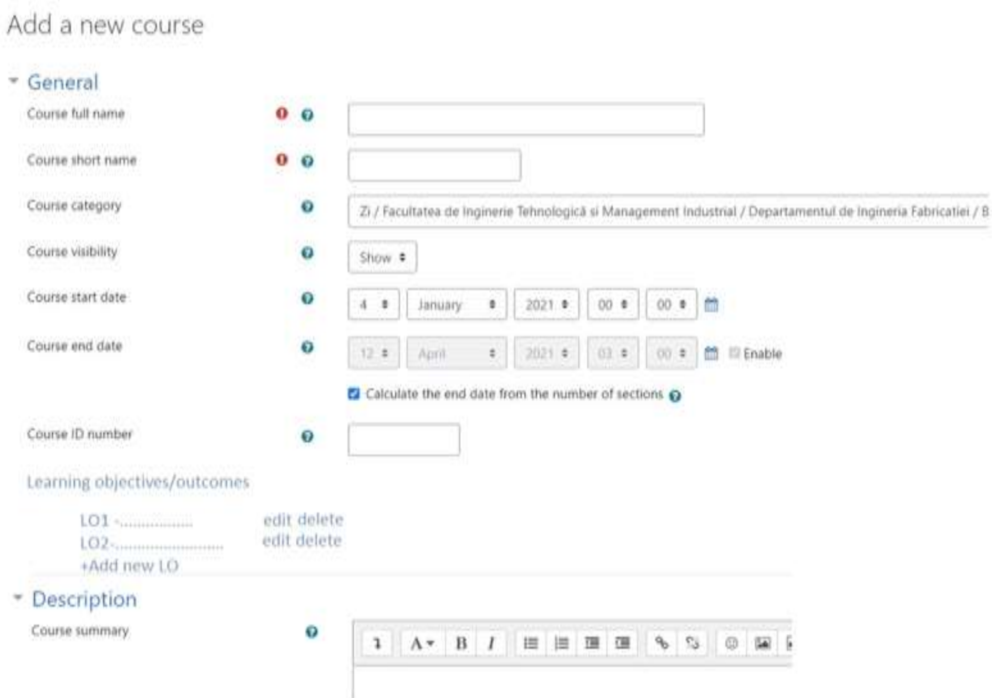
For the GUI, they can be added like this:



For example, if Moodle will be used, they can be added as a new section for a course. It could be done directly in the new distribution and it could be also delivered as a plugin.



GUI

References

[1] Ertas A, Maxwell T, Rainey VP, Tanik MM. 2003. Transformation of higher education: the transdisciplinary approach in engineering. In IEEE Transactions on Education 4(2), p. 289–295.

[2] Qureshi AJ, Gericke K, Blessing LM. 2013. Design process commonalities in trans-disciplinary design. In Proc. of the 13th International Conference on engineering Design, p.1-10.

[3] Vector Solutions, Convergence Training, available at: https://www.convergencetraining.com/blog/robert-magers-performance-based-learning-objectives, Last accessed on: 03.01.2020

Co-funded by the Erasmus+ Programme of the European Union

This project has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

[4] TeachThought, What Is Bloom's Taxonomy? A Definition For Teachers, available at: https://www.teachthought.com/learning/what-is-blooms-taxonomy-a-definition-for-teachers/

[5] Ilguy, Mehmet & Ilgüy, Dilhan & Fisekcioglu, Erdogan & Oktay, Inci. (2014). Comparison of Case-Based and Lecture-Based Learning in Dental Education Using the SOLO Taxonomy. Journal of dental education. 78. 1521-7. 10.1002/j.0022-0337.2014.78.11.tb05827.x.

[6] Sharunova A, Butt M, Kresta S, Carey J, Wyard-Scott L, Adeeb S, Blessing LM, Qureshi AJ. 2017. Cognition and transdisciplinary design: An educational framework for undergraduate engineering design curriculum development. In Proc. of the CEEA 2017 Conference.

[7] Qureshi AJ, Gericke K, Blessing LM. 2014. Stages in product lifecycle: Trans-disciplinary design context. Procedia CIRP, 21, p.224–229.

[8] Eisenbart B, Gericke K, and Blessing L. 2011. A framework for comparing design Modelling Approaches Across Disciplines. In Proc. of the 11th International Conference on Engineering Design, p.1-12.

[9] Gericke K, Blessing L. 2012. An analysis of design process models across disciplines. In Proc. of the International Design Conference – Design 2012, p.171-180.

[10] Gericke K, Qureshi AJ, Blessing LM. 2013. Analyzing transdisciplinary design processes in industry – an overview. In Proc. of ASME 2013 Internatioanl Design Engeneering Technical Conferences and Computers and Information in Engineering Conference, IDETC/CIE 2013, p.1-10.

[11] Kamsah MZ. 2004. Developing generic skills in classroom environment engineering students' perspective. In Proc. of Conference on Engineering Education, CEE 2004, p14-15.

[12] Huang Y. 2014. Improving engineering students' non-technical professional skills and attitudes to engineering through inquiry based lab learning. Ph.D Dissertation, Michigan State University.

[13] Kirillov NP, Leontyeva EG, Moiseenko YA. 2015. Creativity in Engineering Education. Procedia Social Behavioral Sciences (166), p.360- 363.

[14] Anderson LW, Krathwohl D. 2005. A taxonomy for learning, teaching, and assessing: a revision of bloom's taxonomy of educational objectives. Educational Horizons, 83(3), p.154–159.

[15] Granello DH. 2000. Encouraging the cognitive development of supervisees: Using Bloom's taxonomy in supervision. Counselor Education and Supervision, 40(1), p.31-46.

[16] Goel S, Sharda N. 2004. What do engineers want? Examining engineering education through Bloom's taxonomy. In Proc. of the 15th Annual Conference for the Australasian Association for Engineering Education, AaeE2004, p.1-13.

[17] Narayanan S, Adithan M. 2015. Analysis of question papers in engineering courses with respect to hots (higher order thinking skills). American Journal of Engineering Education, 6(1), p.1-10.

Co-funded by the Erasmus+ Programme of the European Union

This project has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

[18] Thambyah A. 2011. On the design of learning outcomes for the undergraduate engineer's final year project. European Journal of Engineering Education, 36(1), p.25-46.

[19] Fiegel GL. 2013. Incorporating learning outcomes into an introductory geotechnical engineering course. European Journal of Engineering Education, 38(3), p.238-253.

[20] Crawley EF, Malmqvist J, Ostlund S, Brodeur DR. 2007. Rethinking engineering education: The CDIO approach, Springer.

[21] Engineers Canada, 2017. [Online] Available from: https://engineerscanada.ca/sites/default/files/accreditation-criteriaprocedures- 2016-final.pdf

[22] Ulrich KT, Eppinger SD. 2011. Product design and development, 5th ed., McGraw-Hill Education.

[23] New York University Steinhardt, 2017. [Online] Available from: https://steinhardt.nyu.edu/scmsAdmin/media/users/VerbsforStudentLearn ingObjectives.pdf

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The basic use cases (scenarios) are as follows:

☐ **At the offering institution (running an instance)**

Learner (Student)

- Profile (complete, update, etc.)
- Programme (search, explore, enrol, drop, etc.)
- Course (search, explore, add, drop, etc.)
- Classroom (search, explore, join, leave, interact, etc.)
- Content (search, explore, add, drop, assess, etc.)
- Feedback (give, view, etc.)

Classroom Manager (Teacher)

- Profile (complete, update, etc.)
- Courses (express interest, prepare the classroom, etc.)
- Classroom (create, suggest/populate content, set timeline, offer, stop, etc.)
- Content (search, explore, add, remove, etc.)
- Student (mentor, monitor, interact, assess, etc.)
- Interactive resources such as forums (interact, etc.)
- Assessment (schedule, grade, etc.)
- Feedback and Report (prepare, collect, summarize, act, etc.)

Programme Creator / Manager

- Profile (complete, update, etc.)
- Users (create, add, manage, etc.)
- Program (create, update, plan, add/manage users, etc.)
- Courses (create, search, update, etc.)
- Program Objectives/Intended Learning Outcomes (create, update, map, etc.)

☐ **Central System**

Content Creator

- Profile (complete, update, etc.)
- Content (create, update, search, explore, add resources & assessments, etc.)

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- Intended Learning Outcomes (map to content, map to assessment, etc.)

System (Software)

- Program (rank, version control, track credits, etc.)
- Course (rank, version control, enable/track mappings, track credits, etc.)
- Classroom (rank, version control, activity log, etc.)
- Content (rank, version control, etc.)
- Assessments (track mappings, track and map marks to grades, etc.)

Systems Admin (Super Admin)

- Manage the whole system.

See also Annex I: User Stories.

☐ QA and Ranking Engine Requirements

The functionality of the QA Engine is to rank courses and course content based on:

- their usage
- student performance based on actual level of attainment of Learning Outcomes
- student feedback in the form of ranking

Thus the QA engine will have to be able to store student engagement and the level of attainment of Learning Outcomes (LOs), and then use a suitable strategy to rank the courses and the course content.

The QA and Ranking Engine thus needs to perform the following functionalities:

- Create and manage actions that the system offers
- Monitor and log each action
- Rank courses and contents based on usage, students' performance and feedback (anonymous)
- Handle version control
- Track mappings of course LOs to course content and assessments
- Track mappings of student attainment of course LOs through performance (assessments)
- Evaluate the effectiveness of classroom design and delivery based on user statistics and LO attainment
- Store, analyse and evaluate feedback provided by students
- Track credit load of Program with contents followed by a student.

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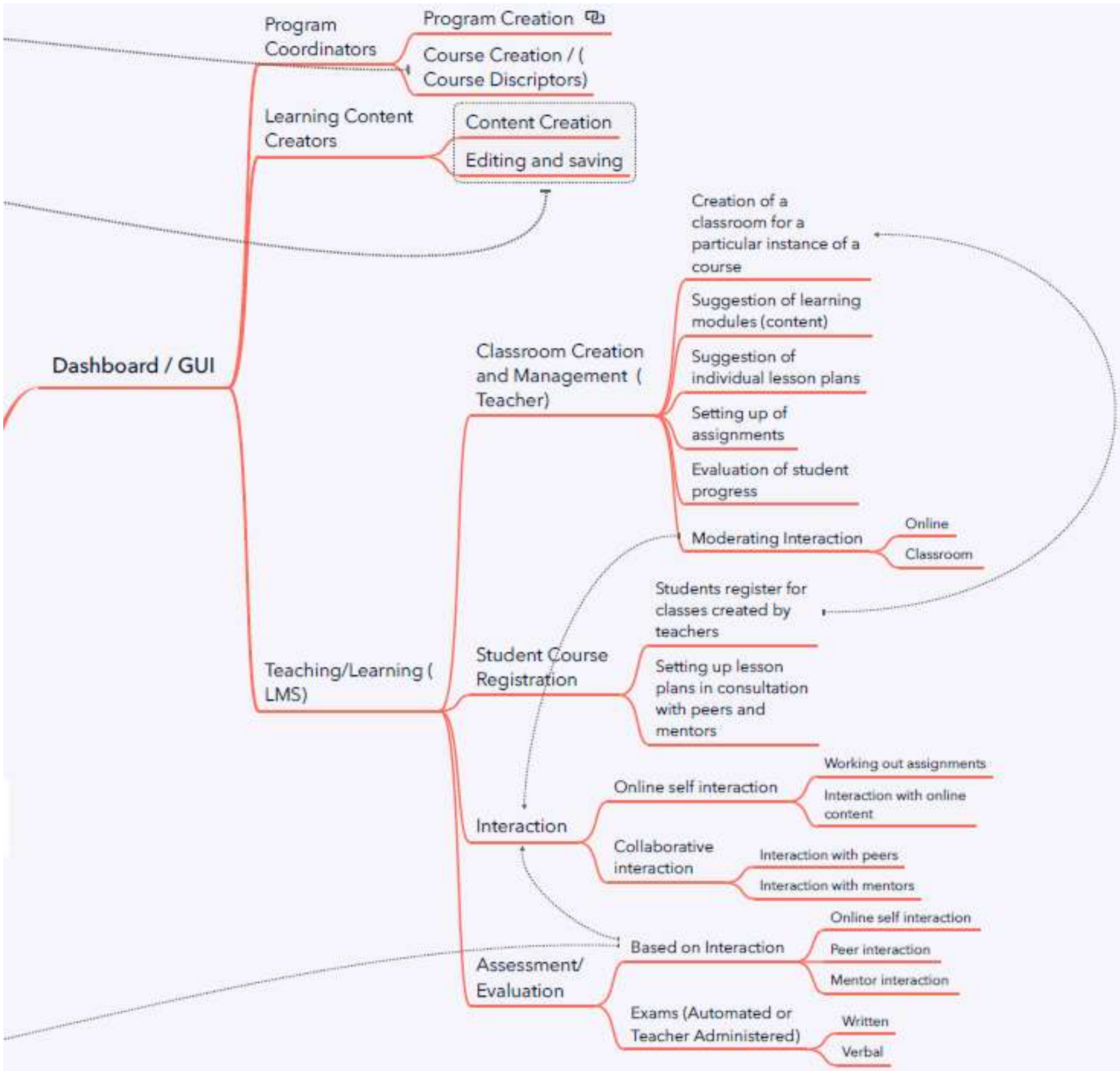

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The system consists of the following broad components:

- Programs and program specifications
- Course modules/course descriptors
- Content/learning modules
- LMS
- QA engine.

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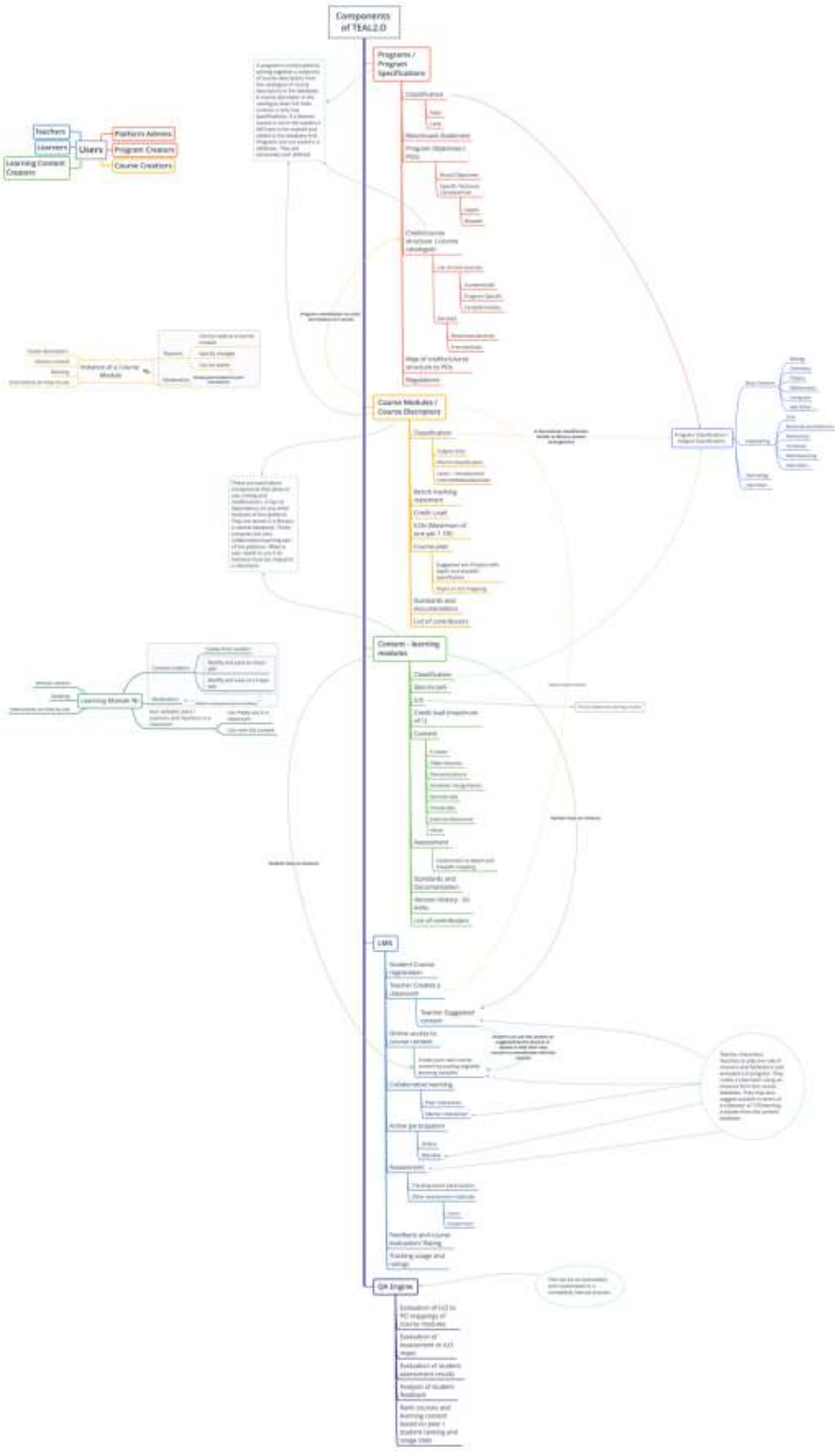
Components of TEAL2.0
Programs / Program Specifications
Teachers
Learners
Learning Content Creators
Users
Platform Admins
Program Creators
Course Creations
Credit Load
List of contributors
LMS
QA Engine

In order to meet the user requirements, the following specific features will be included in the TEAL2.O platform:

- User account management
- Access management
- Personalized dashboard
- Collaborative tools and activities - synchronized session scheduling, forums, workshops
- All-in-one calendar
- Convenient file management
- Text editor with LaTex typesetting capabilities
- Notifications & Tack progress
- Multilingual capability
- Interactive HTML5 compatible content creation and view
- Open standards
- Regular security updates
- Detailed reporting and logs
- Embedding external resources
- Multimedia integration
- Marking workflow
- Peer and self-assessment
- Program creation
- Course creation
- Learning content creation - interactive and static
- Course description classification, management and version control
- Learning content classification, management and version control
- Search for courses and create/edit courses
- Search for content and create/edit content
- LO to PO mapping
- Content to LO mapping
- Assessment creation - HTML5 interactive assessments, quiz, essay, and submission types

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- Assessments to LO mapping
- Classroom creation with customizable content and customizable lesson planning
- Classroom Plans, schedule
- Customized enrolment (Competence-based, learning-plan based)
- Custom report builder
- Graphical reporting
- Ranking courses, learning content based on user ranking and actual student attainment
- Interface to incorporate software-based third party open learning resources
- Interface to incorporate hardware-based third party open learning resources
- Interface to incorporate other third party open learning resources
- Hierarchical access management
- Custom certificates
- Customized notifications
- Team management
- Record of Prior Learning
- QA Engine
    - Student assessment performance monitoring and tracking of LO attainment
    - Monitoring student attainment of POs
    - Monitoring student interaction with content
    - Monitoring student interaction with teacher
    - Monitoring student interaction with peers
    - Other QA functionalities

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- ☐ **Input data**
  - Course descriptors
  - Course plans
  - Assessment and evaluation
  - Feedback
  - Course ratings
  - Content ratings
  - Suggested course content
  - Registration data
  - Interaction content
  - Exam-related data
- ☐ **Transformation of input data**
  - Course descriptors can be used to create programs by the users
  - Users can set up lesson plans
  - Users can edit learning content
  - Usage statistics is being analysed for QA purposes; autonomous ranking process
  - Exam results and evaluation results are being processed in order to allow assessment of student progress
- ☐ **Output data**
  - Programs
  - Courses
  - Database with collaboratively developed learning content
  - Interaction content
  - Assessment of student progress; evaluation records of students
  - Summary of evaluation of programs
  - Summary of evaluation/ranking of content.

The data flow is exemplified in the scheme below:

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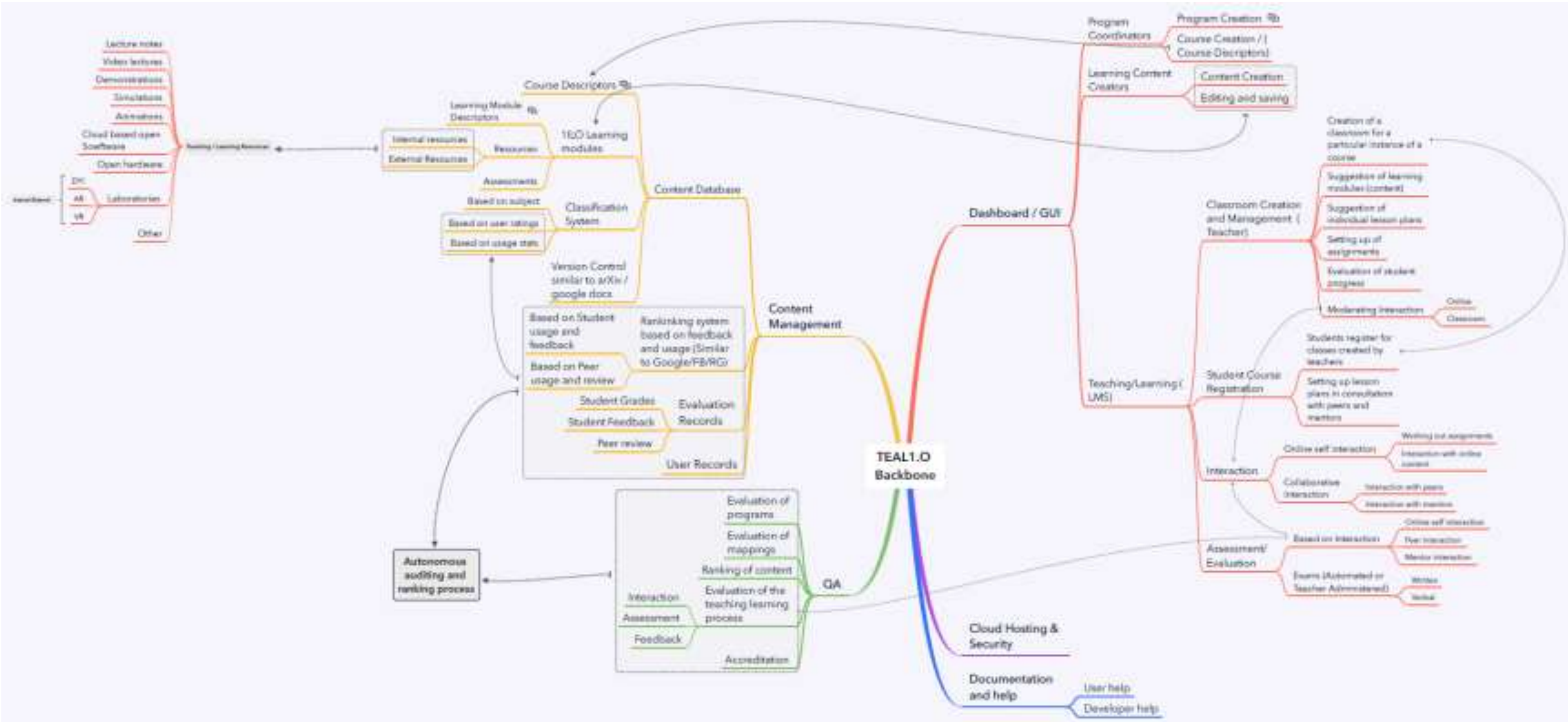
TEAL1.O Backbone
Content Management
Content Database
Course Descriptors
Learning Module Descriptors
1EQ Learning modules
Internal resources
External Resources
Resources
Assessments
Lecture notes
Video lectures
Demonstrations
Simulations
Animations
Cloud based open Sowftware
Open hardware
Laboratories
DIY
AR
VR
Other
Based on subject
Based on user ratings
Based on usage stats
Classification System
Version Control similar to arXiv / google docs
Based on Student usage and feedback
Based on Peer usage and review
Rankinking system based on feedback and usage (Similar to Google/FB/RG)
Student Grades
Student Feedback
Peer review
Evaluation Records
User Records
Autonomous auditing and ranking process
QA
Evaluation of programs
Evaluation of mappings
Ranking of content
Evaluation of the teaching learning process
Interaction
Assessment
Feedback
Accreditation
Dashboard / GUI
Program Coordinators
Program Creation
Course Creation / (Course Discriptors)
Learning Content Creators
Content Creation
Editing and saving
Teaching/Learning (LMS)
Classroom Creation and Management (Teacher)
Creation of a classroom for a particular instance of a course
Suggestion of learning modules (content)
Suggestion of individual lesson plans
Setting up of assignments
Evaluation of student progress
Moderating interaction
Online
Classroom
Student Course Registration
Students register for classes created by teachers
Setting up lesson plans in consultation with peers and mentors
Interaction
Online self interaction
Working out assignments
Interaction with online content
Collaborative interaction
Interaction with peers
Interaction with mentors
Assessment/ Evaluation
Based on interaction
Online self interaction
Peer interaction
Mentor interaction
Exams (Automated or Teacher Administered)
Written
Verbal
Cloud Hosting & Security
Documentation and help
User help
Developer help

Type of User	User Story
Account Holder	As an unregistered student user, I want to be able to register in the system using my Google, Microsoft, or Facebook account, so that I don't have to manage another account
	As Unregistered teacher, I can request user account from the Program creator/ super admin
	As Unregistered teacher, I need to fill teacher application, so that I can become a verified teacher in the system
	As Unregistered Program creator, I can request user account from the super admin, so that I can manage my institution
	As a registered user I want to be able to log in and out of the system using my Google, Microsoft, Facebook, or Moodle account
	As a forgetful user, I can view a password hint, so that I can recall my password
	As a forgetful user, I can request to reset the password, so that I can create a new password
	As an Program creator, I can create teacher/ instructor accounts, so that new teachers/ instructors can be added to the system under the institution
	As a super admin, I can create user accounts, so that new users can be added to the system
	As a super admin, I can control user accounts, so that new users can be added to the system
	As a super admin, I can review account requests, so that I can accept or decline them
	As a user, I want to be able to access the system through my web browser
	As a user, I want to be able to access frequently asked questions and additional documentation
	As a user, I want to be able to store user configuration settings such as language settings, theme, etc.
Student	As a student, I want to find programs, so that I can explore program outcomes, structure, future careers, and areas of studying
	As a student, I want to read program reviews and ranking from others, so that I can decide which course will best suit me
	As a student, I want to register for a program
	As a student, I want to leave a program, so that I can get rid of boring stuff
	As a student, I want to select courses that are prescribed for my program, so that I can get to know about the course structure, outcomes, and workload
	As a student, I want to register for a course, so that I can learn and complete my program
	As a student, I want to drop a course
	As a student, I want to find classes that most interest me
	As a student, I want to enrol for a class that I am able to take online so that I would not need to travel
	As a student, I want to leave a class that I selected and select another class instead
	As a student, I want to find contents to add to the class, so that I can find the most suitable and popular contents for my course
	As a student, I want to read content reviews and ranking from others, so that I can decide which content will best suit me
	As a student, I want to add content
	As a student, I want to drop content
	As a student, I want to create my own lesson plan in consultation with the teacher
	As a student, I want to see which programs I have enrolled
	As a student, I want to go to registered programs, so that I can see enrolled courses
	As a student, I want to see which courses I have enrolled in a program

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	As a student, I want to see which classes I have enrolled in
	As a student, I want to see which contents I have enrolled under a class, along with who teaches, number of credits and the description
	As a student, I want to access contents that I have chosen for a class so that I can study there
	As a student, I want to see announcements/news, so that I am aware of what is happening
	As a student, I want to find other peers who have enrolled in the class, so that I can interact with them
	As a student, I want to interact with peer and teachers in the class
	As a student, I want to use a forum in the class, so that I can post problems, share my knowledge with other peers and share my suggestion
	As a student, I want to access all types of resources provided in the content
	As a student, I want to get notified of upcoming class activities through email, so that I do not miss any of those
	As a student, I want to be able to complete all the assessments
	As a student, I want to be able to view the feedback, and assessments from the teacher
	As a student, I want to give feedback on the content, class, and the system
	As a student, I want to contact the admin using a help forum, so that I can solve problems occurring in the system
	As a student, I want to search information in system using search bar, so that I can get what I want easily
	As a student, I want to see the calendar, so that I am aware of future events
	As a student, I want to manage notification, so that I can arrange important reminders
	As a student, I want to manage my profile
Teacher (leading a class)	As a teacher, I want to find programs, so that I can explore programs which I can contribute to
	As a teacher, I want to search contents, so that I can see what others offer
	As a teacher, I want to create a classroom, so that I can teach students
	As a teacher, I want to create a timeline for a classroom
	As a teacher, I want to terminate a classroom
	As a teacher, I want to accept/ reject students who enrol for the classroom
	As a teacher, I want to suggest contents from the content database to be used in the classroom
	As a teacher, I can moderate content selection by students
	As a teacher, I want to enable/ disable offering of classes, so that I can get students enrolled or prevent them from enrolling
	As a teacher, I want to help students to create their own lesson plan
	As a teacher, I want to make announcements, so that I can inform things to students
	As a teacher, I want to create discussion forums, so that I can discuss things with students online
	As a teacher, I want to reply to forums created by students, so that I can answer their questions and address their problems
	As a teacher, I can monitor student progress
	As a teacher, I can view the forum post count of each student, so that I can identify the activity level of this student in the forum
	As a teacher, I can view user statistics
	As a teacher, I want to see all students' submissions/ performance
	As a teacher, I want to see logged information about submissions
	As a teacher, I want to schedule all the assessments according to ILOs & lesson plan

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	As a teacher, I want to grade all the assessments that require manual grading
	As a teacher, I want to be able to give students feedback on their progress
	As a teacher, I want to contact the admin using a help form/ chat/ email
	As a teacher, I want to interact with students
	As a teacher, I want to obtain feedback from students
	As a teacher, I want to see other teachers' profiles
	As a teacher, I want to see student profiles
	as a teacher, I want to get student login records, so that I can monitor their participation
	As a teacher, I want to search information in the system using a search bar, so that I can get what I want easily
	As a teacher, I want to add reminders to the calendar
	As a teacher, I want to integrate third party calendars to the system
	As a teacher, I want to manage notification, so that I can arrange important reminders
	As a teacher, I want to generate student reports, so that I can easily evaluate students
	As a teacher, I want to limit the number of students enrolled in a class
	As a teacher, I want to manage my profile
Content creator	As a content creator, I want to create contents with its description, outcomes (ILOs), credits, and all information necessary for classification
	As a content creator, I want to search, list and access existing content modules
	As a content creator, I want to update existing contents of a content module, so that I can create a different content module (the system has to take care of version control automatically)
	As a content creator, I want to add resources such as e-notes, videos, demos, virtual labs, etc. to the content module
	As a content creator, I want to be able to create assessments such as quizzes/ exams/ assignments
System	As a system, I want to monitor all activities and log data
	As a system, I want to rank programs/ courses/ contents based on usage, student performance and feedback, so that I can sort popular and effective ones
	As a system, I want to handle version control of the resources, so that I can provide different versions based on user edits
	As a system, I want to map course ILOs to classroom content ILOs, so that students have flexibility to select appropriate content
	As a system, I want to track ILOs coverage by a student through assessments such as assignments, quizzes etc. and therefore, the overall PO coverage
	As a system, I want to analyze and evaluate feedback, so that I can improve system performance
	As a system, I want to track credit load for programs and courses, so that I can restrict students within a range
Program Creator	As a creator, I want to manage users under my institution
	As a creator, I want to manage institution notifications
	As a creator, I want to manage teachers and students for a program
	As a program creator, I want to create programs with classification, benchmark, program outcomes, credit, program structure, map credit/ course structure to program outcomes
	As a program creator, I want to search, list and access existing programs
	As a program creator, I want to update existing program, so that I can create a different program
	As a program creator, I want to create courses with classification, benchmarking, credit load, ILOs, course plan, standards, and documentations

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	As a program creator, I want to search, list and access existing courses
	As a program creator, I want to update existing courses, so that I can create a different course
	As a program creator, want to plan program delivery such as scheduling, assigning teachers to courses, etc.
Super Admin	As a super admin, I want to do whatever system can do

Key User Type	Tasks
Teacher	Create e-notes
	Video lectures
	Demonstrations
	Activity/assignments/ exams/ quizzes
	Labs
	Resources
	Feedback forums
	Track student involvement
	Create classroom
	Add contents to the classroom
	Add students to the classroom
	Create a course along with ILOs
	Create content along with defined ILOs
	Add chat to contents/courses with scheduling
	See program, courses, contents, teachers, student ranking
Student	Register in the system
	Register for a program
	Select courses
	Select contents (based on interaction with a teacher if desired)
	Download resources in a content
	Face for exams/quizzes
Teacher	Complete assignments/ activities
	Collaborate with other peers
	Use forums to ask/ answer questions
	Use feedback forums to evaluate course, content, teachers, programs, institutions
	Use chats to interact with peers/ teachers (private)
	Rank courses, contents, classrooms, institutions
	Log in using Google, Microsoft, Facebook account
System	Evaluate programs, courses, contents, teachers, students
	Rank programs, courses, contents, teachers
	Store user records
	Exercise version control of resources
	Map program ILOs to courses / contents / classrooms
	Save new program, course, content after changes of ILOs
	Track ILOs coverage by assignments, exams, quizzes, labs for a course
	Analyze and evaluate feedback

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