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EDUCATIONAL FRAMEWORK

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Background and Need for an Educational Framework

This document expresses the Educational Framework approach within the Erasmus+ project *Transforming Educational programs For Future Industry 4.0 Capabilities* (TEFFIC). The project addresses a need to develop new approaches to education to match technological convergence in the industry, where new ways to integrate systems enable new products, processes, and business models.

The project is a collaboration between six higher education institutions from five European countries, which educates graduates on European Qualification Framework (EQF) levels 5-8(THE COUNCIL OF THE EUROPEAN UNION, 2017). All the partnering institutions have technological study programs, aimed at the industry.

The Educational Framework stands on an embedded approach, where the digital nature of Industry 4.0 is integrated into the learning space, and the educational activities are seen in the context of an application, rather than as individual disciplines: The task or problem at hand are the midpoint for the learning. At the same time, the activities builds on activation of prior knowledge, demonstration of new content, application and integration as described by Merrill (Merrill, 2015). The operationalisation of the task-centric learning is well described in *Autentic Task Design* as described by Wollong University (University of Wollongong, 2005) This approach can be described as a combination between the agile development process, and a task centric didactic approach .

When an educational designer applies this educational framework as a development tool for a specific field, the resulting educational activity should enable the interconnected understanding of the topic related to other Industry 4.0 topics.

Inputs Developing the Educational Framework

Higher education institutions are very diverse and have different opportunities and resources available to support educational activities. All have a common goal to supply high-quality graduates to job market, but this job marked differs between countries and regions. Different facilities and geographies of the various higher education institutions do also grant significant differences between the educational opportunities.

Higher education institutions deliverer graduates to the industry within a wide range of fields and EQF levels across Europe (Chamberlain and Portenoy, 2008a, 2008b; Andersen and Kruse, 2016; Lemaigre, 2016; Siilivask, Nõmmiste and Silla, 2016). Many of them teach topics within the Industry 4.0 context, and cover different settings and perspectives. These differences call for an agile[1] and flexible approach, which can address the desired educational content of all cases in a meaningful way. This Educational Framework must be able to handle the differences between the institutional settings, while also having an Industry 4.0 aim.

This agile and flexible approach with an Industry 4.0 aim is part of the logic embedded in the educational framework. This embedded logic contains a problem-based learning approach where reflections related

[1] In this context, agile should be understood as an approach where the educational activity is evaluated frequently through the development process.

to the praxis of the knowledge field is used to expand the horizons of the students. Furthermore, the fast-moving knowledge fields call for the developed educational material to be straightforward to redefine as the knowledge base evolves in the industry sector.

The Educational Framework

The flow of information in the developed educational framework can be seen in Figure 1. The analysis before the educational design process results in a set of learning needs to be combined with the boundaries and opportunities within the higher education organisation. These needs and boundaries define a space in which educational programs targeting the Industry 4.0 in the given institution can be developed.

Within this space, four core roles must be identified. These are the educational designer, the educator, the student and the peers inside and outside of the organisation. Each of these roles might be filled by several people and can overlap, but all of them have a function for the educational activity to be designed, executed and evaluated.

The learning designer conduct the analysis in collaboration with the peers and purify the results. The resulting learning goals and boundaries is the basis of the cyclic development process in which the educational activity is created. The cyclic development process allows the learning designer to rethink the program until suitable. The program should not be sent out for execution before it meets the learning goals. This definition of the goals, ideation and building of the program followed by a test and an evaluation of the test compared to the goals ensure a reflection from the educational program designer whenever the goal is met.

Afterwards, the program is carried out by the educator and the students. This takes place in different ways across different platforms and institutions, but all of them should be open for feedback, both towards the specific program, but also development in the learning needs of the industry and the organisation.

Proposed actions:

- Analyse the context of the industry and institution
- Combine these analyses into a set of needed skills that this institution can teach

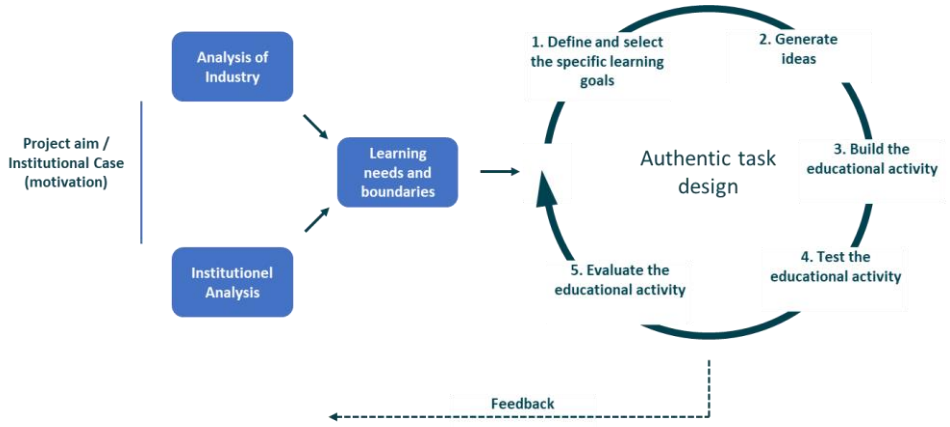

Figure 1 - An overview of the educational development process. The aim or motivation of a given educational activity is determined. After this, analyses are performed to define the learning needs and boundaries. These needs and boundaries are developed in an iterative process until a satisfying educational activity can be executed. This execution grants feedback to all steps in the process.

Define and select the specific learning goals

The learning needs from the industry analysis will, in most cases, span more than a single educational activity. Hence, the development of a given educational activity starts by stating the learning goals for it. This will also have to take the underlying rules of education into account, where some learning goals are predefined.

The learning goals define the topic of the course. To integrate the topic in Industry 4.0, the topic must be in a context, where the students can relate the topic to an application. This context is a part of the embedded approach of this Educational Framework, and a given context can be defined along with the learning goals.

The needed level of individual skills does also have to be defined. The educational designer can investigate the analysis to identify these levels and take the EQF level of the given education into account. The EQF levels provide a set of descriptors, which indicates the learning outcome for a given level (European Comission, 2016). The SOLO taxonomy can be used to translate this needed skill into a learning goal (Biggs and Collis, 1982). It enables the educational program designer to look at the given action the student should be able to perform in an industrial context and put it into a learning goal.

Some institutions do also have an official educational approach. These educational approaches can dictate, e.g. how an educational activity must interact with the industry, whenever it should be problem-centric and so on.

Proposed actions:

- Identify the learning needs that can fit into a given course
- Define the required level of each skill
- Transfer these skills into the EQF template
- Identify relevant parts of the institutional, educational approach to follow

Generate ideas

When the learning needs for the educational activity and their levels have been defined, the educational designer can start getting ideas for how the learning goals relate to an educational activity. This idea of generation is well described in other places.

The outcome of the idea generation is a sketch on an overall level of the desired educational activity, where the overall principles are implemented, but not fine-tuned. This sketch should reflect the learning goals as well as the overall principles which might govern the educational activity.

This sketch can have several forms, a logical framework matrix (European Commission, 2004)

could be one of them. This method lets the educational designer link the overall aim with the outcome of the given educational activity. Then the outputs needed for the given outcome is defined, and the activities needed to deliver this output is found. Afterwards, the logic that allows the activities to grant the output, the output to give the outcome and the outcome to help to reach the aim is investigated, which ensures the underlying logic of the educational activity is documented and not lost through the process of creating the educational activity.

Proposed actions:

- Perform a mind map, brainstorm or other idea generation technique
- Make an overall sketch of the educational activity

Build the educational activity

The next step is to build the educational activity from the sketch. The progression through the activity is planned, and how to conduct certain elements of the teaching, but the process of choosing the right teaching tools for a given learning goal requires the educational designer to enter both a focused mode where a given learning object is developed in detail, as well as a defused mode where the overall program is in mind.

Some learning styles are more efficient when teaching Industry 4.0. A common denominator is that they improve the interdisciplinary reflections of the student, and let the student engage more actively with the Industry 4.0 related topics.

The sketch from the ideation is expanded into a more detailed plan of the progression throughout the course to build the educational activity. To plan a single education element within the activity, three questions should be answered:

- Which value do I wish to provide for the students?
- How can I provide this value (educational element)?
- What is the topic of the educational element?

Furthermore, the available resources within the higher education institution compared to the learning outcome have to be considered. This should be clearly outlined and described if knowledge or facilities are required to meet the learning goals. The discussion of whenever these proposals are feasible takes place in the evaluation phase but must be described along with the design of the educational activity.

Suggested elements

Several elements can be part of the educational activity. Below, a list of suggested activities is given. This list is a pick from the collaboration consortium. The individual educational designer can have other elements that can add value to the educational activity.

The suggested elements represent processes, communicative elements, and technologies that enable a high learning output in an Industry 4.0 context.

Process elements

- Flipped classroom
- Design of tasks and applications
- Creation of groups
- Context of simulations

Communicative elements

- Communication in blended and online learning
- Reflection and feedback
- Supervision and organisation in online learning environments
- Full utilisation of presence in classroom or laboratories

Technological elements

- Video and Podcast
- AR and VR

Process elements

Flipped classroom

Participants	**Learning situation**	**Output**
1+	Online or blended learning	Students obtain knowledge prior to lectures
Description	Flipped classrooms are defined as letting the lecturing taking place as a video, podcast or other digital activity, and using the teaching ours for problem-solving and practice exercises. (Bishop and Verleger, 2013)	
Advantage	The teaching resource is utilised in a more efficient way when the students receive the lecturing content out of class and can use all teaching time for asking specific questions.	
Limitations	The digital lectures must be created before the execution of the educational activity.	

Design of tasks and applications

Participants	Learning situation	Output
1+	All	Well-designed tasks and applications
Description	This design of tasks is based on the *Authentic Task Design* from **Wollongong University**(University of Wollongong, 2005)**.** It requires a task to follow ten basic guidelines, seen in **Fejl! H envisningskilde ikke fundet.**.	
Advantage	By designing task and applications in relation to the real-world scenario, with ill-defined and complex tasks, the students will have to invest time and energy to enhance ownership of the proposed solution. It can require investigating from several perspectives, collaboration, reflection opportunities, and cross-disciplinary content, which all mimics the later jobs for which the Industry 4.0 courses are aimed. Hence, these well-designed tasks and applications have a value on their own and is not merely a preparation for later work. This type of tasks and applications will often enable peer learning, as opponents and peer review between the students can enhance the learning outcome.	
Limitations	N/A	

Creation of groups

Participants	Learning situation	Output
4+	All	Groups with appropriate skill-level and group dynamics.
Description	Groups should be able to work together at a social level, while also having the required skills to solve a given task. This makes it to a two-dimensional problem, where both the skill-level and the personal profile of the students must be considered.	
Advantage	Well-composed groups work well together and enable a high learning outcome among the group members. Furthermore, the group formation process can be used as a learning process on its own, as it resembles team formation processes in the industry, and the personal profiles can be used as a mirror of reflection for the student. Propper groups allow students on all levels to experience coping, as the student will be able to deliver meaningful contributions with regards to both effort and professionalism.	

Limitations	Certain fields have high concentrations of certain personal profiles, which might prevent the formation of totally balanced groups.

Context of simulations

Participants	**Learning situation**	**Output**
1+	All	Context to computational simulation
Description	In order to formulate a conceptual model, before implementation, the student needs to master language and methodology of the field (Abrahamson, 1980). Without insight into the field of application, the model will not provide any value, as it has no context.	
Advantage	By presenting context before simulation, the outcome of given learning activity can be increased. As simpler systems often fit better in the classroom, the gain insights can be used as gearing to investigate more complex problems virtually.	
Limitations	N/A	

Communicative elements

Communications in blended and online learning

Participants	**Learning situation**	**Output**
1+	Blended and online learning	Better communication in non-campus situated learning activities
Description	The communication with the students during off-campus activities are essential to staying aligned. This communication can use several platforms, and good practice is vital when working with this field. Weekly communication with voice and video is encouraged, in order to stay aligned on the learning goals.	
Advantage	The student and the educator stay aligned in terms of expectations. Voice and video-based communication improve the relationship between the student and the supervisor, while text-based communication can be used to frequent exchange of information and supervision.	
Limitations	N/A	

Reflections and feedback

Participants	Learning situation	Output
1+	All	Improved quality of feedback for reflection among the students
Description	Feedback and the resulting reflections among the students are essential for learning. The feedback should be tailored compared to the students reflectional competence and enable the student to identify own learning needs.	
Advantage	Enables the student to identify new areas of improvement and gain educational confidence.	
Limitations	N/A	

Supervision and organisation in online environments

Participants	Learning situation	Output
1+	Online and blended learning	High-quality supervision and organisation thereof for digital teaching
Description	While supervision on-campus most often is a face-to-face or written hand out, there are many different tools to use for digital supervision. These include chat, conference calls, fora and other systems.	
Advantage	With a proper application of different supervision tools in the right organisation, digital teaching can be highly efficient and high standard.	
Limitations	N/A	

Full utilisation of presence in classroom or laboratories

Participants	Learning situation	Output
1+	On-campus and blended learning	Better use of valuable time in the classroom
Description	The time the students are in the classroom is a valuable resource, where the teacher can facilitate many different types of learning. Hence, the effective use of this time can increase the learning output of the teaching activity. It is important to evaluate which activities that need to take place on the institution, which might benefit from it, and which would not.	

	Furthermore, some activities, like presentation, might benefit from a shift in the environment, in order for the student to reflect on different aspects of the task.
Advantage	By focusing on the time in class as a precious resource, the learning output from this activity can be examined for potentials for an increase.
Limitations	The attention of students and teachers can be challenged through a longer period of teaching.

Technological elements

Video and podcast

Participants	**Learning situation**	**Output**
1+	Online or blended learning	Students obtain knowledge before lectures
Description	While possible a part of the blended classroom approach, the use of video and podcast can also be prepared for the lecture. In this context, concepts can be introducing prior to the more in-depth lecture, taking advantage of the principle of spaced repetition. The produced material should be modular, so short films and podcasts can be consumed and consumed by the students as part of the preparation, post reflection and reference lookup.	
Advantage	In several fields, video and audio material becomes available before textbook and articles. In this way, cutting edge material can be introduced to the students as learning content outside of the lectures. The development of audio and video material can be done fast and simple in order to support newly generated knowledge, as well as made into more comprehensive material for key principles.	
Limitations	NA	

Summery

The elements described above can be applied to increase the gain and to expand the learning environment outside of the classroom. In order to move the educational content closer to the Industry 4.0 application, it is important to note the alignment between the assignments, tasks, and problems compared to the case.

Proposed actions:

- Expand the sketch

- Ask which value, how to provide and what to provide
- Choose which elements to which activity
- List required competencies and facilities

Test the educational activity

After the educational activity is built, it must be tested. This test can be less or more formal, depending on the setting and timing. An in-debt read-through and reflection on the proposed educational activity can address issues in some cases, but often others opinion is required. This can be a review from educational peers, e.g. a college, or from one or more students. Furthermore, stakeholders from the industry can also participate to investigate the alignment with the industrial analysis.

The educational designer should consider the best test approach and use different approaches to pinpoint different needs in the proposed design.

Proposed actions:

- Pick a test approach to pinpoint where the educational activity meets the learning goals.

Evaluate the proposed educational activity

At the end of the educational development cycle, the activity should be evaluated. This evaluation might fuse with the test phase if the test is carried out by the educational designer. If the test involves a review from someone else, though, the evaluation address whenever the educational activity fits well enough to the learning goals and format stated in the definition. The review should both cover whenever the learning goals are met, as well as whenever the educational activity can be executed with the available resources.

If the educational activity meets the learning goals it is ready for use. If it does not, the obtained insights should be used to redefine the problem. This redefinition can both be from scratch, where all initial development is put aside, and the learning needs are used again together with the new insight. More often, the educational activity might be sharpened in certain areas, which will then be ideated and build in detail. Then the test will need to show that the improvements in one area did not lead to decreased activity in others.

Proposed actions:

- Reflect on whenever the test meets the learning goals.
- Determine whenever the required resources are or can become, available
- Determine whenever to execute the educational activity or take it through one more development cycle.

Execute the educational activity

When the educational designer has finalised the educational activity, it can be executed. This execution will use the developed educational activity as a plan, and the execution will be the overall reality check for this plan.

In order to secure a smooth execution, a proper schedule based on the designed educational activity should be made. This is the plan for the execution, and it is based on the plan for the educational activity.

Proposed action:

- Make a schedule involving enough space for reflection

Feedback

After the execution of the program, several types of feedback can be obtained. This feedback will target both the execution, the planned activity, the learning goals, the learning needs and the industry.

Several methods can be used to obtain this feedback, including interviews, questionnaires, and workshops. The educators' reflections are also important in this process, as the educators and the students are participating in the educational activity at different premises.

When the feedback has been obtained, it can be ordered into several levels. These levels might be entangled, but for an overall understanding, they are listed below.

Level 1 – The execution of the educational activity. Does the time schedule, the communication to the class or the information in the learning management system offer a proper learning space?

Level 2 – The planed educational activity. Does the sequence of the educational elements enable a learning flow in which the student can reach the learning goals?

Level 3 – The addressed learning goals. Do the learning goals make sense within the educational setting, or should they be modified?

Level 4 – The learning needs. Is the learning need still highly relevant for the job market, and does it fit into the institutional frame?

Level 5 – The needs of the industry. Are the learning needs of the industry that the educational designer pinpointed in the analysis still valid?

Proposed actions:

- Plan the evaluation as part of the educational activity
- Try to obtain different types of evaluations, to gain more overall insights into the quality of education.

List of definitions

Term	Definition
Educational activity	Lessons, courses, semesters and full educations under one therm.
Educational designer	The person(s) who carries out the design process of the educational activities, including the pre-analysis and the iterative activity development. This can be the same as the educator.
Educator	The person(s) who execute the educational activity. This can be the same as the educational designer.
Learning goal	The learning goal is the aim of the educational activity.
Learning outcome	The learning outcome is the combined results of the learning goals, as obtained after the educational activity.

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