Report on the Methodological Framework of new Pedagogical Approaches

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REPORT 6:
REPORT ON THE METHODOLOGICAL FRAMEWORK OF NEW PEDAGOGICAL APPROACHES – SCENARIOS OF FUTURE ENGNEERING EDUCATION

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Executive Summary

This report summarises the methodology used to create scenarios as part of the innovative teaching pedagogies proposed in the A-STEP 2030 (Attracting diverSe Talent to the Engineering Professions of 2030) project. This project is an EU Erasmus+ project funded under call number 2018-1-FR01-KA203-047854. The report begins by describing the overall project and the organisation of the learning and teaching activity. The scenarios were co-created with student participants and academic staff in the learning and teaching activity - A-STEP 2030 Summer School which was held in August 2021.

The specific scenarios created by participants are described in this report and can be used by engineering educators in delivery of engineering programmes. More detailed videos are also included on the project website (www.astep2030.eu)

1.0 Summary of Overall Research Project

The main objective of the A-STEP 2030 project was to develop new and innovative teaching approaches relevant to learners' values yet appropriate to teach a new set of skills and competencies needed for the future. Our goal was to create an attractive and fascinating learning environment thereby encouraging young people and adult learners with diverse backgrounds to engage in engineering studies and the profession as a whole. The project comprised the following three activities:

Activity 1: Determine future roles and skills requirements of engineers to enhance the sustainable development of society.

Activity 2: Investigate the values and motivations of young people, students and adult learners to determine how this influences their future career choices and use this knowledge to make a career in engineering more attractive to all young people.

Activity 3: Develop new and innovative teaching and learning practices to respond to these findings.

The project consortium has 7 members from six EU countries (France, Denmark, Finland, Ireland, Sweden and Belgium) and 10 associated partners. The team includes four different European HEIs all involved in Engineering Education Research. (ENSTA Bretagne, France, TU Dublin, Ireland, Aalborg University, Denmark and Metropolia University, Finland.) The team is also complemented by representatives from SEFI (European Society for Engineering Education) and Universum - experts in research relating to student motivations and career choices. Students are also represented through our project partner BEST (Board of European Students of Technology) which represents HEI students in STEM.

Figure 1 shows the main activities associated with the project. This report focuses on the result of Activity 3: Task 2.

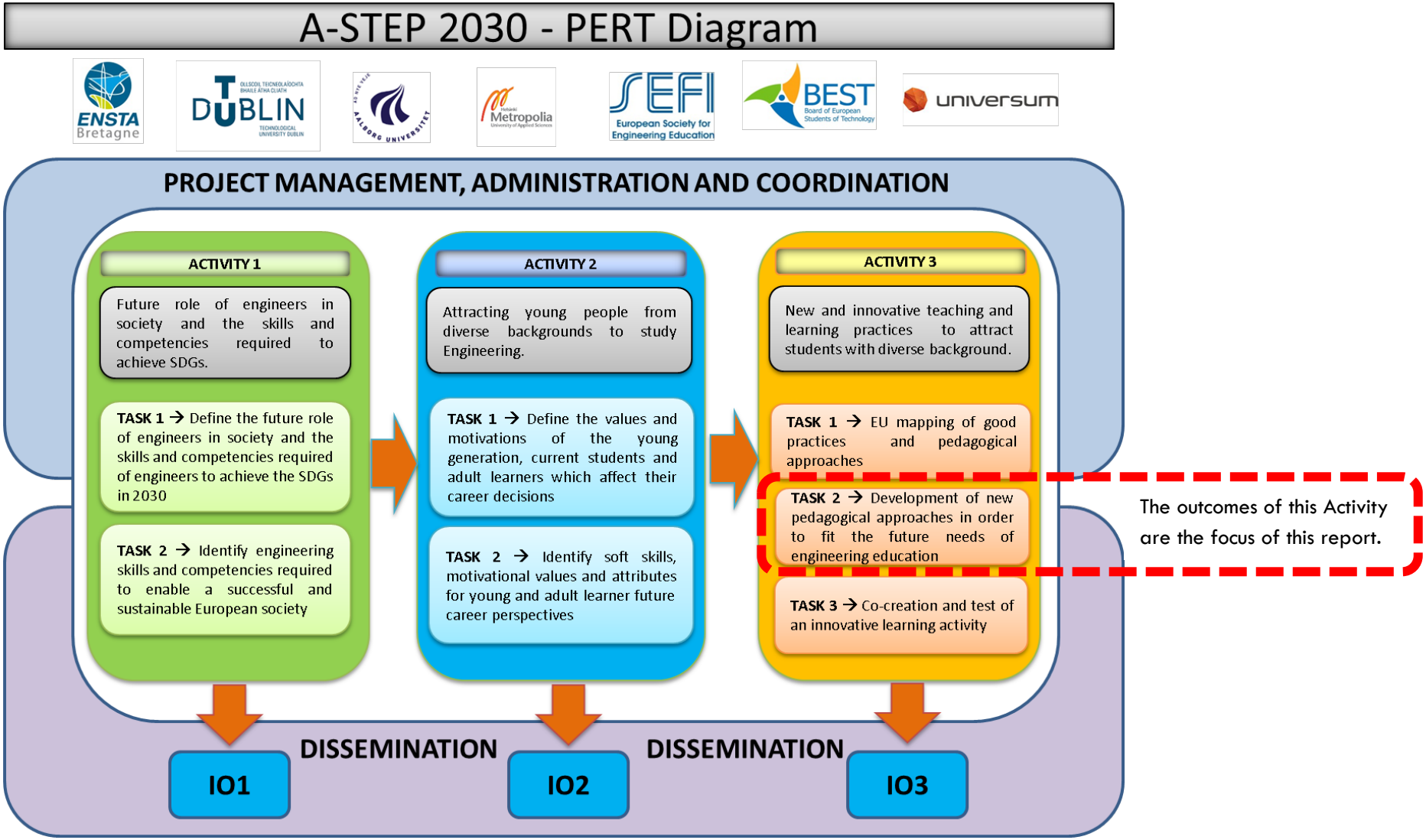

Figure 1: Overall Project details showing the aims of each activity.

3.0 Learning and Teaching Activity

It was originally intended to run the learning and teaching activity face to face with a limit of 30 students. However, due to the pandemic situation, we were unable to host the learning and teaching activity in person, and so we turned this to our advantage and ran the learning and teaching activity online to provide an opportunity for students and academics to develop their digital skills. The learning and teaching activity took place in August 2021 as the "A-STEP 2030 Summer School".

Students were invited to attend the free Summer School through advertisement in student networks, universities, SEFI, Universum networks and on social media. As we wanted to enhance multi-cultural skills by creating diverse teams, the application form requested general demographic details, but also selection of preferred team roles in line with the Belbin Team Roles Framework (Belbin, 2011). Fifty students were offered places from 266 applicants to attend the Summer School. The Summer School took place over 3 days, using 6 sessions of 2 hours. Students were also expected to work together off line.

The team set up a Collaborative Workspace before the event so that each team member could upload pre-reading material and resources. Worksheets and documentation that was required for each activity was also provided within separate folders. This allowed students to access, work on and upload progress in each session and was available to all hosts and students within that group to work on and review. We also provided a Code Of Conduct for student's participation online and a Certificate of Completion.

The Summer School introduced students to the concept of Futures Literacy and Scenario Thinking and sessions were held on developing skills on Backcasting, Roadmapping and Designing a Monster. The Summer School event concluded with a Show and Tell session which allowed students to present their scenarios to the research team. The co-creative exercise enabled the research team to trial this innovative exercise whilst helping students develop their skills in future orientated thinking.

Please refer to Table 1 which outlines the agenda of the learning and teaching activity.

Table 1: Overall Schedule for Summer School

Wednesday 18th August 2021 (9.00-11.00 GMT+1)	**Wednesday 18th August 2021 (13.00-15.00 GMT+1)**
Session 1: Futures Literacy **Session Hosts: AALBORG and ENSTA** Purpose of Session: Introductions to the project and to the participants Schedule: 09.00-09.10 Setting up, welcomes, Code of Conduct 09.10-10.00 Introductions [Interactive Session] 10.00-11.00 Future Literacy Interactive Session	**Session 2: What is scenario thinking?** **Session Hosts: METROPOLIA** Purpose of Session: Introduction to Strategic Thinking, Driver Mapping & Creation of four futures Schedule: 13.00-13.05 Joining the room 13.05-13.15 Introduction to Strategic thinking 13.15-13.30 Introduction to Driver Mapping 13.30-14.55 Students work in groups 14.55-15.00 Wrap Up
Thursday 19th August 2021 (9.00-11.00 GMT+1)	**Wednesday 18th August 2021 (13.00-15.00 GMT+1)**
Session 3: Backcasting **Session Hosts: TU Dublin** Purpose of Session: Introduction to the technique of backcasting and deepening the four futures they have identified in Session 2. Schedule: 09.00- 09.05 Joining the room 09.05- 09.15 Intro to Backcasting techniques 09.15- 10.55 Students work in groups 10.55- 11.00 Wrap Up	**Session 4: Roadmapping** **Session Hosts: ENSTA** Purpose of Session : Deepening of scenario building – Creating a strategic plan Schedule: 13.00-13.05 Joining the room 13.05-13.15 Introduction to Roadmapping 13.15-13.30 Discussion with whole group on realism 13.30-14.55 Students work in groups 14.55-15.00 Wrap Up
Friday 20th August 2021 (9.00-11.00 GMT+1)	**Friday 20th August 2021 (13.00-14.30 GMT+1)**
Session 5: Designing a Monster **Session Hosts: AALBORG** Purpose of Session : Introduction to the technique of Monstering with a view to creating a plan or model for a future classroom and how it will function. Schedule: 09.00- 09.05 Joining the room 09.05- 09.15 Introduction to Monstering 09.15- 10.55 Students work in groups to create their Monster 10.55- 11.00 Wrap Up	**Session 6: "Show and Tell"** **Session Hosts: TU Dublin** Purpose of Session: To see the outputs of the scenarios created by each group Schedule: 13.00-13.05 Joining the room 13.05-14.00 Two parallel sessions of "Show and Tell" 14.00-14.15 Feedback 14.15-14.25 BEST Presentation 14.25-14.30 Wrap up, thank you and goodbye

4.0 Methodological Approach

The methodological approach included taking participants through five sessions which culminated in a final Show and Tell session where students presented their scenarios to the group. Each session is now described in more detail. Full resources including presentations, introductory materials worksheets and so on are available from the project website.

4.1 Futures Literacy

The first session started before the Summer School began, with the students preparing presentations about themselves. We specifically asked them to talk about their childhood and current personal and professional dreams as a way to orientate themselves to the idea of future thinking. Students also were able to read a short introduction about the project and watched video presentations from the session facilitators. Students were organised in groups of 5 and they were also asked to align their group expectations and collaborate in preparing a code of conduct for their group.

To get the students started on future thinking, we began by introducing 'Futures literacy'. They were individually asked questions guiding them into their thoughts of the future. Questions such as: Do you think the future is predictable? When is the future? How far do you plan ahead? etc. After a short presentation, the students joined their groups in breakout rooms to discuss their individual answers to the 'Futures Literacy' concept.

4.2 What is Scenario Thinking?

In the second session, the focus was narrowed to: What is the future of engineering education? The students were introduced to 'strategic foresight' where the overall idea is to avoid making perfect predictions of the future but instead to consider a range of potential scenarios or possible future. To do this 'driver mapping' was introduced which is a critical tool used to help identify high-impact and high-uncertainty drivers, the factors and the forces of change.

Based on the introduction to strategic foresight and driver mapping, the students again worked in their groups on a 2X2 Scenario method to develop a set of future scenarios based on the analysis of drivers of change. This method involves two axes based on positive or negative considerations of each driver of change and provided outcomes resulting in four scenarios depending on the combination of issues identified in each axis. They came up with scenarios on the topic of future engineering education.

4.3 Backcasting

In session 3 the students were introduced to the 'Backcasting Technique', again a short presentation by the facilitators. Based on the scenarios they imagined in Session 2, they were asked to apply the Backcasting Technique to one of these scenarios. In effect, they were asked "What do we need to do today to reach that successful outcome of our scenario?" In groups, the students started from the baseline (current state) and through creative solutions and prioritization they stepped back to their scenario on future engineering education. Student were provided with a template to assist them in their process.

4.4 Roadmapping

Session 4 was dedicated to students making a 'Roadmap' by determining the best future and the best road to get there. Again starting from the current situation and by considering different realisms and expectations, the students were asked: "How do you know if something is possible? What criteria might you use to prove that something is possible?" The students worked on a template for strategic road maps asking themselves the three questions: Why? What? and How?

4.5 Designing a Monster

In this session the intention was to gather the threads and 'Design a Monster'. The Monster was based on the previous days future thinking exercises and focussed on scenarios of the future of engineering education. The students were asked to go one step deeper and apply the methods and tools introduced earlier to "Design a Monster", thinking of "How to become an engineer in the future?" As the workshop was held online the only possibility for a Monster was a video – materialising a scenario often brings out new perspectives and ideas and often makes a presentation more engaging and visual. The students were asked to show illustrations/mind maps/mock-ups/prototypes of their Monsters and to prepare a short video (5 minutes) where they, as a group, tell and show (sing or dance) their monster.

5.0 Future Scenarios of Engineering Education

In this section of the report, we present the future scenarios which were created in the learning and teaching activity. A written scenario does not adequately reflect the creativity provided in the videos, so short summarises are provided here. Please refer to our project website (www.astep2030.eu) where the original videos created are uploaded and available for review.

Scenario 1 – Back to the Future

The video opens with students chatting about their weekend at the back of a lecture hall. One student describes an event which happened to him at the weekend where he travelled in a car such as that used in "Back to the Future". He was transported to another realm, the future in 2045. He describes how he visited a University in the future, where students spoke their own language and used a piece of technology held to their throat to translate it for others. This future university did not have any lecture halls, students sat in pods connected to a laptop so that 1,000 students could attend one lecture. The dining hall used tablets to order food from any country which was delivered to your seat by drone. He also described a watch which was connected to a person's brain, in effect students could look up anything on the watch and it would automatically be translated directly to a student's brain, removing the need to learn knowledge!

Scenario 2 – EPS Out of the Book Podcast and Vision Water

This scenario is described through a podcast and introduces a new software system called EPS "Engineering Positioning System". The EPS system is a metaphorical GPS used to guide engineering

students through their engineering educational journey, in the "fastest, easiest and clearest way possible", removing all bumps in the engineering education journey, guiding students to a new ways of studying. The EPS will help students to decide upon their majors and it's an integration of engineering education into everyday life so that engineering as a career choice becomes more attractive. The podcast finishes with an advert for a new product called "VisionWater", a drink which combats all difficulties engineering students face. One sip gives you access to attain the skills you need to be an engineer. "Side effects include creativity, sharpened technical knowledge, motivation, enthusiasm, critical thinking skills and clear problem solving!"

Scenario 3 – Interview with STEM Agent and College Graduate

Scenario 3 was presented as a radio interview with a mother and daughter reminiscing about the past (in 2021) and comparing college life now (in 2031) with how things were in 2021. We are reminded about the impactful changes we have experienced in 2021 with the move to online learning and the COVID pandemic and what aspects of these changes have continued forward to 2031. Universities in 2031 have a hybrid system with access to tablets for all students and textbooks provided in many languages. Paper based examinations are gone with a positive impact on the environment and Artificial Intelligence has greatly assisted students. The future sees great collaboration between universities around the world and more industrial experience and internships through partnerships with companies. The interview process has also changed dramatically, with the rigid hierarchal structure having been replaced by more creative ways of interviewing. They introduce us to a Career Based Exchange programme (much like a student exchange) where engineers work around the world to gain different experiences and to help even out the imbalance of engineers around the world. Finally, societal norms have changed and this along with equal opportunities and good wages has encouraged many more women to become engineers!

Scenario 4 – The Future of Education

This group presented a scenario of the future of education which included six aspects:

- Free Education for all. They envison a future where education is free, allowing equal opportunities for people with different financial backgrounds which will increase diversity.
- Personalised Education. In this case, students are in charge of their own curriculum and they can optimise their own learning according to their learning style. They plan their own schedule to suit their circumstances.
- Virtual Reality as a learning tool. VR will allow students a more interactive environment which will stimulate creativity and give them access to realistic scenarios.
- Robots as Educators. Robots are proposed as educators to remove bias in the treatment of students, so that there will be a non emotional approach to teaching and efficiency in time management of lessons.

- Accessibility to people with disabilities. The future of education will be accessible to those with disabilities by using a digital campus and techniques such as voice activated learning.
- Holograms as a communication tool. The future of communication will not be virtual team meetings online, but holograms of each person meeting in a virtual space. The benefits include less commuting, reduced transportation costs, reduced carbon footprint and a reduced risk of contracting disease. Holograms are proposed as a way to stimulate social interactions as participants feel they are meeting someone in person.

Scenario 5 – How to become an Engineer in the Future

In this scenario we are introduced to a personal AI Mentor for every student. Over time, the AI mentors will learn the learning styles, strengths and weaknesses of the student, and using this experience will utilise those strengths to teach the student in the most appropriate way. The personalised system allows students to learn in their own way and at their own pace, meaning no student will be left behind. The future will have a standardised and globalised STEM education programme based on technology, where students can learn from anywhere in the world. The curriculum will be standardised across the whole world and education will be free to all. Following the standardised STEM programme, students will be exposed to a virtual gamification programme as a method of learning in the future. Each student will have virtual character with roles and responsibilities and will take on hands on labs and projects as learning by doing is the best way to learn. Engineers in the future, will not be educated by Universities, but by specialised engineering education provided by companies. Future engineers will learn on the job from experienced engineers (such as the apprenticeship / master) model and will be paid to learn, not pay for learning. Benefits of learning directly with the company means that engineers will neither be "over skilled or undertrained".

Scenario 6 – Robotic Assisted Teaching

Key drivers which impact this scenario include Robotic Assistance, Quantum Computing, Virtual Simulation, AI, Miniaturised Nuclear Generation, Neural Implants and Lightspeed and Time Travel. The key drivers considered in this scenario for the 2 x 2 exercise included Quality of Education and Technology. The best case scenario in the case of technology advances and good quality education resulted in a skilled workforce with much innovation, longer life expectancy and more productivity. In this scenario, robotic assisted teaching will yield better results, in a world which is less stressful and more productive. Personalised lessons for students allows for specialisation and the robots also ensure that students progress is tracked. Virtual simulation of laboratories has become the norm in this scenario, building from experience such as flight simulators currently used for training pilots.

Scenario 7 – Artificial Intelligence in Future Engineering Education

Artificial Intelligence is at the core of this scenario which recognises that every student has different learning needs. AI provides an adaptive, personalised experience to deliver on each one. With customised, just in time feedback and contextual hints designed to help solve problems, students excel on the learning pathway built just for them. As students work, AI tracks each action and plans the next activity accordingly. AI is divided into 4 streams including;

- Human-Robot interaction (machine learning techniques and soft computing for vision and learning),
- AI based streamlining of course contents online based on student interest and level of understanding and predictive models for rendering course content.
- There will be Artificial Intelligence agents for the Teaching and Learning experience which includes a capability to deliver in a multilingual fashion and problem solving and decision making support mechanisms.
- AI will also assist with smart classroom design, assessing student behaviour, bridging students' skills and understanding levels and finally an AI for assessing the learning experience.

Scenario 8 – The LEGO Educational Model

This scenario uses the concept of Lego to explain how the future of engineering education will look. "Like LEGO, at the beginning, each one has the same shape and the same size, but with imagination, different outputs are created from the same input". The scenario describes a "HAT DAY", a day when students from primary school find out what they STEM path will be. Primary students wear a hat equipped with AI and walk across an automated path equipped with sensors. As the student walks, both the hat and the path scan their mental and physical abilities. This assessment decides what their career in STEM will be. Children start their careers from this point using their creativity and imagination in problem solving and innovation.

6.0 Conclusions

This report described the methodological approach used in the A-STEP 2030 Summer School to help students develop the skills needed to create future scenarios. The task also aimed to create future learning scenarios which could be used by engineering educators to orientate their student's thinking skills to the future. Eight scenarios were presented which were co-created by academic partners and student participants at the Summer School.

There were some general themes observed in the scenarios presented by students which included:

- **Facilitation/mentoring/tutoring** – A robot/Artificial Intelligence to mould the *personal* studying/learning process: making it easier, more accessible, immediately comprehensible and in accordance with the student's own learning style
- **Communication & comprehension skills** - a focus on "absorption" rather than confusion, stress or inefficiency

- **Transparency & coherence** within the/their educational path (incl. self-chosen curriculum)
- **Open global & hybrid access** to information/knowledge. Accessible & unrestricted education without geographic or language barriers
- **Learning through doing** - meaning application & practice eg. through industrial "on the job" experience & internships; through AI & simulations
- **Unbiased & personalized assessment**
- **Access to and involvement with frontline technology**
- **Diversity** – education which is available to all, those with disabilities, more inclusion of females etc.

The variety of scenarios provided give an insight into the challenges and opportunities that engineering educators and engineering students will face in future years and can be used as a discussion tool for both students and academic staff.

7.0 Acknowledgements

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