e-CLOSE

INTERACTIVE (A)SYNCHRONOUS ONLINE STEM EDUCATION

Photo by Ilyuza Mingazova on Unsplash

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

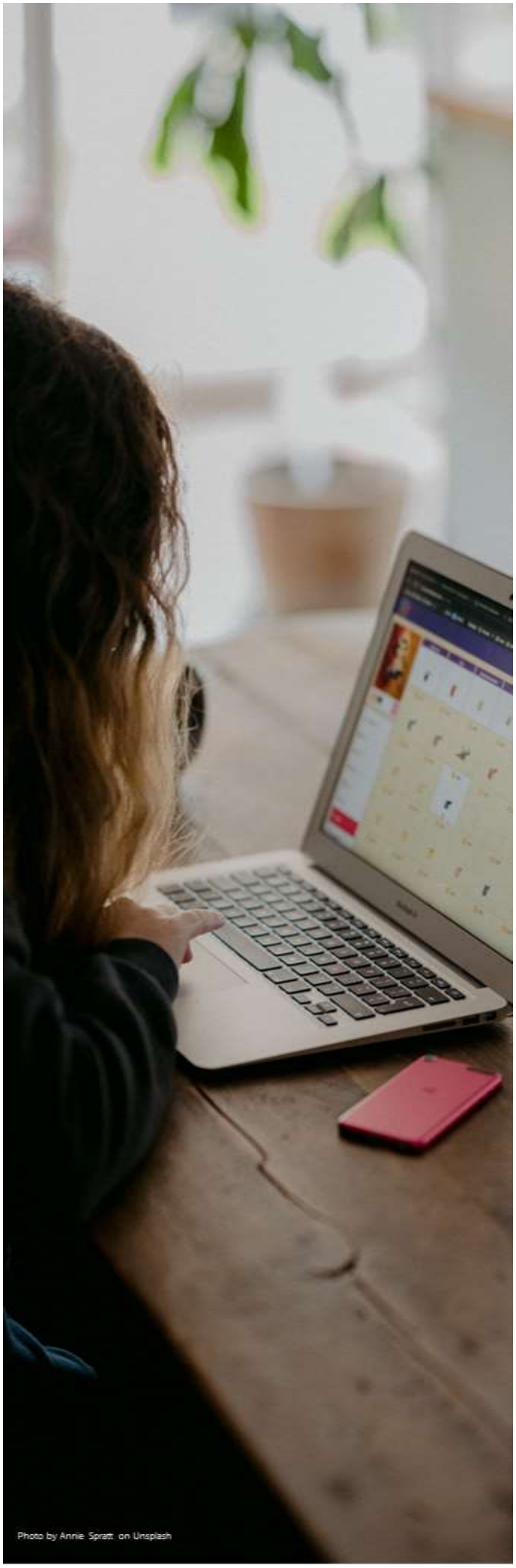


Photo by Annie Spratt on Unsplash

TABLE OF CONTENTS

1. INTRODUCTION

The e-CLOSE Project (A Model for Interactive (A) Synchronous and Synchronous Online Stem Education) started during the COVID-19 outbreak, which had a significant impact on higher education all over the world. Universities had to rapidly transform their study programmes to be delivered online to keep student retention and maintain access to learning. The adjustment, however, comes with significant challenges not only in relation to the technical aspects of handling several hundred online lectures simultaneously, but also to the methodology of the teaching process and the teacher-student interaction. The technological development and wide availability of basic ICT tools made the shift to online education relatively easy. The real challenge, however, is to consciously choose available collaboration tools and engagement methods to arouse student interest and provoke a response for a more efficient and effective communication and learning experience while away from a traditional classroom. To face that challenge, the universities involved in the project – Lodz University of Technology (TUL), from Poland, University of Applied Sciences in Saarbrücken (HTW Saar), from Germany, University of Alcalá (UAH), from Spain, and University of Aveiro (UA), from Portugal – decided to join forces for the development, implementation and dissemination of innovative and comprehensive teaching and learning solutions, supported by advanced IT technologies and tools, to increase the level of student-teacher interaction during online education.

To achieve this goal, the project was divided into six areas, **our six "Intellectual Outputs" (IO)**:

1. Methodology of Interactive Asynchronous and Synchronous Online STEM Education
2. Distance Teaching Toolbox for Educators
3. Teacher Training Courses
4. Smart Gamification Based on Multiple Intelligence Theory
5. Online Badges for Sustainable Education (21st Century Skills)
6. Guidelines and Recommendations

The project is directed towards students and academics of the consortium universities and beyond, ready to bring the ICT technology to the forefront when facing the challenges of online education.

To further benefit the project participants, the consortium offered a series of training opportunities for academic teachers, tailored to their individual needs, to increase their competences for effective online teaching, arousing student interest and responsiveness. Students got the chance to meet in several of the partner universities to conduct a gamification learning experience in the blended formula and to develop the 21st century skills sought by the labour market.

::. IO1: Methodology of Interactive Asynchronous and Synchronous Online STEM Education

The aim of this IO was to conduct research in distance learning, in particular the difference between conventional face-to-face education and what came into being as (emergency) remote

education caused by the pandemic situation of COVID-19. Introductory research was carried out in all partner universities with respect to implemented solutions, followed by a broader look at what happened across university campuses worldwide. Special attention was paid to four specific stages of the teaching and learning process: preparation, delivery, assessment, and evaluation. It is expected that the knowledge gathered through this research might serve as a benchmark or inspirational resource for different higher education institutions (HEI) in Europe and beyond.

::. IO2: Distance Teaching Toolbox for Educators

The aim of this IO was to diagnose needs and tools to support effective education using remote methods and techniques. This IO provided two main outcomes: i) comprehensive knowledge of possible teaching methods that stimulate interaction with students and make online learning very active rather than passive; ii) to sketch the main challenges and innovation initiatives required to match the current needs for active online learning, based on the state of the art. The toolbox is public and completely available, so that any interested persons can either benefit from it or contribute to it. In this way, the product allows for a lot of updates and has the potential to be relevant for decades to come. Moreover, it will be easy to implement in any type of HEI. To this end, the database was populated based on GitHub, which is the most popular framework for open-source project development and shared communities (allowing contributions, downloads, forks of project, pull requests, etc.).

::. IO3: Teacher Training Courses

The aim of this IO was to comprehensively train teachers from partner universities on innovative and active methods. As part of the training, the participants also learned about interesting methods for assessment of learning outcomes achieved through online learning. As part of this IO, teachers were trained with various techniques related to active presentation, selected among the most popular active methods used in partner universities. It provided alternative solutions to typical online presentations, with an attractive alternative to the use of Powerpoint presentations. It also empowered teachers at partner universities to produce out-of-the-box ideas for teacher training courses. As a result, it is expected to result in more impactful teacher engagement, more fun for teachers and students, and lower burn-out rates. Thus, the teachers from partner universities were trained on implementation of visual thinking in didactics. There was also training on the use of “badges” with the analysis of online assessment methods, as well as on smart gamification.

::. IO4: Smart Gamification Based on Multiple Intelligence Theory

The aim of this IO was to increase student engagement during distance learning classes, to help students to be engaged in learning and to give students additional motivation (intrinsic and extrinsic) to spend more time studying through the means of gamification. To cater for the needs of different groups of students, a customized approach seems to be the key. A general concept of smart gamification was developed with sample models for different types of classes (lectures, tutorials, seminars, labs, projects, etc).

::. IO5: Online Badges for Sustainable Education (21st Century Skills)

The aim of this IO was to implement a tool, or platform, through which teachers can create and award digital badges. Students also independently documented, reflected and provided evidence of their competences. Students earned badges by completing sustainable education

challenges. This IO served as a transversal framework to validate transversal skills, classified into two types: soft skills, and sustainable development goals skills. As a result, transnational recognition of skills could be improved, with badges being easily transferable through social media, which can be very useful for different interest groups. Moreover, the whole methodology behind creation and awarding badges can be easily transferred to any area or discipline.

::. IO6: Guidelines and Recommendations

The aim of this IO was to summarise and disseminate results of the project in partner institutions and beyond. This IO was focused on the preparation of a set of concise recommendations, which are useful for different groups. The dissemination activities allowed to spread the information of the e-CLOSE results. As the problem analysed by the project is relevant, it is expected that there will be a considerable interest among academic teachers in solutions that it will offer.

2. PROJECT PARTNERS

Lodz University of Technology, Poland (Project Leader)

Lodz University of Technology (TUL) is a public technical university established in 1945. It ranks as the 4th best technical university and the 3rd most innovative HEI in Poland (Perspektywy University Ranking 2021). It offers 60 engineering study programmes taught at 9 faculties for over 13 thousand students. Doctoral training is provided by the newly established Interdisciplinary Doctoral School (IDS) which offers multiple unique prospects of development for PhD students. TUL's staff consists of over 1500 academics committed to providing high-quality education with the use of innovative student-oriented teaching methods.

University of Alcalá, Spain

Universidad de Alcalá (UAH) dates back to the 16th century, when it was established as a higher education college. The University offers degrees in five branches of knowledge: Arts and Humanities, Law and Social Sciences, Sciences, Health Sciences, and Engineering and Architecture. Its approximately 30,000 students are spread across three campuses, hosting 16,000 Undergraduate Students, 13,000 Graduate Students, 2,100 Teaching and Research Staff, 800 Administrative Staff and 450 Research Assistants among 140 Research Groups. It offers 38 Undergraduate Degrees, 46 Research Master's Programmes and 25 PhD programmes.

University of Aveiro, Portugal

Universidade de Aveiro (UA) was founded in 1973 and now has over 15000 full-time students (graduate and postgraduate). The University has a strong research profile, a unique model of governance (16 Departments, 4 Polytechnic Schools and various training centres), acting as a regional network for education and training promoting strong links with the surrounding community and is a pioneer in Portugal and Europe in launching degrees in new subject areas.

University of Applied Sciences Saarbrucken, Germany

The HTW Saar University of Applied Sciences (htw saar) is the largest UAS in the federal state of Saarland, Germany with a population of 6000 students and more than 900 international students from 76 countries. It is a public tertiary higher education institution offering accredited undergraduate and postgraduate degrees. Education is embedded in real professional life scenario where students apply their theoretical knowledge into real cases from industry.

3. FIVE OUTPUTS FROM E-CLOSE

In this section we describe in more detail the first five outputs of the project. Output IO6 is the present report containing the description of the e-CLOSE project, the results obtained, reflections and recommendations.

① Methodology of Interactive Asynchronous and Synchronous Online Education

To understand how teachers and students dealt with the drastic shift to online education due to the COVID-19 pandemic, two surveys were performed, involving teachers and students from the four partner universities of the e-CLOSE project.

Surveys: the two surveys focused on different issues connected with distance learning, in particular the difference between the traditional face-to-face education and the emergency remote education caused by the COVID-19 pandemic. The questions of the surveys were divided in five categories:

1. General: general questions about the respondents' profile (gender, age, level of studies, etc.).
2. Preparation: questions that deal with the preparation of classes and are mainly related to distance learning tools and techniques.
3. Delivery: questions that are connected with the process of knowledge delivery.
4. Assessment: questions related to different assessment models and difficulties encountered in their application.
5. Evaluation: questions aimed to measure the overall degree of satisfaction with online education.

The questionnaires included questions of the following types:

- Closed-ended questions, allowing for enumerating the most used tools and/or learning/ teaching methods (suitable for quantitative analysis).
- Three/five-point Likert scale questions, indicating how much the respondents agree/disagree with a given statement.
- Open-ended questions, identifying the major challenges that the students and teachers faced during online education (suitable for qualitative analysis).

To analyze the answers to closed-ended and Likert scale questions, Excel spreadsheets were used. The answers to open-ended questions were analyzed by the authors qualitatively. The results were organized in the form of four reports, one for each partner university (read the reports by following the links):

- IO1 Report TUL
- IO1 Report UAH

- IO1 Report HTW Saar
- IO1 Report UA

The surveyed students and teachers rated Zoom and MS Teams as the most effective communication platforms, while the most popular applications were Padlet, Kahoot, Mindmap, and Mentimeter. Both teachers and students agreed that face-to-face communication with cameras on is a very important aspect in distance education. Teachers and students agree that the most effective activities for online learning are having expository demonstrations from the instructor, solving exercises, watching videos, and completing group tasks.

The results and documents produced by the Consortium highlight some of the problems faced by both teachers and students in distance education such as the lack of motivation from students and shortage of modern equipment and/or training from the teachers' perspective.

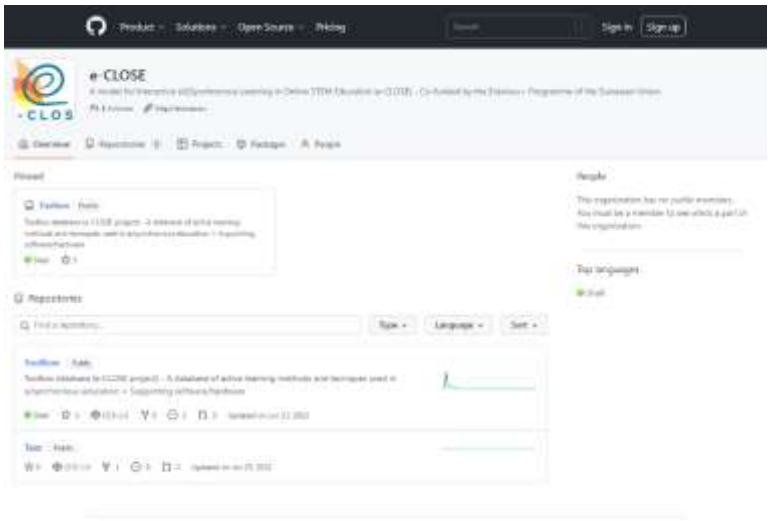
2 Distance Teaching Toolbox for Educators

To support effective education using remote methods and techniques, we researched and compiled a broad array of teaching resources which are organised in three tools: a Teacher's Guide, a Toolbox Database and a Survival Kit.

Teachers Guide: this tool emerged as a compilation of methodologies from the analysis performed during the course of the e-CLOSE project. Diverse active methodologies were examined and classified to generate a quick guide for teachers. The implementation was performed in a web-based interactive framework (Genially), so that it could be user friendly and open access. This interactive guide can be accessed at https://view.genial.ly/6244d9ff4f9a09001871c361

The toolbox database was created based on an analysis of open tools (applications and software) and resources (video, images, audio, etc.). A comprehensive list of more than 100 items was classified. The toolbox can be accessed at the GitHub platform using the link:

https://github.com/e-CLOSE. We envisioned an open listing of resources and references that could be accessed and edited by many people in the future, and that is why GitHub was selected, as it can classify materials by keywords and, at the same time, it allows the submission of new items by anybody registered.



Survival kit: When developing the survival kit, we followed a similar approach to the teacher guide, but with a focus on potential problems in online teaching and methods to implement before and during a problem/issue in online class. For this reason, the same platform (Genially) was chosen, which generated an online web, as well as PDF and MP4 versions of the document. These can be accessed at: https://view.genial.ly/622e6856f15c6f0018d1007b

The toolbox and survival kit were designed with sharing in mind and the appearance Communities of Pedagogical Practice in Europe (e.g. the ColLab platform) provide ample opportunity to participate and share within academic communities in Europe and indeed around the world.

3 Teacher Training Courses

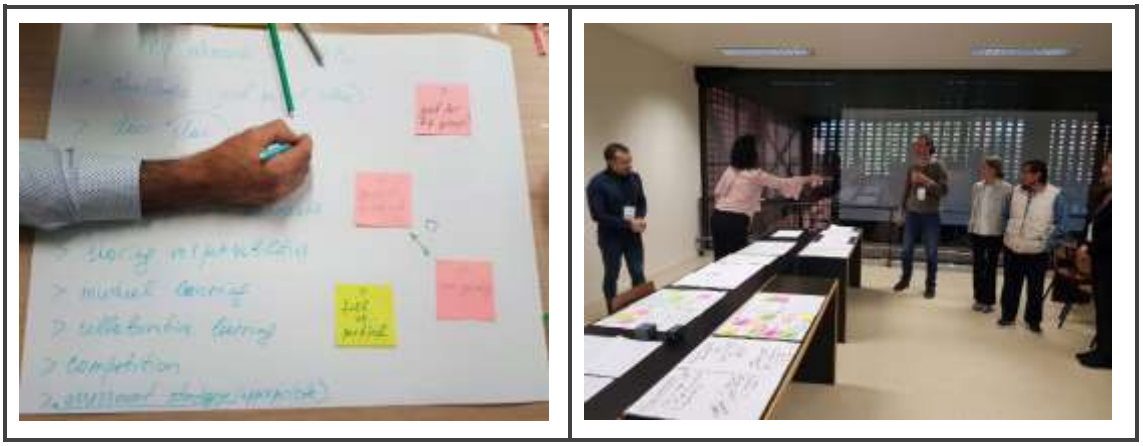
The e-CLOSE project held four teacher training courses.

- Visual Content
- Innovative Student-Activating Methods
- Badges
- Smart Gamification

With the goal of familiarizing teachers with a set of concepts, methodologies and tools to leverage visual content in their daily classes, the training course on **Visual Content** looked at different tools and methodologies in which some type of visual content would facilitate effective learning in higher education. The course covered an introduction to Visual Thinking, Visual creation in 3D + other environments (music/poetry), Visual communication, Visual-based game-based learning, Audiovisual communication and Creation of videos- familiarize the teachers with a set of concepts, methodologies and tools to leverage visual content in their daily classes. Including visual content is not so difficult (since there are many available resources) and it is not necessary to be an expert in arts to do so.

Alcalá, October 17-21, 2022

The teacher training on **Innovative Student-Activating Methods** concerned a selection of methodologies, which could be effectively applied both in classroom and online and may suit individual and group study. The training included presentation of advanced features of popular video-conferencing tools (such as *Zoom* and *MS Teams*) and hands-on experience on selected active teaching methods (such as *explore first*, *mind mapping* and others). The training aimed at rising the students' retention rate of information learned through experimenting and varying study methods. The goal of the training was to expose teachers to a number of active teaching methods and to help them to incorporate those methods in their teaching practice. The explored student activating methods were: the cooperative learning pedagogical model; multimodal mapping methodology; role-play; project-based learning. Some of the training activities were hold in the form of workshops, where the trainees could test the considered tools and fulfil certain assignments either in groups or individually.



Aveiro, November 21-25, 2022

The training course **Micro Credentials and Badges** was focused on badges that can be used by the teacher to increase students' engagement. It includes knowledge what kind of badges can be introduced and what could be the online badge award procedure. The training includes peer learning activity workshop on online assessment. The goal was to familiarize the teachers with idea of badges, how the badge can be created and implemented and what are the benefits of using them.

Lodz, January 23-27, 2023

The training course **Smart Gamification** was dedicated to the use of game design elements in non-game contexts to increase motivation. It included presentations of some models of gamification and gave clues about how to plan and implement this process. Here, the goal was to empower and motivate teachers to use gamification in teaching and learning activities. To achieve that goal, the idea, assumptions, process, and possible models of gamification were covered.

Saarbrucken, 30 January – 3 February, 2023

4 Smart Gamification Based on Multiple Intelligence Theory

In our project we experimented with gamification towards finding ways to help students and teachers to be motivated in online education.

Virtual Campus: The WBS Learnspace 3D®, a virtual campus, was used for distance classes from all partner universities for two semesters. Students and teachers could build their own avatars, walk around freely on this virtual campus, hold classes in the auditorium, have group meetings in smaller rooms or on the terrace, have a coffee break in the lobby or search for books/documents in the library. A survey with the Technology Acceptance Model was conducted and the results show that students felt comfortable in this virtual world and it was easy to use. Even though the relationship between classmates themselves and to the teacher are easier to develop in the real world.[1]

Screenshots from The WBS Learnspace 3D®

Two student exchange workshops (in Lodz, Poland and Saarbrücken, Germany) with the topic of gamification took place where students could experience game-based learning methods. Gamification is a didactic process that increases students' motivation by awarding points for progressive achievement.

[1] A teacher guide is available at tinyurl.com/GuideGamification while a discussion of Gamification models based on Gardener Classification can be read at tinyurl.com/GamificationModels


1st Student Workshop, Lodz, May 9-13, 2022, 20 students


2nd Student Workshop Saarbrucken, June 7-11, 2022, 20 students

When analysing level of student's engagement during face-to-face and during online classes, and comparing it with classes conducted with elements of gamification, we observed that students are enthusiastic about gamification. The customized approach for gamification based on Gardner Classification (Musical-rhythmic and harmonic (MUSIC SMART); Visual-spatial (PICTURE SMART); Verbal-linguistic (WORD SMART); Logical-mathematical (NUMBER/REASONING SMART); Bodily-kinesthetic (BODY SMART); Interpersonal (PEOPLE SMART); Intrapersonal (SELF SMART); Naturalistic (NATURE SMART); Existential (LIFE SMART)) provides a new insight into student motivation and engagement. Activity types in every mission were adapted according to Gardners Classification on Intelligence types. The results can be seen in the project downloads, available at http://eclose.p.lodz.pl/. A Teachers guide for smart gamification approach in the format of a mind map and gamification models based on Gardner Classification were developed within the project team and is available at tinyurl.com/GuideGamification. These products can help other teachers who are interested in gamification/ game-based learning to see different methods that can be used and be inspired. The results were presented at three conferences Innovating Higher Education in Bari (Italy) in 2021 and in Athens (Greece) in 2022, and 1st Conference on Online Teaching for Mobile Education online in 2021.

5 Online Badges for Sustainable Education

The aim of this activity was to implement a tool or platform through which teachers can create and award digital badges. Students were able to independently document, reflect and provide evidence of their competences, earning badges by completing sustainable education challenges.

Badges are non-formal recognition marks for transversal competences gained by learners and documented on a badge platform, which may be connected with social media pages or even the University's formal records. Nevertheless, badges are not understood to provide a formal qualification for accredited teaching and learning processes, whereas micro credentials are. In e-CLOSE, we used Open Badge Factory and tested a suite of badges during the 21st Century Skills Survival Camp, designed to learn more about topics related to the UN Sustainable Development Goals. This initiative took place from July 9th to 13th, 2022, at the Mazury lakes in Poland.

During the student camp, which involved 20 students from the 4 countries that compose the project consortium, students earned digital badges by completing challenges on topics linked to the UN Sustainable Development Goals. After successful completion of all challenge tasks, the badges' platform awarded a digital badge to the students.

4. BEST PRACTICES

The **WBS Learnspace 3D**, which is a virtual campus, was used during the project time among the whole consortium. Teachers from all groups held their STEM classes in there and students joint for lectures, group meeting and they held their presentations in there to get a grade at the end of the semester. Also, the simulation of 3D models was used in the virtual auditorium e.g., for the classes in fluid energy machines and fluid dynamics. So, international students from the partner institutions could show their graphics of wind turbines with different shapes. This virtual campus helped to keep everyone engaged in times of online education because of COVID-19. Students mentioned that it is more fun to use and motivates also with different triggers from the Gardeners laws more than classic videoconferencing tools like Microsoft Teams. It was a new experience for everyone and a great change of software. Our experiences have been published at European teaching conferences:

- Hülsmann, X.; Rückert, F.U.; Khiar, T.: Gamification in a blended exchange program; Innovating Higher Education Conference 2022 (I-HE2022); AthenS (Greece); 19-21 October 2022; https://i-he2022.exordo.com/programme/
- Rückert, F.U.; Hülsmann, X.; Junker, A.: Smart Gamification based on Multiple Intelligence Theory in STEM modules; I-HE2021 - Higher Education in the new normal: the role of online, blended and distance learning; Innovating Higher Education Conference 2021 (EADTU); ISBN: 9789079730483; 3-5 November 2021, Bari (Italy); https://conference.eadtu.eu/download/2630/
- Rückert, F.U.; Hülsmann, X.; Junker, A.: Multiple Intelligence Theory for Gamification of Online STEM Modules; 1st Conference on Online Teaching for Mobile Education (OT4ME! 2021); 22-25 November 2021, Alcala de Henares (Spain); https://ot4me.web.uah.es/

Our future plan is to develop our own virtual learnspace for teaching, even new techniques as VR (virtual reality) should be introduced, while also remaining attentive to the appearance of ever-new, and often less expensive technologies, including in the Multiverse.

Jigsaw experience: This activity follows the collaborative learning method known as Jigsaw or Group Puzzle, (Aronson, 1978), which consists of dividing the students into groups and assigning each of the students in the group a part of the content. It is important to allow sufficient time for study and reflection. Afterwards, the students from the different groups that have been assigned the same content are brought together so that together they can resolve any questions they may have and so that each student can find the best way to explain his or her part to the members of his or her team. Finally, the students meet with their respective teams and each student presents, exposes or explains their part of the contents to the rest of

the members of their team.

The experience, with some variations to the original method, was carried out in 5 different subjects of the computer science degrees of the Polytechnic School of the University of Alcalá. Thus, in each activity there was a student with the role of leader or expert who oversaw organising the study meetings and making sure that the whole group understood the content. The expert role rotated so that everyone was an expert in some activity. At the end of each activity, the students evaluated the work done and the help given by each member of the team. The teacher awards points based on these evaluations.

Outcomes were presented in EIDU XIV (2022) as part of a teaching innovation project. The study examined how different forms of collaborative learning and teamwork affect the development of collaborative competence. For this purpose, the responses of 203 students and 6 teachers to questionnaires after the end of the different collaborative learning activities were analysed. The results showed a high degree of satisfaction with this type of method among the students, and a significant relationship between the students' playfulness and the development of collaborative competences. From the teachers' side, there was a significant improvement in the teachers' opinion of its implementation. It was easier and they felt more comfortable than expected.

Further experiences using methodologies such as gamification or active learning have been detailed at publications such as Estriegana, R., Garcia-Esteban, S., Rojas, E., & Medina-Merodio, J. A. (2021:124-131), available at https://ieeexplore.ieee.org/abstract/document/9638830). The outcomes were also described in the communication "Analytics and predictive models of student's activity in off/on-line learning environments" presented at the 1st Conference on *Online Teaching for Mobile Education* OT4ME (https://ot4me.web.uah.es/index.html#schedule). The outcome of this practice was to identify the relevant factors that influence most in teaching and the academic outcomes in engineering. For this purpose, on the one hand, the team developed online tasks within an online learning environment through virtual laboratories and analysed interactive activities and game-based learning techniques. On the other hand, participation in face-to-face activities were evaluated. The correlation of different parameters was studied and models that allow predicting whether a student would pass, were applied. The results obtained are expected to allow personalizing the educational experience and help in making decisions to improve learning. Furthermore, findings suggest a strong correlation among online practical activities, activities developed in the classroom and course outcomes.
Gamification was also implemented in the "Network Management" courses taught in Computer Science and Telecommunication Engineering degrees of UAH.

To test e-CLOSE outputs, various assimilation and **Flipped learning activities** were proposed outside the classroom at UAH online subjects such as "Computer Assisted Instruction".
This was developed with the supervision and support of the teacher using different resources and techniques (i.e., videos, online critical readings, collaborative Padlets and infographics, Web

questionnaires on DigComp., etc.) to promote active learning in class. This can be replicated in coming courses and different subjects. Flipped classroom was also implemented working in small groups collaboratively in "Computer Networks" courses taught in Computer Science and Telecommunication Engineering degrees at UAH.

The **toolbox database** was proposed in UAH subject "Computer Assisted Instruction" as a repository to create digital Lesson Plans for teaching English as a Foreign Language (TEFL). To familiarize users with the tool, the TEFL student-teachers had to reflect and explain how they could use at least 5 tools in the classroom. This can be replicated in coming courses and different subjects.

University of Alcalá (UAH) **Innovation project ColaboraTec**, developed separately from e-CLOSE, but with clear synergies brought on board members of the e-CLOSE team to propose an institutional innovation project that would structure and carry out innovative approaches to teaching with the aim of determining teachers' needs and online tools that promote effective education. The achievement of these objectives helped to outline the main challenges and initiatives necessary to meet the current needs of collaborative learning and to make a joint proposal for the methods and resources that stimulate interaction and active learning. UAH members participated in UAH Conference "XIV Encuentro de Innovación en Docencia Universitaria (EIDU)" to share findings from ColaboraTec -UAH Innovation project and disseminate e-CLOSE UAH outputs. This practice will be published at Garcia & Estriégana (accepted for publication in 2023).

The **survival kit** was leveraged as a quick guide to check before online classes and obtain good ideas in case of problems. As it provides hints to help in diverse situations, and even to anticipate them, professors can check it from time to time to avoid online teaching problems, and also suggest or ask about solutions for other problems they would find, which would be included in the guide as well.

Training teachers in active learning methodologies along with ICT tools was highly valuable (in our project we covered «Visual Content», «Innovative Student-Activating Methods», «Badges» and «Smart Gamification»). The visual content training provided numerous solutions for using visual elements in teaching and learning settings, irrespective of academic field. We also learned that the software for awarding digital credentials like badges is not complex but is rewarding for both students and staff, while the use of smart gamification provides powerful

returns on the investment in training, as we outline in this report. The point being, of course, that training is decisive – and when carried out among peers in attractive and inspiring settings (like the Masurian Lake District of Poland!), training is a true game changer for the future of higher education.

Research on the best online teaching and learning practices that would be beneficial for distance, blended and traditional on-campus education within STEM courses, was conducted by the e-CLOSE team and published in three articles:

- Skliarova I., Meireles I., Martins N., Tchemisova T., and Cação I. Enriching traditional higher STEM education with online teaching and learning practices: student's perspective. Educ. Sci. 2022, Volume 12, Issue 11, 806.
- Skliarova, I.; Meireles, I.; Tchemisova, T.; Cação, I.; Martins, N. Teachers' Appreciation of Benefits and Shortcomings of Online and Blended Higher STEM Education. Educ. Sci. 2023, 13, 338.
- Rojas, E.; Hülsmann, X.; Estriegana, R.; Rückert, F.; Garcia-Esteban, S. Students' Perception of Metaverses for Online Learning in Higher Education: Hype or Hope? Electronics 2023, 12, 1867. https://doi.org/10.3390/electronics12081867

The analysis of the students' survey results allowed delivering some recommendations, mainly aimed at increasing the students' motivation and engagement as well as identifying their in-class activities that are directly correlated with the students' appreciation of their progress and outcomes. The students indicated the most efficient actions for improvement of their learning environment and their favourite activities during online classes. From the research, it becomes clear that much more interactivity is expected from the teachers, who should be enthusiastic enough to gain and keep the students' attention during the synchronous activities, and that students consider active learning effective. The analysis of the results of the teachers' survey allows us to conclude that the majority of the academic teachers surveyed prefer face-to-face teaching to distance teaching. Teachers indicated that it is a challenge to keep students motivated during online classes, reported a lack of immediate feedback from students, mentioned that they could not follow students' progress from a distance and that they missed contact with students and colleagues.

5. REFLECTIONS AND RECOMMENDATIONS

- Gamification – give it a whirl!
- Making an impact
- Students' recommendations for more engaging distance classes
- Teachers' recommendations for more engaging distance classes

Gamification – give it a whirl!

The results and documents of this project show that gamification is an innovative teaching method and motivates the students (and the teachers as well). Teachers who are interested and want to try something new, can get inspired by many different fields of application that teachers of all partner universities used for gamification. Furthermore, teachers can see how the Gardener Classification can be implemented in gamification workshops and how teachers can address the different intelligence types of their students.

This output gives other teachers the chance to see different gamification methods for class and to consider that all students learn differently and to use special methods for different needs. Recommendations for teachers is to use gamification in class. The theory of multiple motivation is not new and was used in several ways, especially in the 1980s. However, this can be seen in a new light in combination with the lack of motivation during the pandemic homeschooling and the decrease of stimuli. Howard Gardner understands intelligence as several abilities and skills that are necessary to solve real-life (genuine) problems or to overcome difficulties in a certain cultural environment. This includes the ability to recognize new circumstances and thus lay the foundation for the acquisition of new knowledge.

1. Use games in class to motivate students.
2. Do not be shy! Try new gamification methods in teaching.
3. Think of different innovative methods to engage students.
4. Don’t be afraid to fail (sometimes you will). Learn from it and try again.

We found that the simplest idea was to use Gardner’s classification efficiently is to award students with badges (find out more)

Further research: How can gamification contribute to lifelong learning and not only to motivation of students during one class? As the virtual learning will be forced in future e.g., by companies like META a free European framework for teaching will be needed. At our smart gamification workshop an introduction to new techniques like Unity Game Engine and VR (virtual reality) glasses have been given and first examples where developed.

We concluded that in general the concept of Gamification STEM Learning is flexible - it can be implemented everywhere, but in its delivery, it has to be tailored according to students' needs. Teachers would do well to try out new innovative gamification methods to motivate students during class, while remembering that gamification is not only tech-based (use of props, artefacts and just good "old-fashioned" paper and pencil are perfectly relevant for gamification making it accessible and inexpensive). Clearly also gamification techniques can be linked with rewards like badges and digital credentials.

The possibility of virtual reality offers a much better possibility to interact with different new teaching and gamification methods. Read more on this topic: EU Projekt e-CLOSE geht in die nächste Runde – htw saar blog (htwsaar-blog.de)

Making an impact

Considering the evaluation of online learning tools and educational strategies that stimulate interaction with students, it can be considered that the Toolbox database created cooperatively in this project will help to enhance the integration of Gamification resources in the higher education classroom. Among all the tools from the Toolbox database, we can highlight the use of resources such as Kahoot for face-to-face teaching and social networks (eg. Padlet), Kaltura or Teams for online subjects following the Flipped classroom method.

Concerning the projects carried out, the training course on Visual Content contributed to detecting the main teachers´ needs such as having the camera on in videoconferences and the use of graphic tools and simulators with appropriate resources. The outputs produced (Toolbox Database, Survival Kit and Teacher guide as well as the training course on Visual Content) are replicable and can be applied in any educational area and context.

The exchange of good practices has been reflected in the Methodologies book and the repository Toolbox database https://github.com/e-CLOSE, which structures the methods and online tools revised. It is expected that this database will not only promote homogeneity in the use of technological resources by teachers but will also favour the development of the competencies and soft skills.

The following recommendations for sustaining the outputs of the project in the future can be done:

1. For academic teachers & students:

- The Toolbox database represents a useful resource in any educational subject, for both graduate and postgraduate teachers and students. In the case of education, this tool can be also acceded by student and teachers to search for digital interactive resources to create their own lesson plans or didactic units.

- Apart from the inclusion of the gamification resources recapitulated in the Toolbox database, the use of badges integrating them in the institutional platform would be recommended. This could contribute to promoting motivation and the development of

transversal skills.

- Concerning the Teacher Guide, teacher trainees can revise this material to reflect on the technology- supported pedagogic models and theories to be applied in teaching.

- The creation and dissemination of both the Teacher Guide and the Survival kit will remain useful for teachers willing to apply interactive educational technology appropriately in their classroom or to solve possible technical issues in any educational area.

- Outcomes have pointed out that engaging with content motivate students and enhance learning, and this is where visual content excels. Therefore, Training in Visual content is also proposed for any educational approach.

2. For HEIs in the area of STEM:

- The inclusion in several subjects of interactive online resources from the Toolbox database for the development of global competences through the Sustainable Development Goals (SDGs), such as Goal 4: Guarantee inclusive, equitable and quality education and promote learning opportunities throughout life for all; Goal 5: Achieve gender equality or Goal 17: Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development, contribute to the development of Global Competence (OECD 2018: 25) and, as proposed by the UN in its 2030 agenda, to achieving an education that fosters a better and more sustainable future.

- Further research would be required for the development of global competences using interactive online resources. This requires the collaboration of several members due to the complexity of its sub-competences and areas.

Students' recommendations for more engaging distance classes

The results of the student survey suggest the following recommendations (for more details see Skliarova, I., Meireles, I., Martins, N., Tchemisova, T., Cação, I. (2022)[2]:

- teachers should be more engaging and open to more innovative distance learning methods;
- teachers should be prepared to deal with lack of personal contact, eventual technical problems and students' loss of concentration;
- class attendance rate could increase by enforcing more motivation for students;
- classes should be shorter, less expositive, with more solved exercises, accompanied by interactive activities and quizzes;
- students should be more involved and engaged in the classes.

Some specific ideas mentioned for improvement in Estriégana, García & Rojas (in progress) are:

- promote the use of gamification and upload appealing videos (e.g., Kahoot);
- provide classes prepared to be taught online as a face-to-face class in which the teacher is

[2] Skliarova, I., Meireles, I., Martins, N., Tchemisova, T., Cação, I. Enriching Traditional Higher STEM Education with Online Teaching and Learning Practices: Students' Perspective. Educ. Sci. 2022, 12, 806. https://doi.org/10.3390/educsci12110806):

seen, for instance, writing on the blackboard;
- adapt online lessons so that they resemble to a face-to-face class recorded with acceptably good video and audio quality;
- deliver lessons face to face using Artificial Intelligence and make sure the students really commit to the sessions;
- turn on cameras and deliver online activities which involve students´ interaction;
- promote small group work with classmates and teacher to foster collaborative classes;
- avoid focusing on scheduled classes and make longer projects.

Finally, according to the students, exams should be substituted by written-papers or presentations, etc. and include dynamic activities –such as regular quizzes or taking surprise tests in the middle of a conference, as some suggested. A revision of the evaluation methods and the class programme trying to be comprehensive with each student situation should be also considered. This would involve rethinking the syllabus.

Teachers' recommendations for more engaging distance classes

The analysis of the results of the teachers' survey permits the following recommendations to be derived (for more details see Skliarova, I., Meireles, I., Tchemisova, T., Cação, I., Martins, N.(2023)[3]

- provide a modern technological equipment for teachers and ensure a good internet connection for both students and teachers;
- provide training sessions for teachers in active learning methodologies and in ICT tools;
- shorter lessons with smaller groups of students and incorporating more interactivity;
- apply adequate measures for fair distance assessment.

As revised by Estriégana, Garcia & Rojas (in progress) training should be also provided to avoid professors' feeling overwhelmed by the circumstances and distressed, frustrated and overloaded with work or even anxiety about the use of educational technology. Some measures should be adopted to improve the quality of distance learning. These involve greater interaction in smaller groups of students, greater use of cameras, and improving the way of evaluating. Finally, the use of active and participatory methodologies that motivate and engage learners are especially necessary in online learning.

[3] Skliarova, I.; Meireles, I.; Tchemisova, T.; Cação, I.; Martins, N. Teachers' Appreciation of Benefits and Shortcomings of Online and Blended Higher STEM Education. Educ. Sci. 2023, 13, 338.

6. PRODUCTS AND DOCUMENTS

Table 1. List of products / documents resulting from the e-CLOSE project

Title (follow links provided)	**Description**
Teacher Guide Gamification	Mind map which shows several examples how Gamification can be used in higher education (tips included).
Gamification Models based on Gardener Classification	Examples within the project are adapted to Gardeners Classification and show how it can be adapted into gamification.
Teacher guide Methodologies	The teacher guide is a compilation of teaching methodologies implemented in three different formats (HTML, PDF and MP4). Methodologies are classified based on different parameters so that teachers can easily look for them at request.
Toolbox database	The toolbox database is a comprehensive web-based database of tools and resources for online teaching. All items are classified based in different types (communication, design, evaluation, etc.) and provide quick links and guides for the resources. Additionally, the database is implemented in GitHub so it openly accepts contributions from any participant (internal or external to the project).
Survival kit	The survival kit is a quick guide that classifies potential problems in online teaching and provide methods and techniques to mitigate their effects either anticipating to them, or acting when they happen. The guide was implemented in three formats (HTML, PDF and MP4).
IO1 Report TUL	TUL report on the impact of COVID-19 on university teaching based on the surveys conducted to students and teachers.
IO1 Report UAH	UAH report on the impact of COVID-19 on university teaching based on the surveys conducted to students and teachers.
IO1 Report HTW SAAR	HTW SAAR report on the impact of COVID-19 on university teaching based on the surveys conducted to students and teachers.
IO1 Report UA	UA report on the impact of COVID-19 on university teaching based on the surveys conducted to students and teachers.
e-CLOSE Training: Visual Content	Document contains description of the Visual Content training: goal, value added, learning

	outcomes, trainers, each day content, conclusions and references.
e-CLOSE Training: Active Teaching Methods	Document contains description of the Micro Credentials Badges training: goal, value added, learning outcomes, trainers, each day content, conclusions and references.
e-CLOSE Training: Micro Credentials and Badges	Document contains description of the Visual Content training: goal, value added, learning outcomes, trainers, each day content, conclusions and references.
e-CLOSE Training: Smart Gamification	Document contains description of the Micro Credentials Badges training: goal, value added, learning outcomes, trainers, each day content, conclusions and references.
Survey about virtual campus	Reflection of the use of the WBS Learnspace 3D among students from all universities (with the Technology Acceptance Model).

The e-CLOSE Team

(in alphabetical order)

Adrianna Kozlowska

Centre for Teaching and Learning, Lodz University of Technology

The e-CLOSE project was a true adventure and a melting pot of cultures, ideas and tools. I loved the whole atmosphere of collaboration and proactivity exhibited by all – students, teachers, admins e-CLOSE has a lot of names: teamwork, partnership, collaboration, fun, challenge, research, online mode, variety, perseverance, sharing and many more - that's what teaching and learning should be like in our times.

Agnieszka Roganowicz

International Cooperation Centre, Lodz University of Technology

Participating in the e-CLOSE project, collaborating with such wonderful, dedicated people was an incredible experience. Exchanging experiences and joining forces to work on developing outputs yielded great results. Involving students in the project work enriched it and allowed us to look at the learning process from a different perspective.

Anna Łuczak

Centre for Teaching and Learning, Lodz University of Technology

The 2020/2021 pandemic was a difficult experience for all of us. We had to quickly adapt to the new reality that surrounded us. The e-CLOSE project allowed us to explore the advantages of e-learning and develop good practices for the future. New tools that we had to work with allowed us to improve teaching and develop innovative methods, which makes teaching more flexible and tailored to students.

António José Ribeiro Neves

Dep. Electronics, Telecommunications and Informatics, University of Aveiro

I believe that we must create conditions for student to feel that they are part of the teaching and learning process, and that the objective of their passage through Higher Education is not just to obtain approval for the various courses, but also as an opportunity to acquire unique skills that will allow, in the future, to successfully carry out a profession and contribute positively to the society in which they will live. The project e-CLOSE provided a relevant contribution to this idea and allowed the teachers and students from the partners universities to share and have access to best practices and tools, both online and in person.

Dorota Piotrowska

International Cooperation Centre, Lodz University of Technology

I am passionate about driving innovation in higher education and creating new opportunities for flexible learning pathways for diverse learners. The e-CLOSE project has brought together creative and committed partners to develop a range of very proactive tools that I hope, staff and students will find useful in developing active learning pathways. The project also touches on recent trends in the provision of micro-credentials. We were interested in exploring flexible and tailored learning pathways that combine smaller learning experiences at different European universities. We believe that universities should provide more learner-centred, accessible and inclusive learning for people with more diverse profiles and needs.

The e-CLOSE Team

(cont'd)

Elisa Rojas

Departament of Computer Engineering, University of Alcalá

I consider the e-CLOSE project to be a true treasure chest. This project has produced valuable results (tools, technologies and methodologies) from which I've learnt to improve my teaching. The poignancy of the training and practical sessions, particularly those involving both teachers and students, is truly remarkable. I feel more personally involved in my lessons in a different way now, thanks to e-CLOSE, and I also know that "la vida pirata, la vida mejor".

Fernanda Rodrigues

Department of Civil Engineering, University of Aveiro

Suddenly, the learning and teaching practices drastically changed! Without any support teaching activity went online. J.F. Kennedy said "Change is the law of life, and those who look only to the past or present are certain to miss the future". So, I am sure that e-CLOSE project will contribute to boosting the change of the teaching approaches. This project gives a large and interesting set of tools that contributes to effectively support and help teachers in innovative learning and teaching methodologies, enriching their practices.

Frank Ulrich Rückert

Saarland Business School, htw saar Saarbrücken

Our wish for e-CLOSE project was, what the acronym implies. After closing in its own pupation, the butterfly should have the chance to fly away free. We had the idea to develop skill of the students during their time in the home-offices (and our own skills as teachers, as well). Both sides were important. New digital tools, that could be used today e.g., the teachings and meetings in virtual space, but also the important development in real life has been trained. And we hope to contribute to the framework of teaching to enable a free open-minded living in European Union.

Gertruda Gwóźdź-Łukawska

Centre of Mathematics and Physics, Lodz University of Technology

e-CLOSE let me be closer to after-pandemic students and teachers not only from Poland but also from other European universities. The knowledge and experience exchange let me enrich my didactic skills and extend the toolkit what makes my current students more motivated to work.

Inês Meireles

Department of Civil Engineering, University of Aveiro

"The world is changing at a dizzying speed, and we cannot just stay still, as educators." In her opinion, e-CLOSE was just perfect to strengthen her skills in STEM education, giving the opportunity to look at different perspectives and learn innovative ways of teaching that most of the teachers (at most) superficially touched during the COVID-19 pandemic

The e-CLOSE Team

(cont'd)

Iouliia Skliarova

Dep. Electronics, Telecommunications and Informatics, University of Aveiro

Education digitalization is one of the effective means to address key challenges for higher education. The recent COVID-19 pandemic contributed to education digitalization by forcing many higher education institutions to significantly accelerate the transition to adopting various types of digital technology, opening a pathway to new educational strategies but at the same time constituting a big challenge for university teachers. The e-CLOSE project, joining efforts of four European universities, contributed positively to the process by providing a platform for discussion and training opportunities for academic teachers and students.

Isabel Cação

Department of Mathematics, University of Aveiro

Technology is constantly changing and advancing in all areas of daily life. In education, innovative learning approaches increase student motivation and improve the student engagement rate. The COVID pandemic forced higher education institutions to rethink e-learning development by increasing digitalization in the teaching-learning process, changing the way of teaching and introducing new technological tools and methodologies. The e-CLOSE project gave an excellent opportunity to share digital competences among partners, to enhance teaching strategies and to incorporate new methodologies.

Joaquim Macedo

Department of Civil Engineering, University of Aveiro

Fostered by the COVID-19 pandemic, higher education teachers are changing their practices creating a learning environment where students are in the centre of their learning process. In e-CLOSE project some new ways of teaching were explored, supported by digitalization and gamification tools and strategies, which are increasingly being used to motivate and engage students, preparing them for the challenges of the future. In his opinion, e-Close project was a fantastic opportunity to exchange information and experiences about active learning methodologies, supported by different types of technologies, among teachers from several European countries and with very distinct backgrounds.

Marcus Bauer

Saarland Business School, htw saar Saarbrücken

Though I only joined e-CLOSE at a very late stage, this project was tremendously valuable. The input and inspiration I got was priceless, so were the professional contacts with dear colleagues from my own institution and from our partner universities.

The e-CLOSE Team

(cont'd)

Margarida Pinho-Lopes

Department of Civil Engineering, University of Aveiro

Until recently, most of us looked at the teaching and learning processes as a somewhat private experience, for a teacher and a group of students. COVID-19 changed that. Suddenly, our classes were online, on open platforms and accessible to a wider audience. That brought advantages and problems. The e-CLOSE project enabled sharing experiences with remote teaching and developing tools and resources to help other teachers in shifting to a-synchronous teaching.

Mário Lima

Dep. Electronics, Telecommunications and Informatics, University of Aveiro

My involvement in the e-CLOSE project allowed me to have access to a range of teaching methodologies and technologies that will certainly be very useful to me in the future, not only in online teaching but also in person. It also allowed me to get in touch with Professors from other educational Institutions that enriched me a lot, both professionally and personally.

Monika Potyrała

Centre of Mathematics and Physics, Lodz University of Technology

Teaching in pandemic period was a challenge. The teachers and students were expected to start a new life … "a second life" in virtual reality. Fortunately, this resulted in the development of teaching tools. The e-CLOSE project was the one that enabled to find answers for teachers in need, collect a large number of teachers' experiences, develop the most valuable ideas and adapt them for use in the current – post-pandemic period.

Natália Martins

Department of Mathematics, University of Aveiro

As is well known, the COVID-19 pandemic forced a sudden transformation of the teaching-learning process at all levels of education. In a few days, teachers had to reinvent themselves and transform their face-to-face classes to online mode. The e-CLOSE project, which was already being developed during some of the lockdowns, was very important to me as it allowed me to learn about new ICT tools and methodologies that are very useful in the teaching and learning processes both online and in person. Moreover, it was a great opportunity to collaborate with many colleagues from different areas and different countries.

Niall Power

University of Aveiro – Office of the Rector

The ERASMUS+ programme has afforded Higher Education Institutions in Europe and around the world a unique opportunity to collaborate and co-create virtual spaces and contexts where teaching and learning is flexible and innovative, and to adopt the methodologies that support them. We have the opportunity now to link those efforts to the agendas for digital skills and jobs, to monitor our progress and to constantly improve the way we develop skills for the 21st Century.

The e-CLOSE Team

(cont'd)

Paulo Cachim

Department of Civil Engineering, University of Aveiro

The COVID-19 lockdowns forced us to move from face-to-face to online teaching and learning, bringing attention to a world of powerful tools and techniques that are out there. The e-CLOSE project, which started during these challenging times, was an opportunity to share my experiences and learn with colleagues that faced different realities, different successes and different failures. Among the outputs of the project, the databases of tools, resources and active learning strategies used in a/synchronous education are certainly a valuable resource for future use and inspiration.

Pedro Miguel Cabral

Dep. Electronics, Telecommunications and Informatics, University of Aveiro

Due to COVID-19, the last couple of years were very demanding in terms of teaching and researching throughout the world. This project was a good opportunity to have access to several technologies and teaching methodologies that I will certainly use in the future. This project brought together several European Universities that shared problems and contributed to find innovative solutions for both teachers and students in this new and more digital world.

Romeu Vicente

Civil Engineering Department, University of Aveiro

In his opinion teaching is more than communicating and sharing knowledge in respect to a weekly timetable, it is be based on an overall strategy served by tools that motivate, inspire, and nurture entrepreneurship skills in an environment that changes the mindset of students and teachers with regard to learning and knowledge transfer.

Rosa Estriégana

Department of Computer Engineering, University of Alcalá

I am a firm believer in John Cotton Dana's quote "Who dares to teach must never cease to learn". The needs and the way our students access and understand information is very different from what they were a few years ago. Teachers cannot remain indifferent to all the changes that are happening. e-Close has helped to explore different tools and methodologies, as well as to enable a productive exchange of ideas and experiences from the partner universities. Participating has been a truly enriching experience.

Soraya Garcia-Esteban

Department of Modern Philology, University of Alcalá

Some of the main objectives of the e-CLOSE project involved seeking out dynamic remote educational techniques and resources in higher education. To achieve this, professors from different grades and areas in the EEA have worked collaboratively to present appropriate approaches to teaching with digital tools that stimulate active learning. Cooperating with such a great team to achieve common goals has contributed to enhance learning with innovative resources and methods that promote effective education.

The e-CLOSE Team

(cont'd)

Tarek Khiar

Saarland Business School, htw saar Saarbrücken

Starting with e-CLOSE as a student I became a staff member during the project and had very much good experiences during several teaching activities e.g., the sailing event. Now my future activities are based on the virtual reality teaching, and we have the plan to develop our own future learnspace with a game engine for htw saar. The e-CLOSE project was the base for these future developments.

Tatiana Tchemisova

Department of Mathematics, University of Aveiro

In her opinion, the positive experience gained during the COVID-19 pandemic cannot be forgotten. University teachers and students, set in a difficult and unusual situation of social distancing, had to find new channels of communication and techniques of knowledge transfer, and to develop new skills that allowed us to continue teaching, studying and being involved in social life. Some of these new techniques and channels can be used to do our work in a more efficient and sustainable way. The e-CLOSE project has permitted the teachers from the partner universities to share their best practices in an enjoyable way of joint work and research while having nice time together.

Xenia Hülsmann

Saarland Business School, htw saar Saarbrücken

After my master studies, e-CLOSE was a real door opener for me. As the project coordinator of our university, I learned not only about teaching methods but also about the benefits of international cooperation. My counterparts in the other institutions were great support for creating something that is built to last. A set of tools and methods that will improve and possibly transform the way we all – as students in the lifelong learning process – will learn in the future.

ACKNOWLEDGEMENTS

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

This publication has been co-funded by the Erasmus+ Programme of the European Union and reflects the views only of the authors, the National Agency and European Commission cannot be held responsible for any use, which may be made of the information contained therein.

Erasmus+ National Agency of Poland
Fundacja Rozwoju Systemu Edukacji (frse.org.pl)

"e-CLOSE has shown that it is worth looking for unusual solutions to help the university achieve its main goal of becoming a 'place of useful learning'. I would like to thank all the project partners for this great learning adventure."

- Dorota Piotrowska (e-CLOSE Co-ordinator)

Project title: A model for Interactive (A)Synchronous Learning in Online STEM Education
Project number: 2020-1-PL01-KA226-HE-096239