The Be Ready

Handbook

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EDUCATIONAL TECHNOLOGY

THE BEREADY HANDBOOK

Intellectual Output 1

Supporting the continuation of teaching STEM subjects during the COVID-19 Pandemic through project-based online practices

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Declaration

This report has been prepared in the context of the BeReady project. Where other published and unpublished source materials have been used, these have been acknowledged.

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Introduction

COVID-19 has proven to be a disruptive force massively affecting numerous aspects of daily life. For public health-care reasons, certain activities normally taking place in physical space were restricted or prohibited, forcing many organizations and professions to seek hybrid or exclusively digital solutions. Schools and educational organizations were among those. Educators and teachers were forced to abruptly adapt in this new virtual era. They had (and still have) to quickly get acquainted with new methods and tools and find ways to confront all the emerging difficulties, while maintaining the teaching and learning qualities of a live classroom. In short, they are called for turning their teaching – a heavily interaction-based practice – into a distant and isolating but still live and collaborative experience.

In this context, the present handbook aims at supporting STEM (Science, Technology, Engineering and Maths) educators overcoming the aforementioned struggles and finding ways to fit their teaching into this new reality. Towards this direction, and through the lens of project-based learning methodology, the handbook presents several available digital platforms and tools as well as a number of exemplary and inspiring stories and scenarios exhibiting solutions emerged from similar challenging situations. Therefore, the aim is not only to present platforms and media that facilitate remote communication, but also tools that can meaningfully support and sustain (synchronous or asynchronous) distant learning methods, and especially the stages of ideation, communication, planning, creation and sharing inherent in STEM project realization. Moreover, a number of good practices coming from real-life paradigms as well as indicative scenarios containing ideas for the potential use and deployment of the proposed tools, are presented to encourage and inspire the teachers and educators.

The handbook does not provide ready-made solutions but aims at showing teachers and educators that different tools can be combined to facilitate student online learning and engagement in STEM projects.

About this handbook / How was this handbook written

While going through this handbook, one might wonder how this collection of tools was shaped. One may also realise that there are additional tools which although suitable for facilitating the online realization of STEM projects and distance learning are not listed here. The BEREADY handbook does not aim to cover all the available tools; this would be impossible. It aims at providing a sufficient list of tools which can transform online learning experiences into more engaging, meaningful for the students, real and relevant ones. Our methodology for gathering input focuses on extended review over the internet as well as on feedback retrieved from the consortium of the BEREADY project through an online form. The online form (see appendix, page 85) aims to gather input for 7 different categories, namely:

- existing digital platforms for online education,

- tools that can support online collaboration,

- online tools that can support ideation/brainstorming,

- online tools that can be used by students for doing the necessary planning,

- digital tools that can support the stage of creation,

- online tools and/or services that can support the stage of sharing, as well as

- good practice examples, strategies and/or inspiring stories concerning the enhancement of learning experience through and with the help of digital online technology.

In this way, the recording of the existing platforms and tools is not only based on the popularity of each service (a parameter which is mostly formed through anonymous ratings), but also on preferences and opinions coming from educators' experiences.

In all cases, searching was narrowed down to services that are mostly suitable for secondary education level. Each partner was asked to mention different examples by providing the name of the suggested platform or/and tool, the relevant link and a short description. Regarding the stage of creation, the partners were also asked to report the subject/field that the proposed tool would be useful as well as the users that the tool will be intended for (i.e., teachers, students or both); a parameter that will reflect aspects related to the inherent level of difficulty/complexity of each tool (i.e., for beginners, intermediate users etc.).

Each platform or tool is briefly described revealing the most significant qualities regarding implementation towards online education and project-based learning. Therefore, and in line with the intention of creating a comprehensible handbook, a number of implementation examples are also contained, showcasing ways of utilizing the proposed tools. An extensive analysis or guidelines regarding specific features (of each platform or tool) is beyond the scope of this document.

Presenting the pedagogical methodology

Project-based learning (PBL) is a dynamic methodology that organizes learning around projects. PBL can transform the way STEM subjects are taught. Recent studies show that PBL supports learners to explore in a more authentic way scientific ideas and practices, make decisions, solve problems and reflect upon the way they learn better.

What is a project?

"Projects are intensive experiences that engage students in activities that are interesting to them and important to the course(s) of study. They can involve community members and settings, and they often result in an exhibition or product for a real-world purpose or audience" [39].

The duration of a project varies. Usually a project is not concluded within a few hours. Typically a project can last for two weeks to a whole semester. An innovative aspect of Project-based learning (PBL) is that it pushes against teacher-centred lessons and helps make learning meaningful and useful to students by establishing connections to life outside the classroom, addressing real world problems, and developing real world skills. A project encourages collaboration with experts/mentors/professionals or representatives of specific communities and accommodates different learning styles.

The project is the central teaching strategy through which the students are introduced and engaged with the central concepts of a subject [40].

> *"I can see how PBL is the vehicle by which I can teach both the Common Core Standards and the 21st century competencies [...] I am also very excited that I don't have to throw out all the great units I have taught in the past, but instead can view them through a PBL lens".*
> *Teacher's reflection on PBL, retrieved online from https://www.edutopia.org/discussion/example-pbl-early-elementary-how-i-started*

PBL supports learners to develop a variety of skills including the ability to work well with others, make thoughtful decisions, take initiative, solve problems, develop self-directed learning skills and motivation for learning [41]. Thus, established principles of learning, such as motivation, relevance, practice, active learning, and contextual learning operate significantly in a PBL environment, and to a much lesser extent in conventional curricula.

> *"One of the major advantages of project work is that it makes school more like real-life. It's an in-depth investigation of a real-world topic worthy of children's attention and effort"* (Sylvia Chard, Associate Professor of Education, University of Alberta, Alberta, Canada)

Practicing project-based learning online

When practicing project-based learning online or in a distance context, the social aspects inherent in this methodology can be further enhanced leading to significant educational outcomes. The challenges imposed by the distance between the participants can potentially enhance the critical reflections upon planning and the sharing procedures.

As George and Leroux [41] point out, the projects by nature require interaction and good collaboration among the learners but also among learners, teachers, mentors and other participants. In the distance context this need is real and from the very beginning mechanisms

for ensuring smooth collaboration should be activated. Reflecting upon collaboration and collaborative practices well in advance can set a basis whereupon meaningful interactions can happen in the context of the project. In addition, in a distance context the participants are often challenged to resolve disagreements, misunderstandings, conflicted views and practice their communication skills. They are challenged to work in advance on how they will present their ideas, negotiate and critically comment on one another's work so as to ensure that they will achieve their common goals and that they are all on the same page [41].

In PBL, the teacher's role changes: the teacher is not the sage on the stage but the guide on the side. He/she facilitates the learning process, ensures that the project has a temporal structure and important milestones and deadlines are taken into account. He discreetly invites students to work on a plan of actions when needed and consider specific points in order to reach their goals [41].

Tips for teachers for planning and scaffolding students' projects

1) Choose a focus for a project

2) Identify essential knowledge and skills that will be stressed through the project

3) Introduce the project and invite students to shape it. The final project should reflect students' interests and preferences

4) Give students an active role and act as a facilitator of the learning process. In PBL there is less emphasis on teacher presentation and more on providing support and guidelines.

5) Establish milestones and set deadlines

6) Monitor student progress using planning, reporting, and feedback tools

7) Invite students to extend the project and document ideas for new projects

8) Bring students in contact with experts and/or representatives of specific communities (collaboration with others may inspire their thinking and boost the project progress)

Reviewing supporting tools for online STEM education

Digital platforms for online education

As digital platform is defined a digital service that facilitates interactions between two or more distinct but interdependent sets of users who interact through the service, and via the internet. When this platform is implemented for educational purposes, it can be described as a digital space to share information and educational content, which is intended to be accessed and used both from teachers and students [1][2]. This type of platforms can also be identified as computerized learning systems, electronic educational technologies or/and e-learning platforms.

One of the reasons that an educator may use a digital learning platform is for turning the entire educational process into a more interesting, engaging and interactive experience and probably/possibly to a personalized one. Another reason – which was highly dictated during the pandemic – is the need of finding alternatives in cases that the access to physical class is difficult or restricted. On top of that, and from a financial point of view, digital learning platforms can offer a rather cheap solution for engaging a wider audience to the educational process. This is also facilitated by the wide spread of technology (i.e., smartphones, tablets etc.), and the vast number of applications that can offer access to more or less serious online educational platforms and tools.

Most of the platforms designed for educational purposes integrate the so-called Learning Management Systems (LMSs) or/and Virtual Learning Environments (VLEs) applications, enabling teachers to perform educational coursework online, thus permitting "a more connected and accessible educational experience for students" [3]. They are also enhanced with education software, such as Student Information Systems (SIS), that allow students' data management (i.e., storing and tracking student information, grades, attendance record etc.) [5].

The tools included in each platform aim at different needs regarding the learning process and the educational objectives, offering synchronous (i.e., methods that reflect and simulate the dynamic of a live classroom where "students learn simultaneously and collectively" [15]) and asynchronous (i.e., students learn on their own pace) eLearning services. It is highlighted that those systems and/or environments facilitate the creation of multiform educational content such as syllabi, lectures, multimedia files and readings [3] [4]. They also support the evaluation of students through quizzes and tests, while facilitating the distribution of assignments and the corresponding feedback on an individual or on a class level. Moreover, they provide channels for communication not only with students, but also with parents, through personal messages, mobile notifications and forums.

Some rather well-known international examples of digital platforms for online education that were recorded are Microsoft Teams, Moodle, Webex, Google Classroom and Edmodo. Other paradigms coming from national level (e.g., eClass offered by Greek Academic Network GUnet) may equally offer convenient solutions regarding synchronous or asynchronous eLearning services. The majority of those platforms offer tools for online synchronous or asynchronous teaching, assessment and feedback, collaboration and communication as well as video conferencing.   In particular:

-Microsoft Teams

Microsoft Teams is a communication platform developed by Microsoft, as part of the Microsoft 365 family of products (*Figure 1*). It offers a variety of features and tools for communication and collaboration (like public and private chat workspace, ability for videoconferencing etc.), as well as a shared storage space for uploading multitype of files (such as word, excel, video, documents etc). Teams is considered as an appropriate platform for both educational and

business purposes. It is free-accessed via email account, which should be verified by the hosting organization, providing a rather safe digital environment. Moreover, it can be connected to applications (e.g., Flipgrid, Discovery Ed, Quizlet) that can facilitate and enhance the various stages of teaching process (i.e., communication, evaluation, assignments etc.).
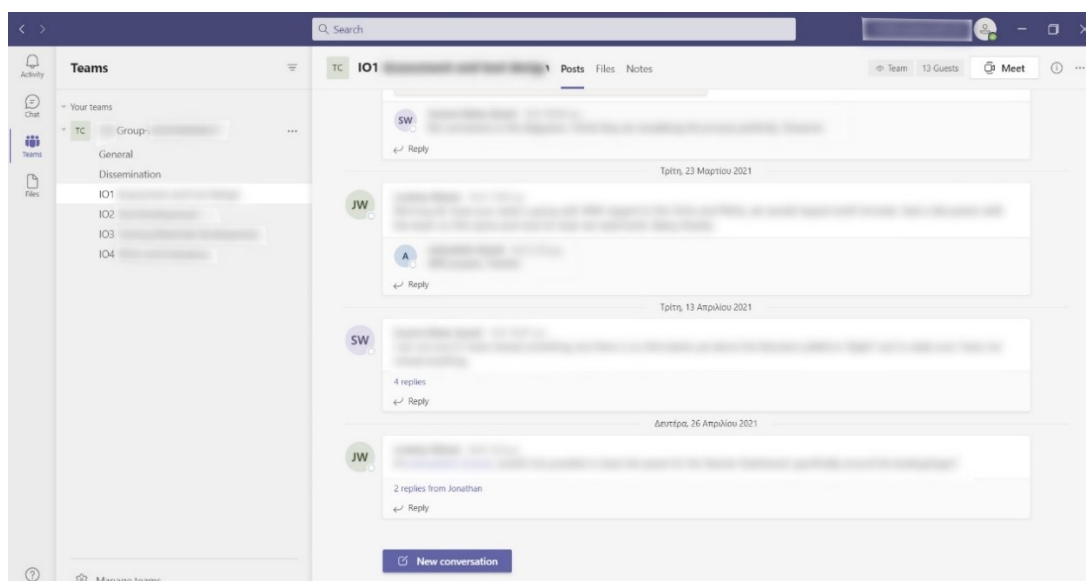

Figure 1: Screenshot of Microsoft's Teams environment – Image produced by the authors

-Google Classroom

Google Classroom is a free service for anyone with a personal Google account (*Figure 2*). For educational purposes, Google Classroom is using the services of "G Suite for education" (or Google Workspace for Education fundamentals), a suite of cloud-based tools and applications, such as Gmail, Google Drive, Google Calendar etc. From the aspect of setting up a virtual class, Google Classroom is considered as a rather easy solution. It permits the creation of a general class, or multiple classes hosting different teaching subjects, in which students can join through an invitation and a given/shared code. Teachers can post announcements to the entire class, or to specific students, thus communicating in a public or an individual level, as well as distributing assignments (including evaluated tasks) and multiform/ multitype material (e.g., documents, links, questionnaires, quizzes etc.), while grading the submitted assignments.
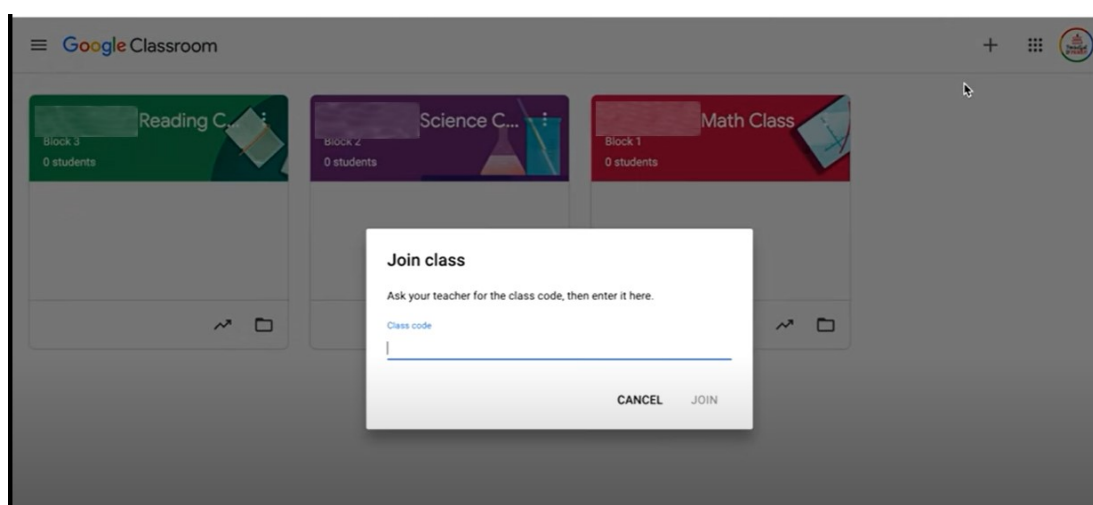

Figure 2: Screenshot of Google's Classroom environment – Image retrieved from:
https://www.youtube.com/watch?v=rCNImsWUxZA

-Moodle

Moodle (Modular Object-Oriented Dynamic Learning Environment) is a free and open-source learning management system (LMS) distributed under the GNU General Public License (*Figure 3*). Developed on pedagogical principles, Moodle is used for blended learning, distance education, flipped classroom and other e-learning projects in schools, universities, workplaces and other sectors. Teachers can create a number of for a of different content (e.g., forum for history class, forum for math class etc.) and share information, quizzes, and links with their students, while allowing them to share their ideas as well as submitting their assignments. Through the messenger and notification function, Moodle is a establishing a channel of communication between teachers and students, while allowing students to become engaged in collaborative activities.
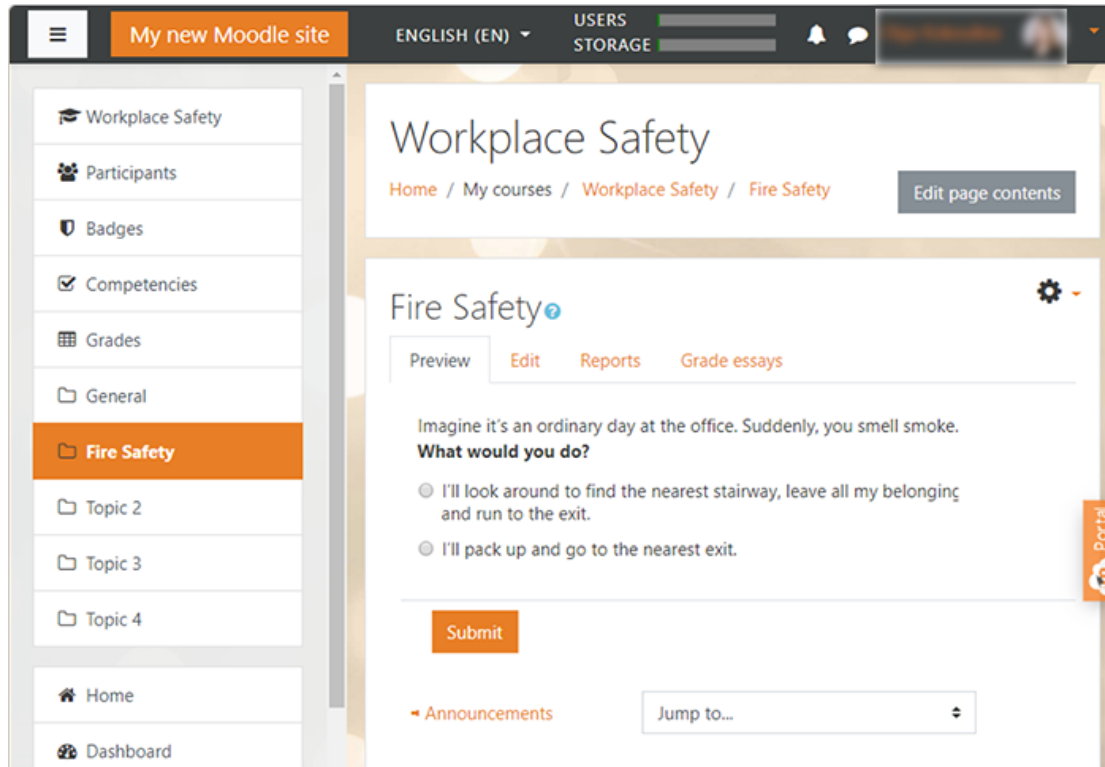

Figure 3: Screenshot of Moodle's environment – image retrieved from:
https://www.ispringsolutions.com/blog/how-to-create-a-course-in-moodle

-Webex for Education

Webex services were initially oriented towards hosting and providing web conferencing tools and videoconferencing applications. However, the needs for wider digital engagement of the public, across several subjects, lead to the creation of a digital platform that could facilitate a variety of activities. On this basis, Webex for Education was created in order to provide online tools and services that could facilitate hybrid and distance learning (*Figure 4*). In detail, it provides tools for video meetings and messaging, boosting communication and collaboration, as well as live broadcast, even from the classroom, enhancing students' sense of presence, and therefore creating a higher engaging learning experience. During assignments, teachers can also split the class to groups, in break-out rooms, encouraging collaboration among classmates. Teachers can even allow students to arrange a practice meeting as a group, in order to get prepared, before they present to the class, enhancing their confidence. Moreover, they can record their courses, making them accessible anytime by anyone belonging to the class.
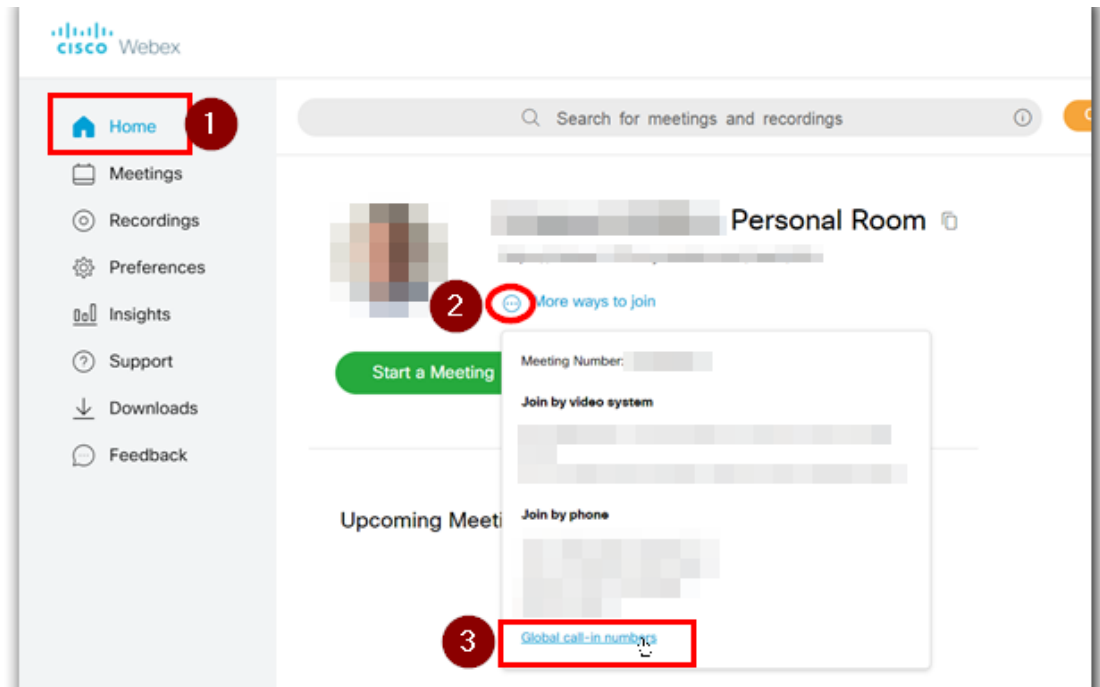
Figure 4: Screenshot of Webex environment – image retrieved from: https://community.cisco.com/t5/webex-administration/what-webex-version-do-i-need-for-toll-free-calling/td-p/4061287

-Edmodo

Edmodo is an all-in-one LMS (Learning Management System) free-accessed platform for K-12 schools and teachers, that enables them to share content, distribute quizzes, assignments, and manage communication within students, colleagues and parents (*Figure 5*). Like Google Classroom, students can join a class/group by accepting an invitation and entering a specific code. Uploaded content (documents, announcements etc.) can be organized in folders, while important notifications/announcements can be pinned at the top of the screen, grasping the attention of students. Students can also upload content but is up to the teachers to approve sharing with other members of the class/group.
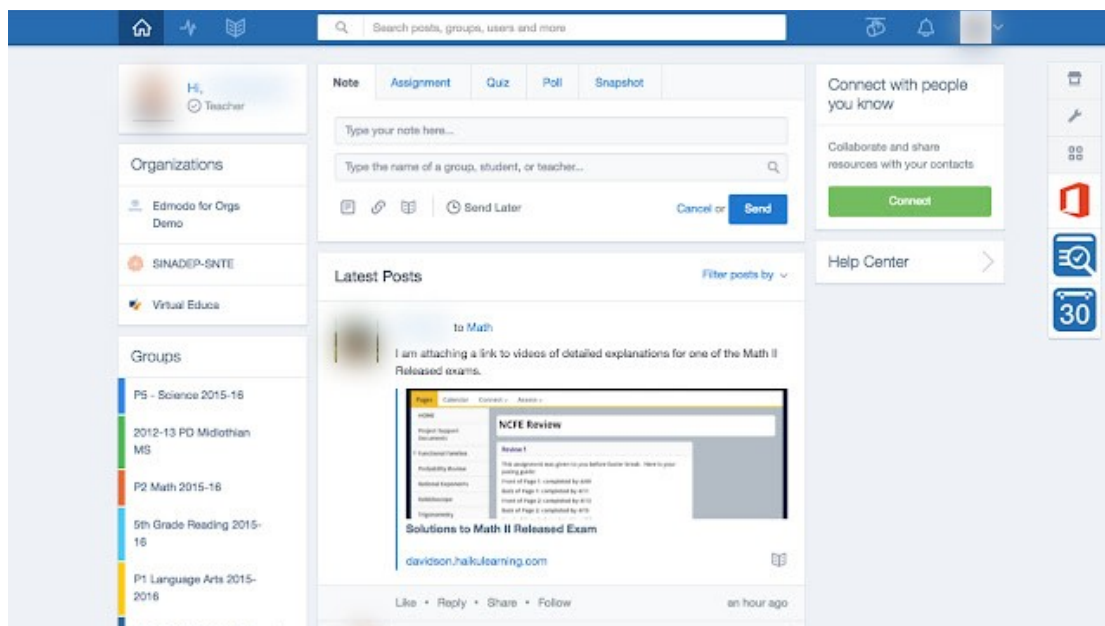

Figure 5: Screenshot of Edmodo environment – Image retrieved from:
https://chrome.google.com/webstore/detail/edmodo/ohpppancgeopfjndlaodikbinmkepfml?hl=el

-eClass

The Open eClass platform is a complete Course Management System. It is the solution offered by the Greek Academic Network GUnet to support asynchronous eLearning services (*Figure 6*). It is free as open-source software and can be used at secondary and higher level for teaching and learning process. Apart from Greek it is also available in English, covering the needs of a wider audience. It includes online collaboration and communication tools, assessment and feedback tools, tools for uploading recorded lectures, user administration and educational content management. Multitype educational material is supported (i.e., texts, documents, presentations, images, videos etc.) permitting teachers to organize their courses in a dynamic and multifunctioning way, in terms of interactivity. Students need to register in a course in order to get access to the uploaded material, participate in working groups and conversations taking place in fora, as well as communicate with teachers.
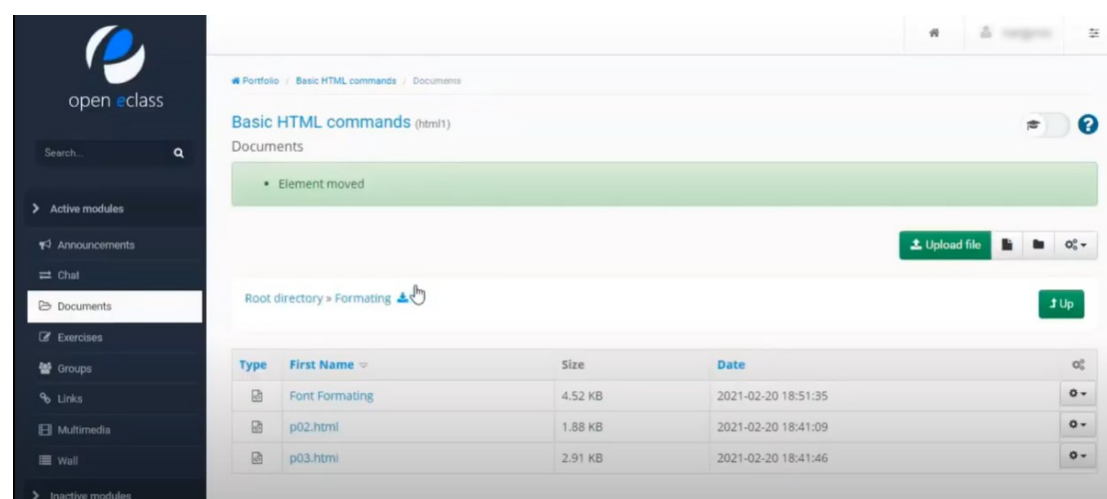

Figure 6: Screenshot of Open eClass environment – Image retrieved from:
https://www.youtube.com/watch?v=Y3KMPtPhiPQ

-Blackboard

Blackboard is a Web-based course-management system – initially designed to function as a complementary tool for face-to-face teaching - that allow students and faculty to participate in classes delivered online or use online materials and activities (*Figure 7*). Through Blackboard Unite: K-12 Digital Learning – an exclusive service for K-12 – Blackboard offers a comprehensible, intuitive and fully responsive interface that is equipped with flexible features and tools, supporting and enabling personalized learning. Multitype material (i.e., text, documents, videos etc.) as well as alternate formats (i.e., Electronic Braille, audio etc.) are supported giving the opportunity to the teachers to create more engaging courses and learning activities, based on their students' needs. Moreover, Blackboard Unite is hosting safe classroom-to-home communication tools, providing a secure online environment, while establishing communication among teachers, students and parents.
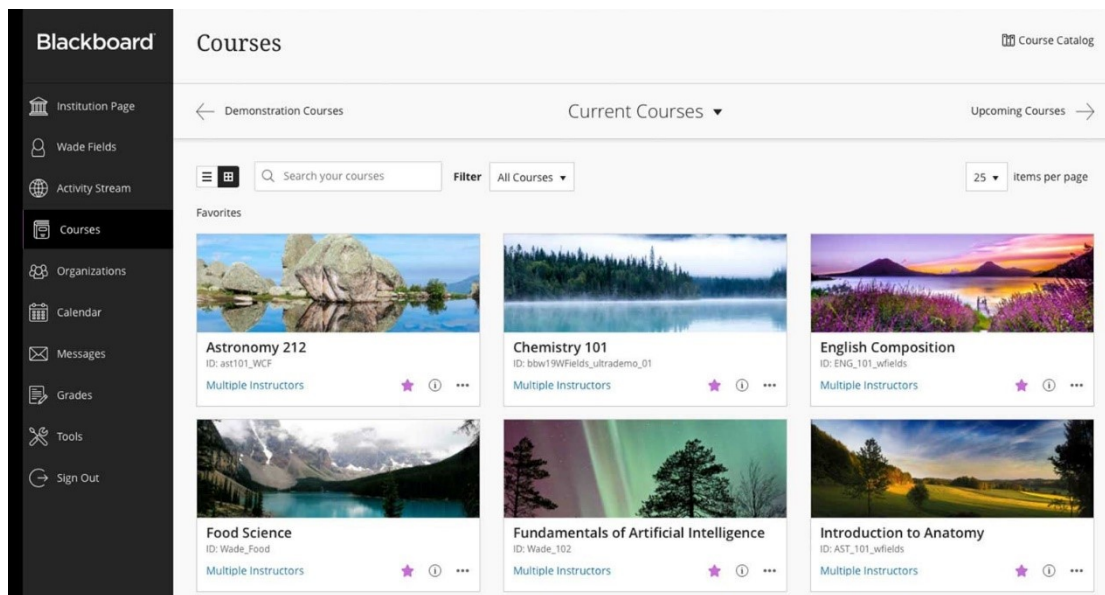
Figure 7: Screenshot of Blackboard's environment – Image retrieved from:
https://www.blackboard.com/industries/higher-education

-Khan Academy

Khan Academy is an asynchronous learning platform created by the homonymous nonprofit organization (*Figure 8*). The initial goal of this platform is to make educational content – related to a variety of subjects, such as mathematics, biology, chemistry, physics, history etc. – accessible to students and teachers from all over the world. The content is created by experts who are using material hosted in Khan Academy's library of trusted practice and lessons, and is provided as resources available in multiple formats (i.e., videos, diagrams, on-line test etc.) and in multiple languages. Students can practice at their own pace, while teachers can discreetly observe their progress, identify their gaps and respectively provide feedback and instructions.
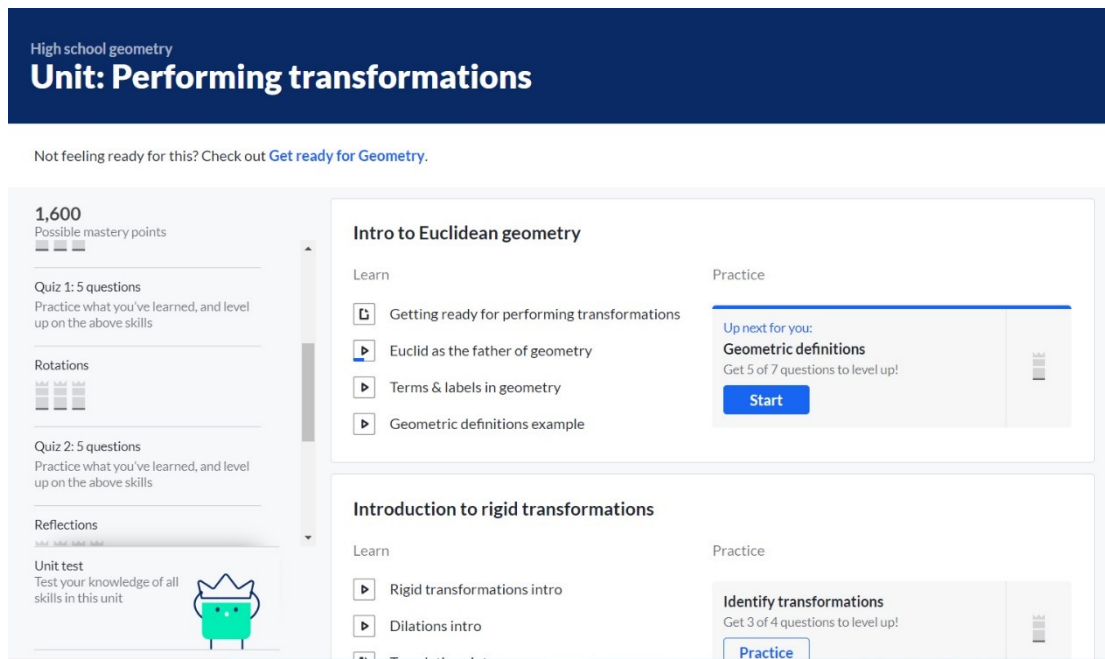

Figure 8: Screenshot of Khan's Academy environment – Image retrieved from:
https://www.khanacademy.org/math/geometry and produced by the authors

The following table gathers all the aforementioned digital platforms and a number of features and services that are considered crucial being included in tools aiming to facilitate online teaching. Through this table, educators can have a quick overview of the existing environments for supporting eLearning processes, compare the offered services and features, and decide which one fits better to their needs.

	MsTeams	Google Classroom	Moodle	Webex	Edmodo	eClass	Blackboard	Khan Academy
Synchronous	√	√		√				
Asynchronous	√	√	√	√	√	√	√	√
Video Call/ Conferencing	√	√		√				
Uploading/Sharing Files	√	√	√	√	√	√	√	√
Chat room/ Messenger	√	√	√	√	√	√	√	√
Tracking progress and grades	√	√	√	√	√		√	√
Monitoring activity	√	√	√	√	√		√	
Free License	√	√	√	√	√	√	√	√
Application for smartphone	√	√	√	√	√		√	√

Tools for online collaboration/communication

Most of the digital platforms, mentioned in the previous section, host tools that can facilitate the collaboration and communication not only among teachers and students, but also between teachers and parents.

Collaboration – and communication in terms of collaborative activities – are both very important parts of the learning process. According to the National Education Association guide [6], the creation of collaborative learning experience in the classroom leads to better understanding of the learning process and therefore – in comparison with individual efforts – to gain more knowledge. Students are able to build upon the experiences and results of others and others can learn from their own experiences and outcomes. In this sense, communication can be crucial for developing social skills, as well as for enhancing students' self-esteem.

Therefore, supporting collaboration and communication in an online learning environment is considered as a crucial factor for sustaining the qualities of the learning process, met in a physical class. The face-to-face interaction cannot be substituted but a careful selection of tools can enhance the online learning experiences.

Some of the gathered paradigms referred to tools that are embedded in digital platforms for online education (i.e., Google Classroom, Webex, MS Teams etc., the majority of which has already been mentioned and presented in the previous section of the present document), while others referred to individual tools such as Zoom, Skype and ClassDojo. The tools presented bellow encourage the exchange of ideas, feedback, while allow the communication of students' future plans and ways of dealing with emerging problems.

 In detail:

-Tools embedded/hosted in digital platforms for online education

The majority of the digital platforms for online education host – among others – tools and/or services for facilitating collaboration and communication between participants. Synchronous digital platforms (i.e., MsTeams, Google Classroom, Webex, Moodle) provide services for video meetings, organization of video conferences, live broadcasting, break out rooms for smaller groups or interpersonal communication, as well as tools for commenting and instant messaging; while asynchronous digital platforms (i.e., Edmodo, Blackboard, eClass) host services and tools for enabling a more mediate communication and collaboration (e.g., hosting Zoom tools for video and/or audio calls, or teleconference tools that combine real-time on-line conversations and message exchange etc.).

-Zoom

Zoom (*Figure 9*) is a partially free web service providing an easy and efficient cloud platform that facilitates online audio and video communication, by hosting tools for organizing and accommodating meetings, webinars, and break-out rooms [7]. Concerning education, zoom can support remote and hybrid learning environments, suitable for every educational grade. It also supports a wireless content sharing through screen sharing and recorded video stream, which both are considered as very beneficial features for teachers and students [7]. Zoom proved as one of the favorite tools for teachers and students during the COVID 19 pandemic. However, issues related to streaming bandwidth (i.e., need of fast internet speed) and security are some of the major disadvantages that might lead users seeking for alternative solutions.

Figure 9: graphical representation of Zoom's environment – image retrieved from:
https://www.zdnet.com/article/new-zoom-feature-can-alert-room-owners-of-possible-zoombombing-
disruptions/

- Skype

Skype is a proprietary application providing online video chat and voice calls between computers, tablets, mobile devices, and wearables (i.e., smartwatches), as well as instant messaging services. Users may transmit text, video, audio and images, as well as make online presentations by using sharing screen feature (*Figure 10*). Video conference calls are also allowed.
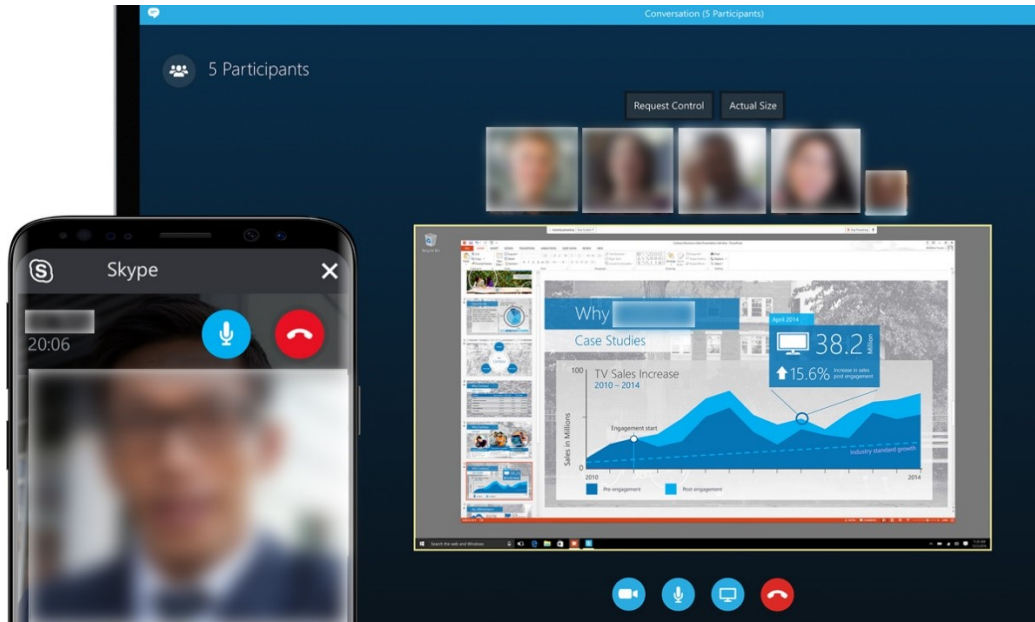

Figure 10: Preview of Skype's environment during a video call – image retrieved from:
https://www.plainconcepts.com/alternative-skype-business/

- ClassDojo

ClassDojo is a communication platform (*Figure 11*) that facilitates teachers to build classroom communities by engaging both students and parents in an online behavior management system that aims to promote and develop a sense of "classroom culture" [8]. Students are encouraged to adopt positive behaviors, while parents are encouraged to communicate on a frequent base in order to be informed about students' development. Teachers can establish "class values" such as "helping others", "participating" and "teamwork" and provide feedback according to students' scoring and performance. They can also post messages to keep both students and parents up-to-date.

Figure 11: Preview of ClassDojo – Image retrieved from: https://www.plainconcepts.com/alternative-skype-business/

- Discord

Discord is a digital platform developed toward creating communities where members are communicating through a variety of ways such as, instant messaging, voice and video calls, chat rooms, and in two different modes, namely in private or in public channels (*Figure 12*). Discord is considered as a rather popular service for teenagers. It was initially designed for gamers but recently has been expanded for broader use. Apart from tools for communication it also hosts servers for sharing media and files as well as tools for sharing screen, providing ways for collaborative activities (e.g., drawing). However, since Discord is not initially intended for education, it has some drawbacks concerning security and the content that can be hosted (i.e., ethically ambivalent content can be uploaded).
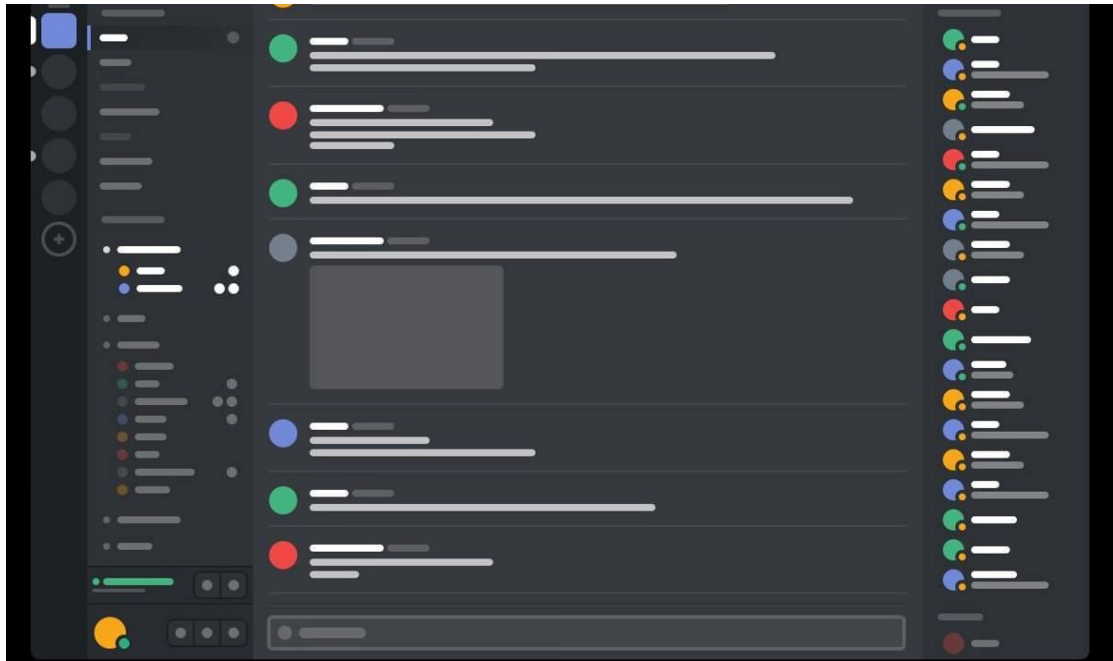
Figure 12: Graphical representation of Discord's environment – Image retrieved from:
https://www.hongkiat.com/blog/discord-chat-social-hub-gamers/

Online tools for supporting ideation/brainstorming

Ideation (or brainstorming) is considered as a method of implementing cognitive processes towards the generation and development of ideas in order to solve a problem [9] [10]. It is a collaborative process, and therefore it is normally performed as a group activity. In this process all the members of a group/team suggest and discuss their ideas revolve around approaching a given problem. In design thinking – towards the creation of projects linked to interaction design – the ideation stage includes a number of sessions such us sketching, prototyping, brainstorming and brainwriting [12]. Therefore, it is considered as a crucial part of the process since it puts the design process into an anthropocentric perspective. Through ideation, designers are able to gain "*a deeper understanding of design principles, of human psychology, technology and society*", thus designing more meaningful projects [12]. Many ideas can be formed during ideation stage, generated from previous knowledge, personal experiences, analogies to the existing problem, as well as from abstract words and hypotheses [13].

Likewise, and in the context of education, ideation/brainstorming is considered as a strategy, implemented by teachers to actively engage students on focusing on a problem and generating ideas towards its solution [11]. Expressing ideas and listening to others, are both critical parts of the ideation process. All students should have the opportunity to express their ideas as well as being encouraged to express anything that comes to their mind, without fear of receiving negative feedback. Thinking outside the box should be more than welcomed. Recording ideas, by writing them down on papers, on a white/blackboard or even on sticky-notes that would be placed on the wall, can ignite more ideas, and turn the entire process to a fruitful and lively discussion.

Through this process – and by respecting others' opinions/ideas – students are able to understand the problem, see it from different perspectives, and adjust their previous knowledge by accommodating new information [11]. As a result, students are able to become more aware of the different aspects of a problem that needs to be solved.

Therefore, ideation/brainstorming is perceived as a critical part of the learning process, especially for STEAM oriented activities that promote the DIY culture.

With this as a solid base – and in the context of the present project – a number of online tools that can support ideation/brainstorming stage were recorded. Some of the gathered paradigms are digital workspaces for visual collaboration and online collaborative whiteboards (e.g., Miro, Mural), Mind Mapping Tools, and tools generating World Clouds. The suggested tools encourage the online recording of ideas, while facilitating the entire process through visualizing the incoming data (i.e., generating word clouds, producing diagrams etc.).

In particular:

-Online digital workspaces/ online collaborative whiteboard platforms

Online digital workspaces such as Miro (*Figure 13*) and Mural (*Figure 14*), are online visual collaboration platforms for teamwork, empowering ideation/ brainstorming. They are equipped with an infinite digital whiteboard in which users can write down their ideas and thoughts by using a set of widgets, such as sticky notes, freeform pen, shapes, and arrows, as well as prebuilt templates that facilitate the organization of inserted information. This kind of platforms facilitate collaboration and sharing with other members of a team through features such as mouseover (i.e., indicating the location of other users' cursor), screen sharing as well as video, chat and commenting.
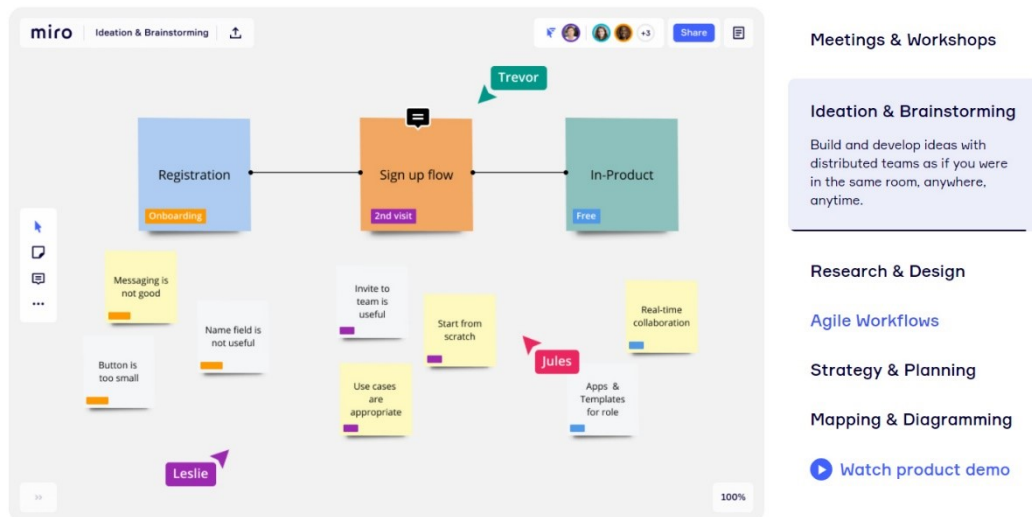
Figure 13: Screenshot of Miro's environment – Image retrieved from: https://miro.com/
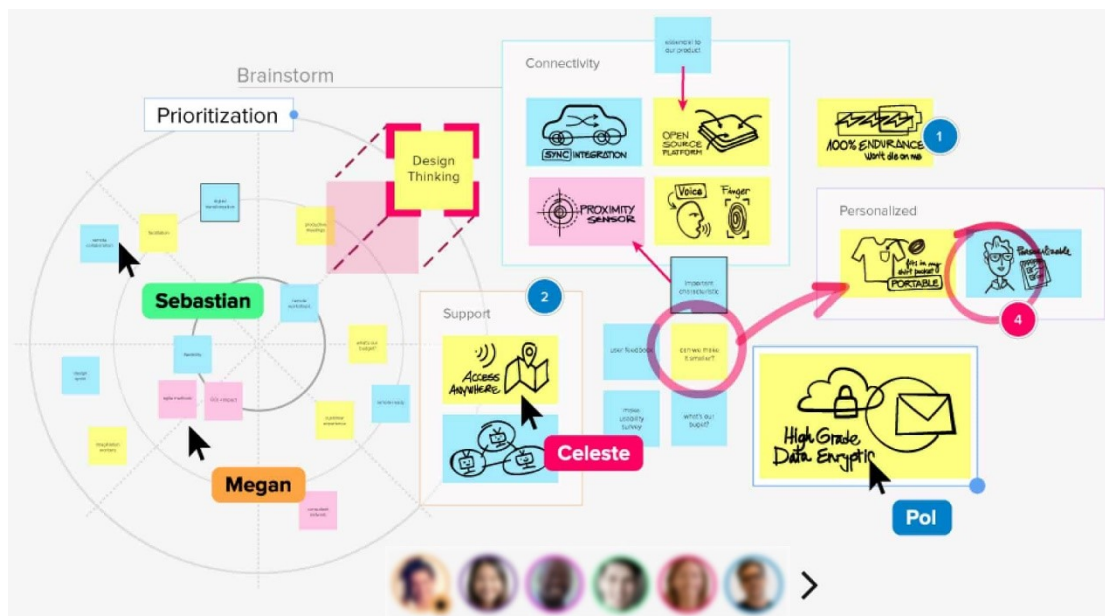
Figure 14: Screenshot of Mural's environment – Image retrieved from: https://www.innovationtraining.org/what-is-mural-and-how-to-use-mural-for-design-thinking/

-Mind Mapping Tools

Mind Mapping tools (such as Mindmaps and MindMup) are mind mapping maker design tools that facilitate the organization of ideas and thoughts by turning users' notes into tree-like diagrams (*Figure 15*). The maps can be stored in the cloud and shared to and with other users, assisting ideation stage and consequently collaboration, planning and teamwork, while Mindmaps application can be also operated in an offline mode.

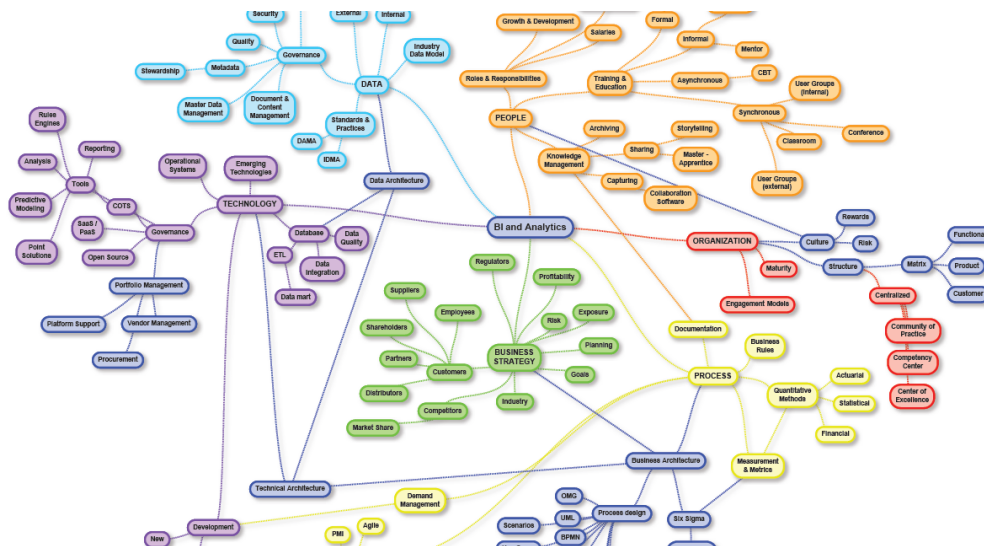*Figure 15: Example of using MindMup – Image retrieved from:*
https://gr.pinterest.com/pin/360076932677077586/

-Word cloud generators:

Word cloud generators are used to visualize and summarize data into a word cloud. A word cloud is an image consisting of different words, appearing in different colors and sizes. The size of each word is determined according to specific criteria such as the significance of each word or the frequency that a word appears in a text. An example of such tools is WorditOut word cloud generator (*Figure 16*), which can also recognize a variety of symbols, while allowing editing and filtering out words that eventually users don't want to include in their word cloud. Another example is Wordclouds that enables users to also generate a word cloud through a pasted text, an uploaded document or an imported URL.
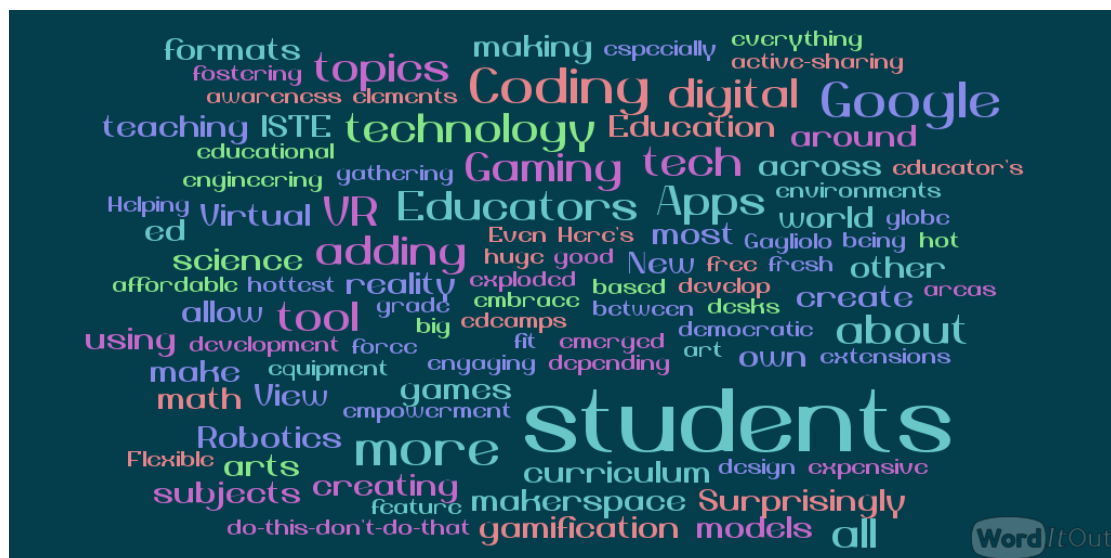

Figure 16: Example of using WordItOut – Image retrieved from:
http://teachtekbeck.blogspot.com/2015/01/2014-in-review-my-blog-word-cloud-and.html

-Tools for shared editable documents

This kind of tools (such as Google Docs, Google Sheets, Google Slides, Goodnotes etc.) allow the creation of a shared digital space (i.e., a shared document, a sheet, a slide etc.), in which every user with granted access can add and edit content or even comment (*Figure 17*). Compared to the aforementioned tools, the offered digital space of these services is less flexible and therefore this solution might be proved as less dynamic for the process of brainstorming. Moreover, applications, such as Goodnotes, that are only available for particular operational systems, might not be a convenient solution for all the users.
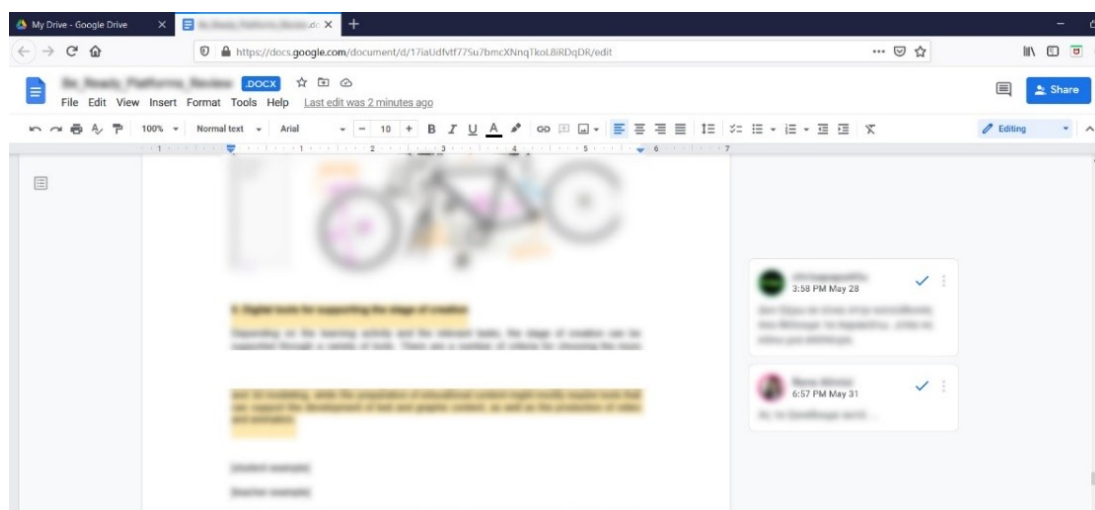

Figure 17: Screenshot of Google's Doc environment – Image produced by the authors

Implementation example:

Lena is an IT teacher in junior high school. She is planning to introduce the lighthouse project to her class. In order to engage her students to this activity, she is initially asking them to record their ideas based on their experiences, on their knowledge and on short research over the internet about lighthouses, how they were working in the past, who was operating them etc. Currently, she is teaching through a virtual class. Therefore, she needs to find a solution on how to recreate the ideation/brainstorming stage via the internet. She decides to use an online visual collaboration platform (such as Miro and Mural). She splits the students into groups, and creates a template for each one of them. After briefly introducing them to the tool, she is giving time to the teams to collaborate through the template by noting down their ideas to sticky notes, creating sketches, uploading images and sharing links. When everyone is ready, she is giving the floor to each one of them to present their ideas in the (virtual) plenary by sharing their screen. The following image (Figure 18) presents an example of the ideas that were recorder by Team A, consisting of Maria, John, Alex and Kate. After presenting their ideas, Lena is making some suggestions to help them better organize their notes and plan their next steps.
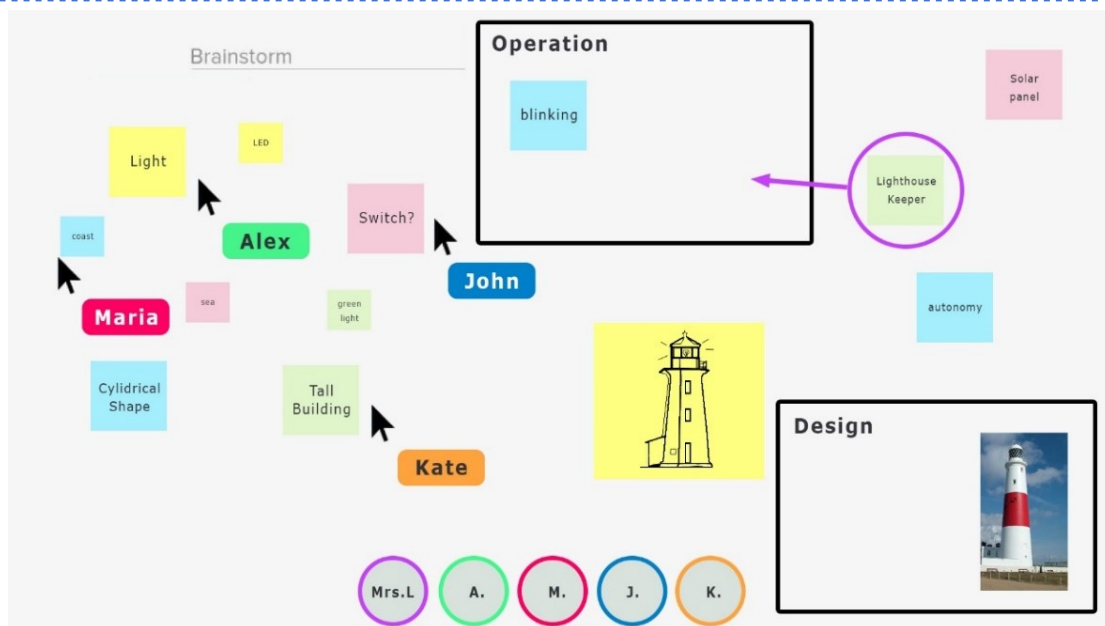

Figure 18: Example of brainstorming stage through the implementation of an online tool such as Mural and/or Miro – Image produced by the authors

Online tools for supporting planning

Planning is defined as the process of thinking about the activities (i.e., identifying key steps, setting deadlines, listing of materials needed and more) required to achieve a desired goal. In the context of BeReady project, the goal is performing an online educational activity.

> *"when students independently or in teams interact with the materials to answer a question or solve a problem, they are developing higher order thinking skills that are so foundational to a STEM education." [14]*

The stage of planning is usually inherent in project-based learning practices. By using notebooks, agendas or even sticky notes on boards, students can organize a roadmap of their work, thus understanding the key steps that need to be performed towards the realization of a learning activity. In this process, a variety of approaches are revealed, which can lead to a profound and more lasting learning experience [14]. Moreover, and regarding teamwork, planning can lead to a (better) role allocation.

In order to recreate this experience in a digital environment, online tools that can facilitate the aforementioned activities are explored and recorded. Some representative examples are Trello, Asana and OneNote.

-Trello

Trello is an application functioning as a collaboration tool that helps users to organize their to-dos, projects, and other lists onto "cards" and "boards" (*Figure 19*). Users can add new tasks or comment on existing one. Moreover, users can change the position of a card over the board, in case they want to inform others for the progress of a work/task, helping the team to keep track of what projects are in progress, who is working on what, and how far along a task is. Cards can also function as repository space for ideas and thoughts on the project.
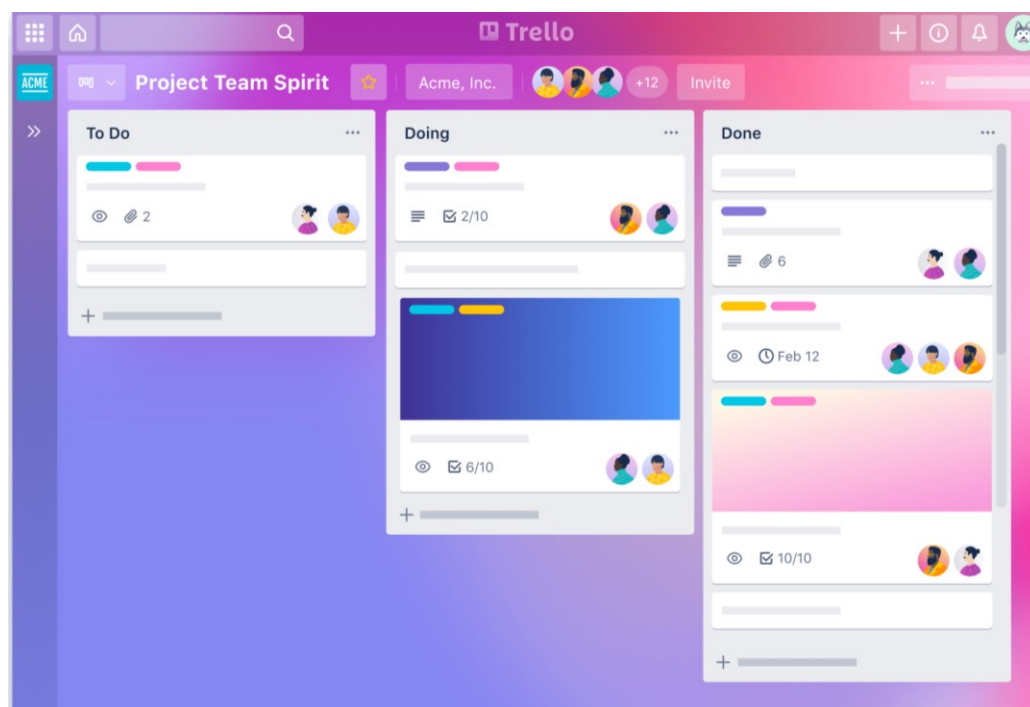

Figure 19: Graphical representation of Trello environment – Image retrieved from: https://trello.com/

-Asana

Asana is a web and mobile application for workflow management and team collaboration. Through the Board menu Asana permits users to plan the tasks of an existing project by organizing them in sub-categories (*Figure 20*). These sub-categories appear in columns, providing a rather clear view of all the needed steps towards the realization of a project. Also, through Calendar, Asana permits users to keep track of tasks over-time and therefore meet deadlines, if any.
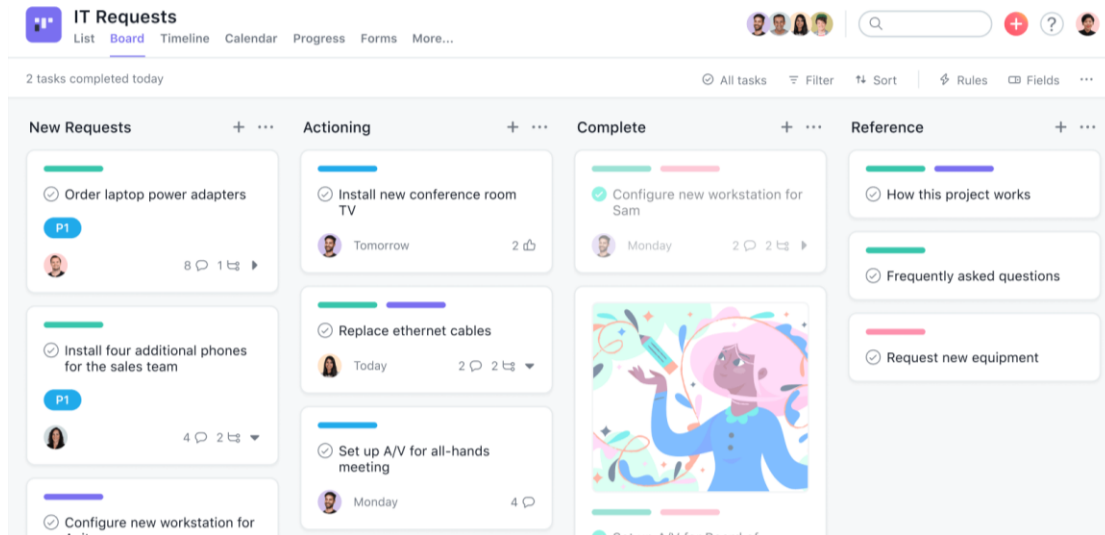
Figure 20: Preview of Asana's environment – Image retrieved from: https://asana.com/

-OneNote

OneNote is available as part of the Microsoft Office suite, as well as a free, standalone application via the official website. It is a digital notebook that allows free-form information gathering (*Figure 21*). It can host multitype of inserted information such as notes, drawings, screen clippings, and audio commentaries. The content can be shared with other users (i.e., members of the team, teachers, family etc.) offering a multi-user collaboration digital environment.
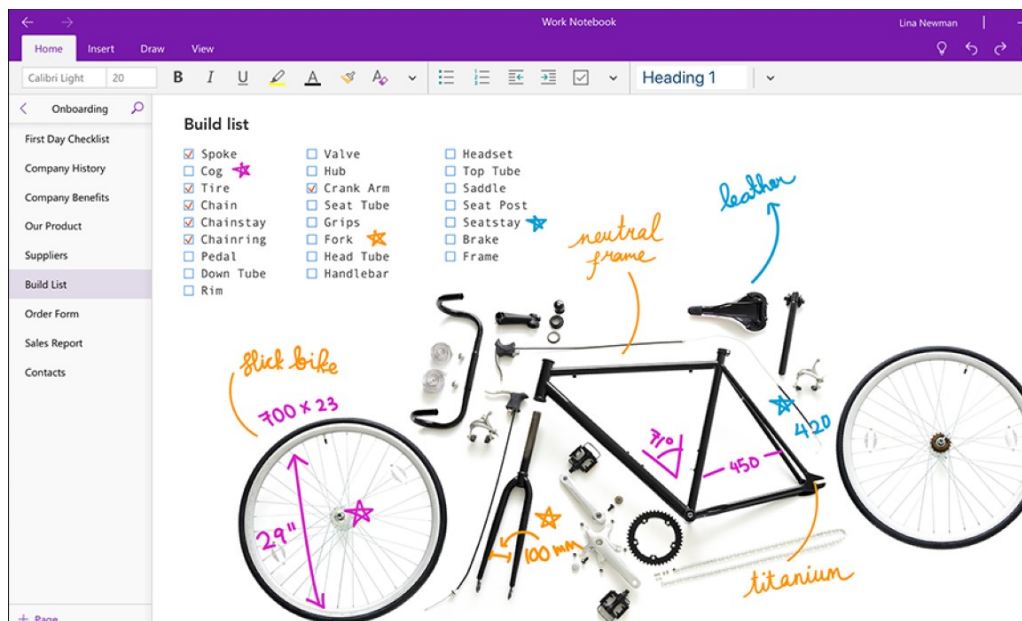
Figure 21: Preview of Microsoft's OneNote background – Image retrieved from: https://www.microsoft.com/en-us/microsoft-365/onenote/digital-note-taking-app

-Todoist

Todoist is a to-do list application, which permits users to create reminders, projects, goals and more (*Figure 22*). The primary functionality of this application is to tracking and checking off the aforementioned tasks, while organizing them in a daily agenda format. Therefore, it can be implemented either for individual purposes or for teamwork, since it provides tools for planning a project, assigning responsibilities, sharing files, discussing details, as well as tracking progress of a single task and/or the entire process. Todoist is offered in a free but limited space edition, which alongside its incompatibility to some operational systems, might be considered as significant drawbacks.

Figure 22: Preview of Todoist environment – Image retrieved from:
https://www.g2.com/products/todoist/reviews

Implementation example:

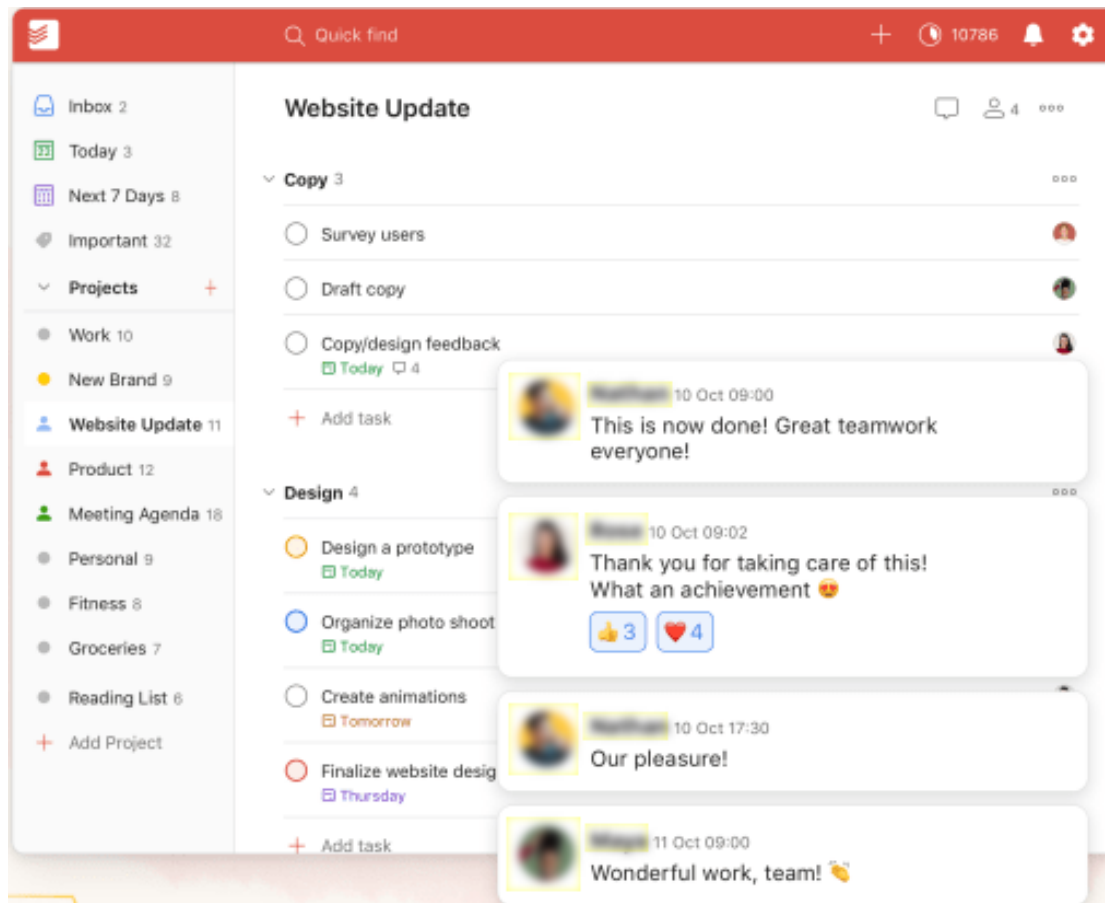*Maria implements the lighthouse project with the students online. The students work in teams. The project revolves around the creation of the model of a lighthouse that blinks at dark and includes levels that scale in difficulty. In the context of the project the students will be encouraged to explore 3D modeling, programming and circuit making. Reflection upon the several stages of the project and careful planning are crucial. Thus Maria early from the beginning invites her students to use Trello. Students' planning is transparent as Maria can have a look. The following image (Figure 23) is after several sessions and presents how Team 2 is planning and keeping track of their progress. They created 3 main categories, namely "To do", "Doing" and "Done" as well as a number of labels (i.e., Level 1, Level 2, programming etc.) to better organize their work and have an overview of all the steps towards the realization of the lighthouse project.*
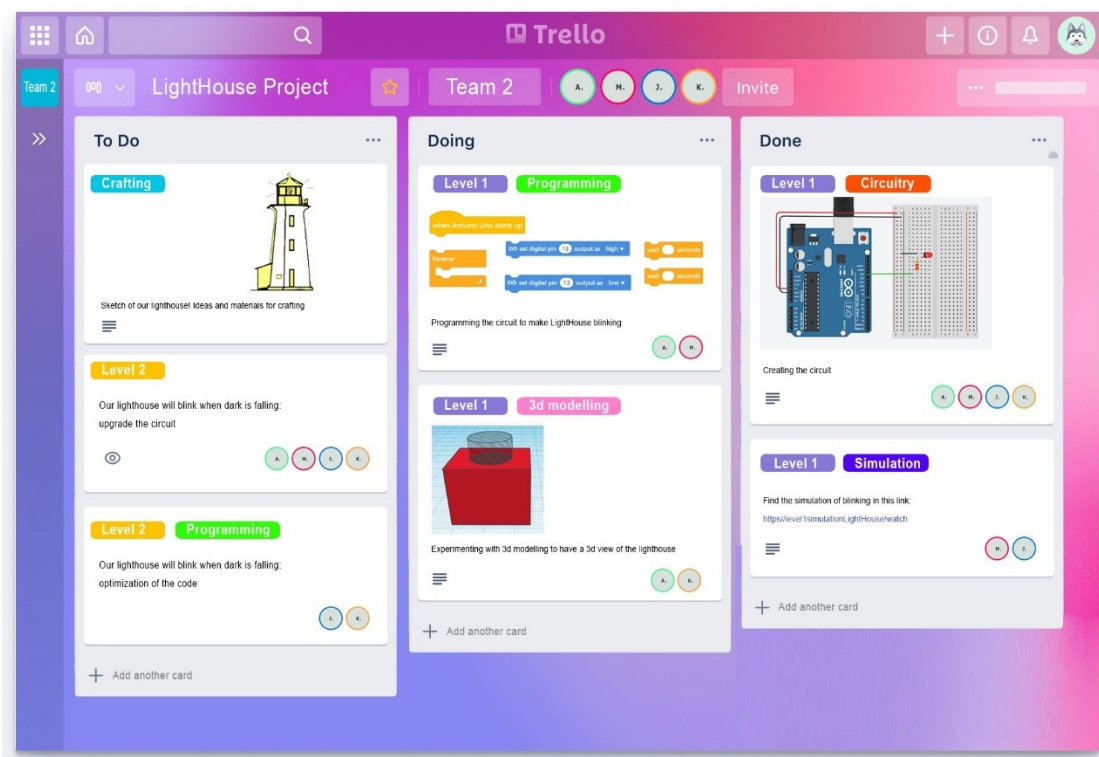

Figure 23: Using Trello for the planning stage of the Lighthouse project – Image produced by the authors

Digital tools for supporting the stage of creation

Depending on the learning activity and the relevant tasks, the stage of creation can be supported through a variety of tools. There are a number of criteria for choosing the more suitable tools, which vary based on the user (teacher or/and student) and the project to be developed. Another criterion can be the field of implementation and if the tool will be used for general scope or should be related to a specific area. Moreover, since, the tools are intended for use by the teachers (i.e., for preparing educational content) and/or by the students (i.e., for practicing their skills towards implementing their STEM project), another criterion should be the inherent level of complexity/difficulty of each tool (i.e., for beginners, for intermediate users or for professional users).

Last, another important factor is the technical aspects of a tool (i.e., if is a web-based tool or offline installation is required, if it is compatible with all the operational systems etc.) as well as its accessibility (i.e., whether is a license free tool or not, and under which conditions).

Based on the aforementioned criteria, a number of different tools were gathered and are accumulated in the following table. The selected tools – which will be analyzed in the following pages – are categorized according to the implementation they are intended for (i.e., programming, production of 2d visualizations and graphic content, 3d modelling etc.).

Digital tools for supporting the stage of creation	
Category	**Tools**
Visualization and graphic content production	Canva, GIMP, Inkscape, Sketchbook
3d modelling and parametric design	TinkerCAD 3D, FreeCAD, AutoCAD, 3dsMax
Circuit making	TinkerCAD circuit, Circuito, Eagle
Block-based programming	Scratch, mBlock, Open Roberta Lab, Microsoft MakeCode
Interactive simulations/ representations in Maths and Science	Geogebra, Free Math Apps, CanFigureIt, PhET Interactive Simulations, Physics Interactives, TEAL Studio Project, Biology Simulations, Virtual Labs by MERLOT, Virtual Biology Lab, LabXchange
Utilizing the concept of gamification	Cells Alive, Socrative, Kahoot!, Quizizz
Multipurpose/Multitasking	Explain Everything, Padlet, Nearpod
Creating and editing audiovisual material	FilmForth, Adobe Spark Video, Animoto, DaVinci Resolve, Audacity, Storyboard That

- Tools for visualization and graphic content production

Teachers and students need to frequently produce visual graphic content to illustrate part of their ideas or parts of an activity (i.e., create an image for a tutorial, create a diagram to present the work flow etc.). A tool that can be rather convenient for such processes is **Canva**. Canva is a graphic design platform, used to create social media graphics, presentations, posters, documents and other visual content (*Figure 24*). It has a wide variety of editable ready-made templates, and a user-friendly toolkit, making the software a suitable option for beginners. Therefore, it can be used by both teachers and students towards the preparation and the production of educational material and content for any subject.
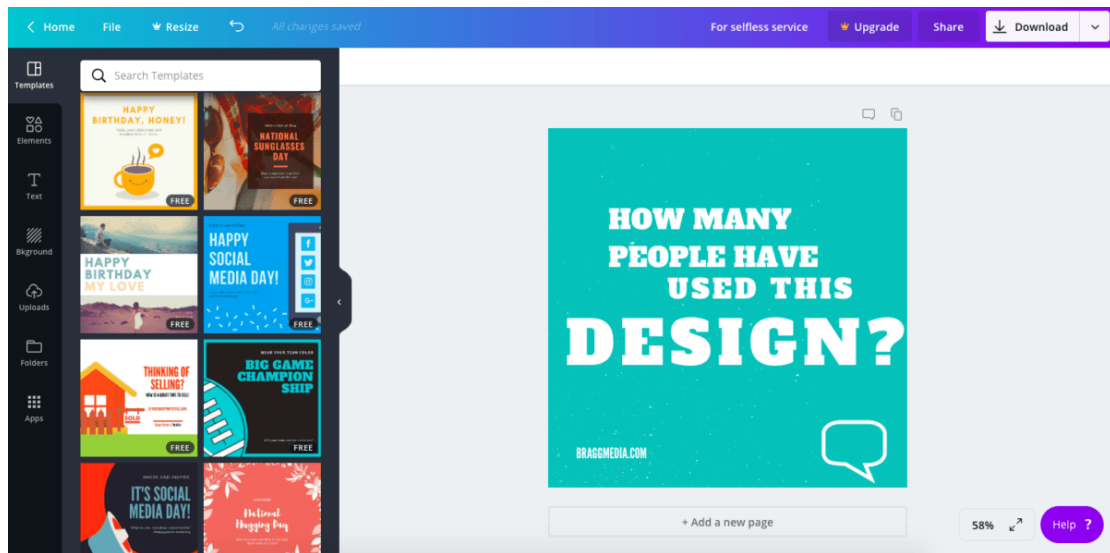
Figure 24: Screenshot of Canva's environment – Image produced by the authors

Another tool for graphic design is **GIMP**. GIMP is an open-source raster graphics editor used for image creation and image modification, as well as for free-form drawing (*Figure 25*). It is slightly advanced compared to Canva, but still is considered as an easy and user-friendly solution for beginners and intermediate users, and a convenient option for users who prefer producing their images from scratch.

Figure 25: Screenshot of GIMP's environment – Image retrieved from:
https://commons.wikimedia.org/wiki/File:Gimp_2.13_Ubuntu.png

Inkscape is another tool for graphic design which - among others - allows users to create vector images (*Figure 26*). Unlike raster graphics which are composed of pixels, vector images consist of points, and consequently lines and curves, enabling the production of images ideal for

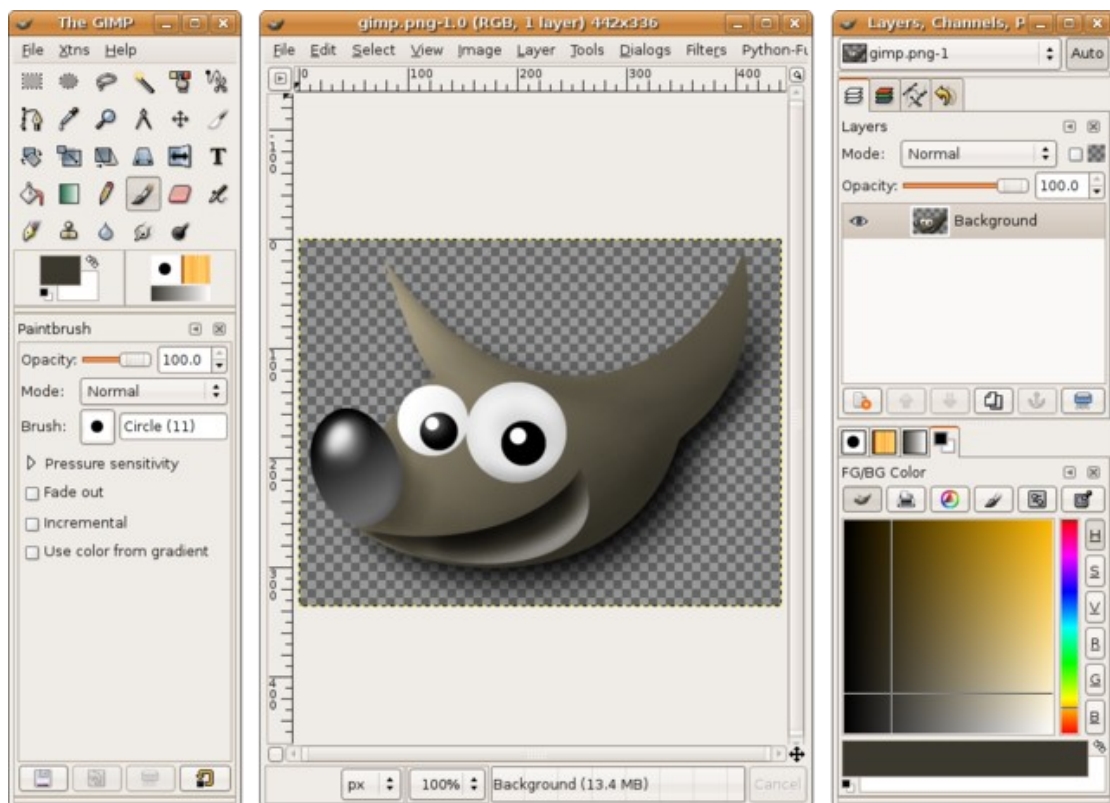printing (e.g., technical designs, logos etc.). Multiple formats of files (i.e., jpeg, png, pdf etc.) are supported for editing, saving or/and exporting by both GIMP and Inkscape.
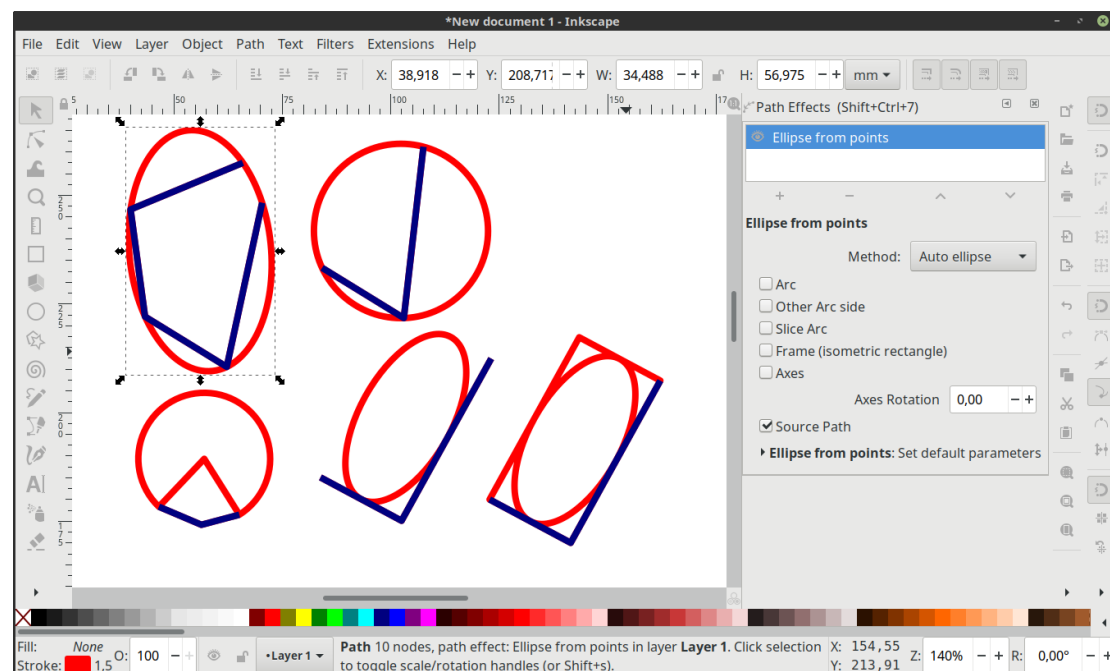
Figure 26: Preview of Inkscape environment – Image retrieved from:
https://wiki.inkscape.org/wiki/index.php?title=File:Ellipse_from_points_LPE.png

A more intuitive but less user-friendly tool, especially for beginners, is **Autodesk Sketchbook** (*Figure 27*). Sketchbook is a painting and drawing application for users that are natural on creating freeform drawings and sketches. Through a touch screen or a stylus on a touchpad, users can easily and quickly draw down their ideas (as they will do on a paper), turn them into graphic designs and share them with other users. This tool can be very powerful for different stages of creation but it can be less convenient for those who are not comfortable with freeform drawing or for those that do not have a device with touch input.

Figure 27: Example of drawing created at Sketchbook – Image retrieved from:
https://gr.pinterest.com/pin/529595237408571897/

All of the aforementioned tools are free or partially free, providing a convenient solution in terms of accessibility and availability.

- Tools for 3D modelling and parametric design

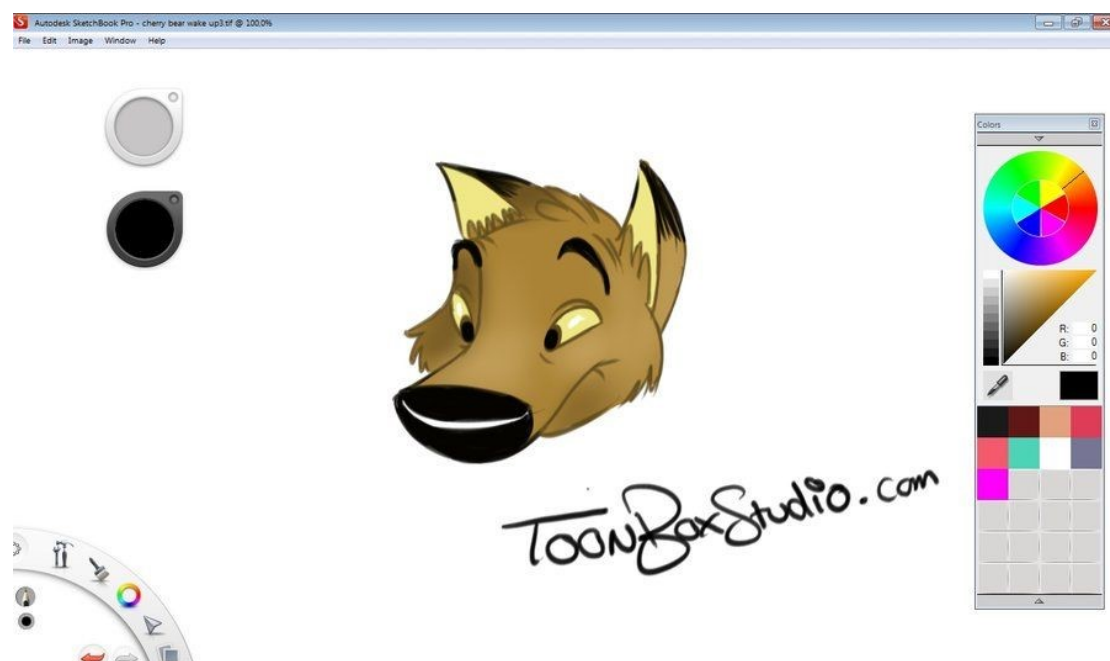An important part during the creation of a robotic artefact is crafting. Crafting can be done by using (and assembling) physical materials (e.g., cardboards, glue, scissors etc.) or (3D) parts that have been mechanically fabricated (i.e., by a 3D printer, a laser cutter etc.). In order to produce the latter, a 3D model need to be initially designed. 3D modelling (and parametric design) is often perceived as a rather complicated process that demands years of practice. However, during the last years, several software suitable for beginners have been produced, giving the opportunity to a wider audience to get involved with 3D modelling (and parametric design). **TinkerCAD 3D** is such a tool. TinkerCAD 3D is a free application for developing/ "sculpting" 3D models through easy-to-use and rather intuitive commands. Through the contained toolkit and by combining simple and semi-parametric commands (such as place, move, rotate, scale etc.) the user can easily create and modify a model that reflects his/her demands (*Figure 28*). Also, through current updates providing more components for modelling, users can add a number of electronic parts to their 3D model, thus testing their ideas regarding crafting towards the realization of a project-based scenario. After creating the model, the user can share it with other users, or s/he can proceed it for 3D printing.
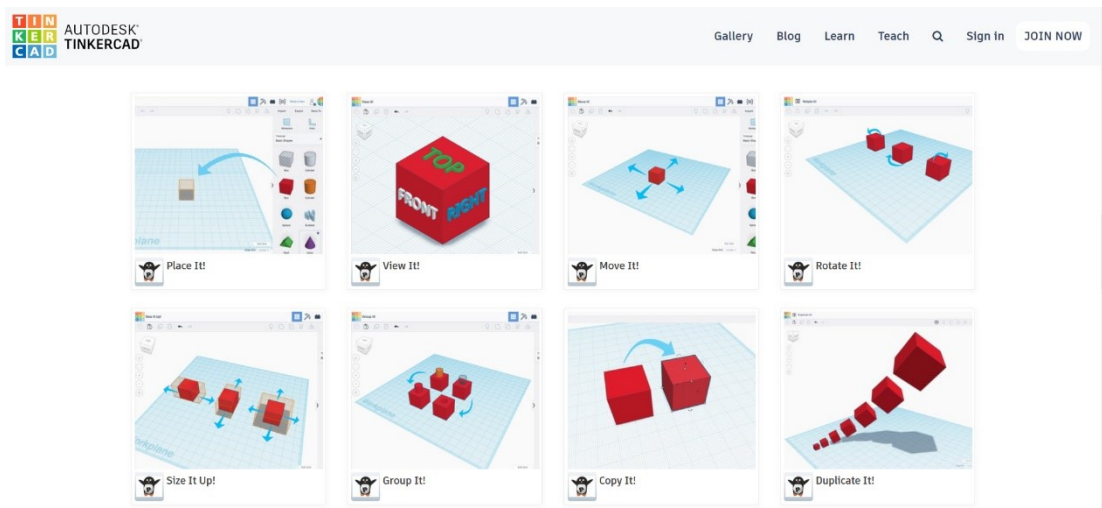
Figure 28: Examples of TinkerCAD's 3d available tools – Image retrieved from: https://www.tinkercad.com/

Another tool for 3D modelling is **FreeCAD** (*Figure 29*). FreeCAD enables users to create fully parametric 3d models for general purposes. Its toolkit contains a variety of tools for creating and modifying polygon or NURBs 3D models. It also allows users to export their 3D models in multiple formats, including those that are supported by software for 3D printing. The variety of contained tools making FreeCAD a rather powerful tool, but potentially less user-friendly, especially for beginners.
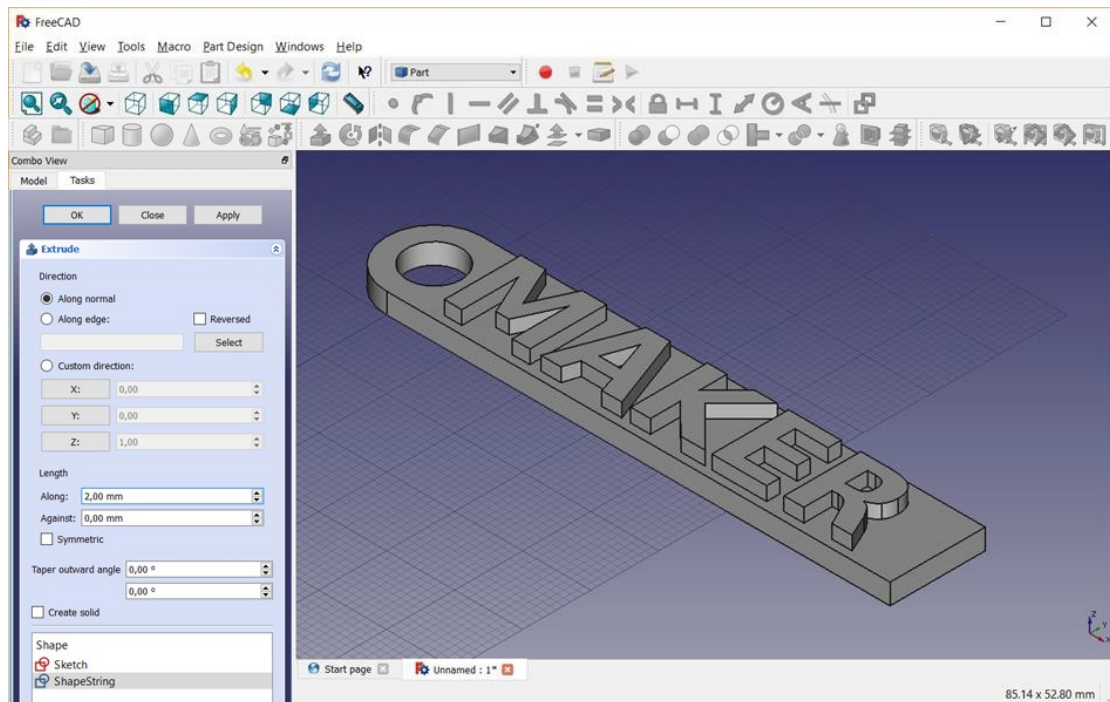
Figure 29: Example of model created in FreeCAD – Image produced by the authors

Onshape (*Figure 30*) is another powerful web-based CAD software allowing parametric 3D modelling, but also supporting cooperative design through cloud-computing services. Multiple users can collaborate and work on the same file, in real time, in order to co-design and produce a single 3D model. The environment is similar to FreeCAD, so it can be less intuitive for beginners, but since it is a web-based tool, is less unstable regarding processes related to the generation of a model. OnShape offers a free license to educators and students with an email account affiliated with a formal or non-formal educational institution, with some limitations regarding managerial and commercial related features (i.e., analytics, data management etc.).
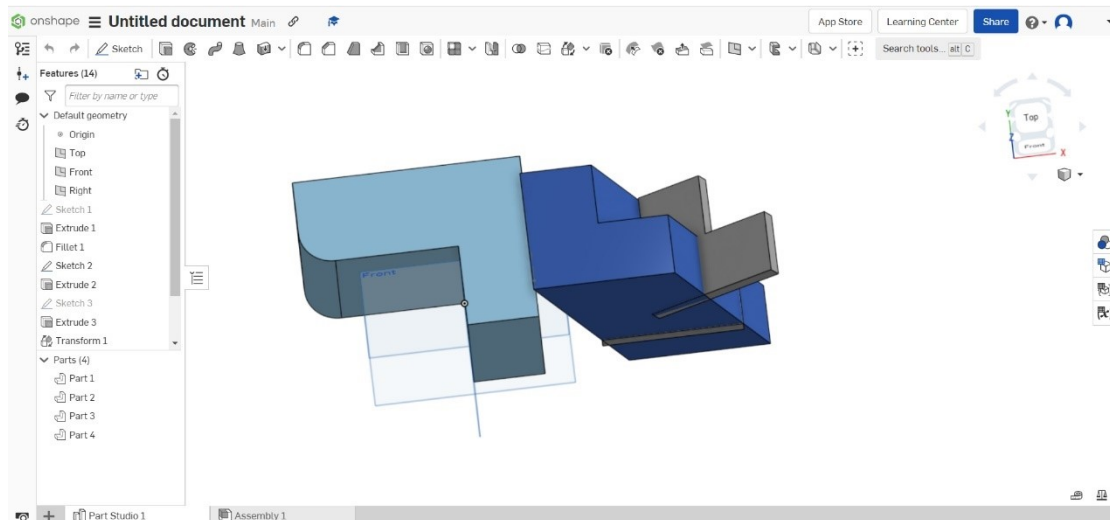
Figure 30: Example of model created in OnShape – Image produced by the authors

Autodesk's AutoCAD and **3dsMax** are both very powerful software for parametric 2D and/or 3D drawing and design (*Figure 31*). Both of them contain a variety of tools for creating and modifying models, as well as for creating animations. They can be accessible by the educational community since Autodesk offers a free license for a limited time (normally from 1 to 3 years). Even though they are powerful tools, they are both considered as professional tools and therefore not recommended for beginners or intermediate users. However, they could be

a challenging solution for those who have become familiar with similar to FreeCAD designing tools.
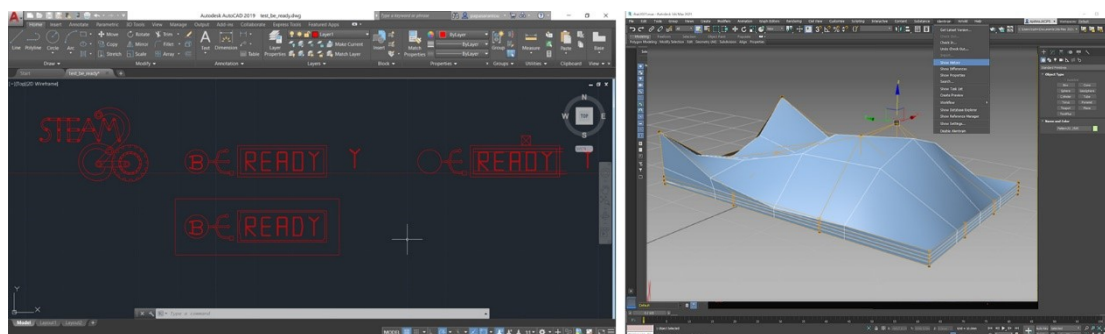
Figure 31: Examples of works in progress at AutoCAD (left) and 3dsmax (right) – Image produced by the authors

- Online tools for circuit making

TinkerCAD circuit is a free and easy to use application for creating electronic circuit simulations (*Figure 32*). Through menus containing several electronic components, users can assemble multiple and different kinds of circuit and with different power supply sources (i.e., batteries or/and microcontrollers such as Arduino board, Microbit etc.). Moreover, in the case of circuits containing microcontrollers, they can also use the coding menu in order to program the circuit through block-based or text-based programming environments. Apart from constructing -and in cases programming - a circuit, users can also test it by running simulations. The simulator is a powerful feature since it helps students to check the created set up without fear of damaging the equipment or harming themselves. Therefore, TinkerCAD circuits is a rather useful tool, especially for the creation of robotic artefacts, which can also help students to feel more confident on experimenting with different electrical components, set ups and programming solutions.
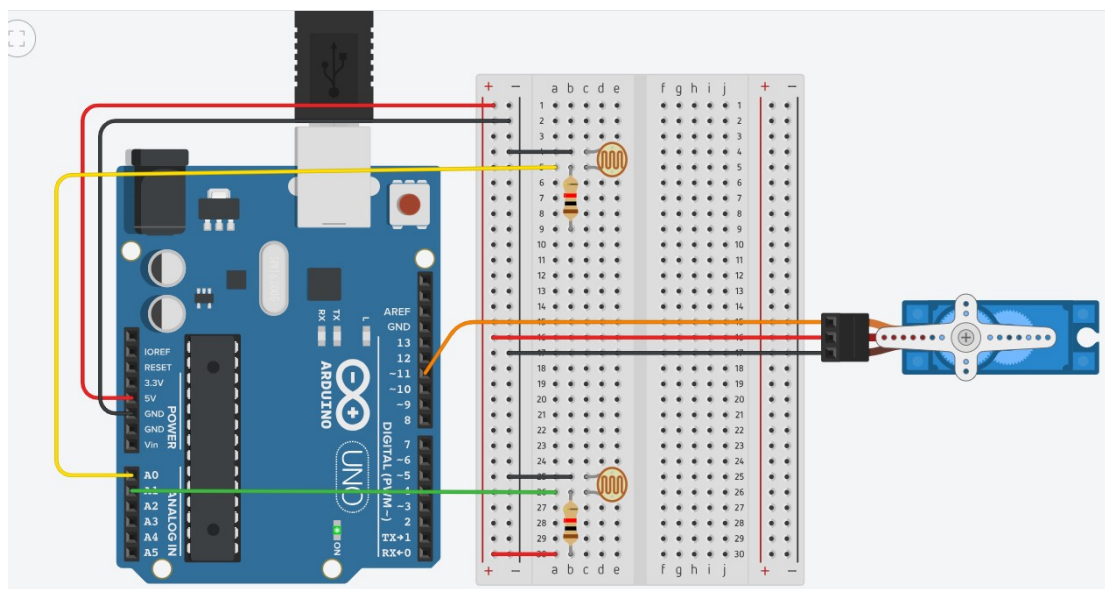
Figure 32: Example of circuit created in TinkerCAD circuits – Image produced by the authors

Circuito is an online tool for designing electronic circuits for Arduino based projects. The user can select among a variety of components, those that want to be included in the circuit, and drag and drop them in the design area. Then, the software instantly indicates the way that each component should be connected on the Arduino board. For example, if the user wants to add a LED light (see *Figure 33*) in the circuit, s/he just needs to drag it from the menu and drop it in the design area. Circuito will properly connect the LED light by also including a resistor to the circuit. By hovering the mouse over the added component (the resistor in our example), the

user can be informed of its identity and its value (i.e., a resistor of 100ohm). Due to these features, Circuito is considered as a rather useful tool for Arduino based projects, since it can produce instant and flawless solutions regarding circuit making. However, there is no flexibility regarding the designing of the wires, which may lead to the production of complex and confusing illustrations, especially when several components are combined in a circuit.
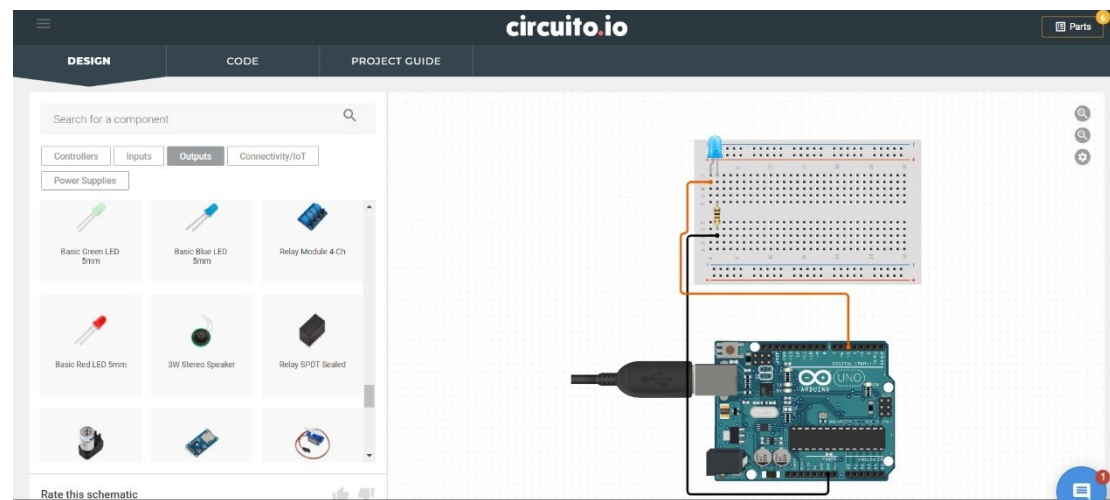
Figure 33: Automatically created circuit in Circuito indicating how a LED light should be connected on Arduino board – Image produced by the authors

Eagle is an electronic design automation (EDA) software produced by Autodesk that allows users to design their own circuit board (*Figure 34*). It offers several tools that permit designers to create a schematic diagram of the circuit board and use it as the base for developing a 3D model of it. In the 3D model mode, the user can decide how s/he wants to place the different components on the board while designing the circuit routes among them. The designer can share the outcome of his/her work with other users or s/he can use the computer-aided manufacturing (CAM) features to get a printed version of the designed model. Eagle is a powerful tool but is more appropriate for professional users and especially for users with a background in Electronics and Design. Moreover, the free version is limited for personal use, and therefore it cannot support collaborative work. However, it could be a challenging tool for those who want to explore more professional tools after becoming familiar with more elementary and/or intermediate circuit design processes.

Figure 34 Example of desding produced in Eagle – Image retrieved from: By CadSoft Computer GmbH - My office computer running Windows XP, Fair use, https://en.wikipedia.org/w/index.php?curid=52167837

- Tools for block-based programming

Block-based programming environments are considered more suitable from a pedagogical perspective for introducing young learners into the programming process. This is due to the fact that they 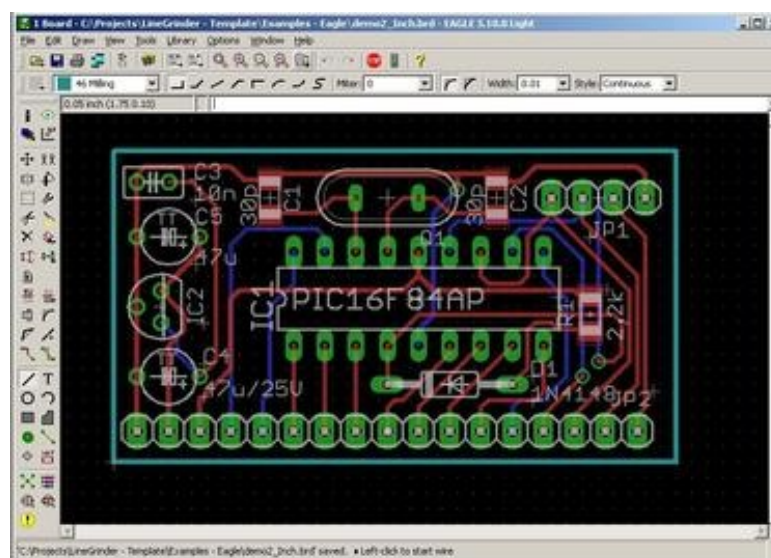are more accessible, intuitive, and user-friendly compared to text-based programming environments. They have graphical drag-and-drop user interfaces that allow users to focus on the programming process by creatively snapping together blocks of commands. Noteworthy, a number of quite promising block-based programming environments are available that are often practiced in the ICT lab and/or in the context of STEAM (Science, Technology, Engineering, Arts and Maths) related disciplines. Block-based environments usually support the constructionist approach to learning and are a great fit into project-based, creativity-enhancing and interest-driven educational activities. These environments can support learners to engage in personally meaningful projects such as animated stories, simulations, games, linking the digital and the physical world [42]. Indicative examples of such environments are Scratch, mBlock, OpenRoberta Lab and Microsoft MakeCode.

Scratch is a free programming block-based programming language and online community permitting the creation of interactive stories, games, and animations (*Figure 35*). The contained commands are grouped under distinctive and meaningful labels (e.g., Events, Control, Motions etc.) and in colorful pallets, enabling users to be easily oriented towards finding the needed blocks for assembling a code. Apart from the Command menu, Scratch has also a design area for drawing the sprites and the background of the created story. Therefore, by combining these two features, the users are able to create interactive animations and arcade-like video games. Moreover, through the Extensions menu, Scratch permits the enhancement of the digital content (i.e., animations and games) with physical input (e.g., makey-makey board, Microbit, RaspberryPi etc.).
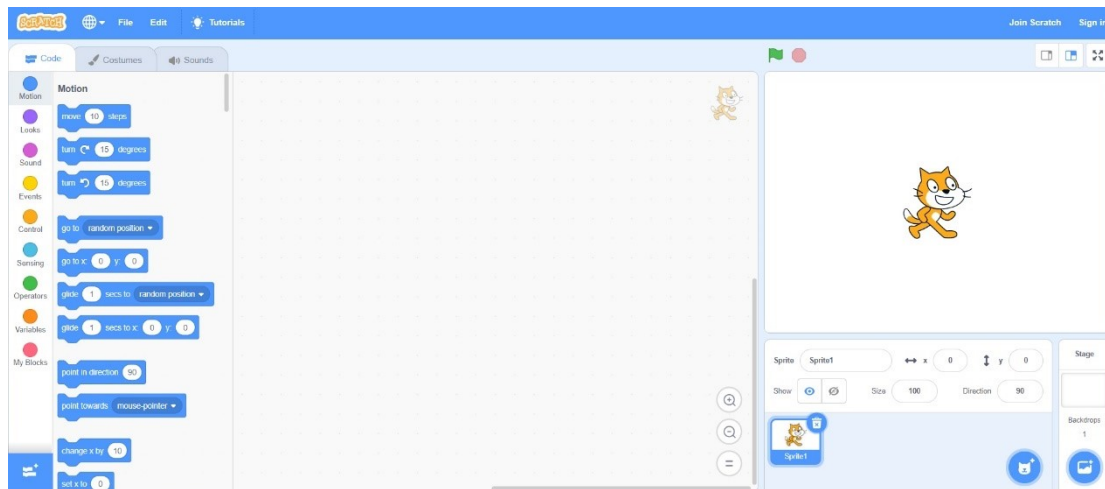
Figure 35: Screenshot of Scratch environment – Image produced by the authors

Scratch has been the cornerstone for other block-based programming software. mBlock is one of them (*Figure 36*). Just like Scratch, **mBlock** enables users to create and code animations and arcade-like games as well as program different types of robots. Unlike Scratch, mBlock can be also used for programming Arduino-based robotic artefacts. Another difference is that mBlock can support text-based programming and can be used as a mediator from block-based visual code to Python code. Therefore, it can be a useful tool for beginners as well as for intermediate users, as far as STEM education is concerned. In some cases (e.g., Arduino based projects), mBlock cannot yet support live-testing, which can be considered as a significant drawback since the constant uploading of code to the board can be proved time consuming and a bit frustrating.
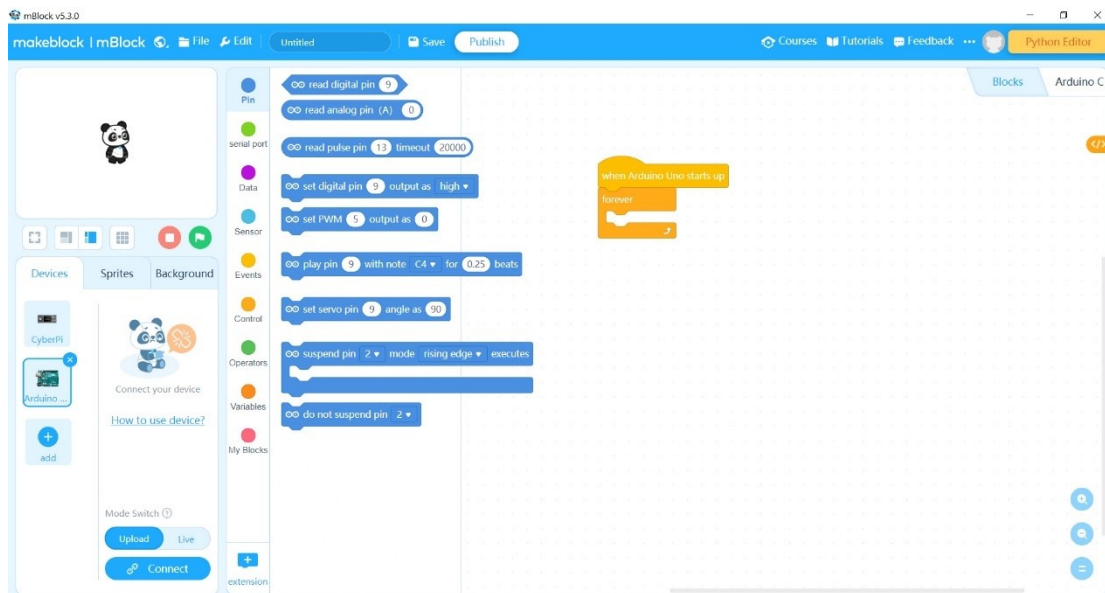
Figure 36: Screenshot of mBock environment – image produced by the authors

Open Roberta Lab is a cloud-based and block-based programming environment for coding different types of robots and microcontrollers such as LEGO Mindstorm, Arduino board and Microbit (*Figure 37*). In comparison to mBlock, Open Roberta Lab can support the programming of many more sensors, especially those compatible with Arduino board. It also supports a simulator for some of the compatible robots and microcontrollers, permitting users to experiment with a virtual robot or with a virtual equipment, in case s/he doesn't own a physical one. As other block-based programming software, it is also considered as a useful learning tool for STEM education and especially for novices.
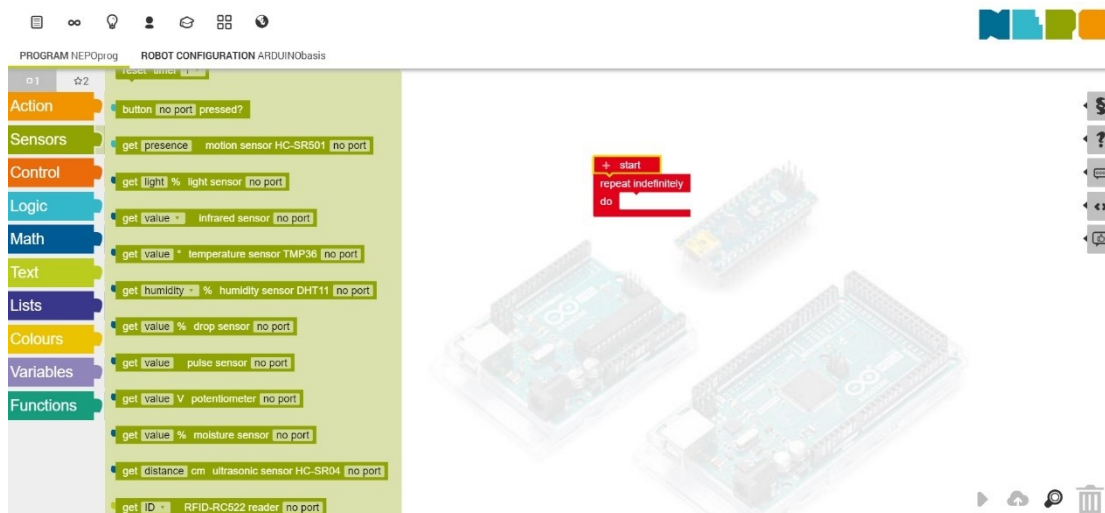
Figure 37: Screenshot of the Open Roberta Lab environment – Image produced by the authors

Another online environment for block-based programming is Microsoft MakeCode (*Figure 38*). MakeCode is an open-source project described as a framework that enables novices to create interactive and engaging programming experiences, and become familiar with fundamental steps of coding while testing the results to embedded simulators or actual hardware [37]. MakeCode is not a standalone environment but is interrelated to specific hardware created for educational purposes such as Micro:bit board, LEGO Mindstorms and Chibi Chip board. After choosing a board, users can use the corresponding editor. Each editor contains a block editor for assembling a code, a language editor that turns block-based programming into text-based while allowing user to modify it by adding new lines of code, a simulator for virtually testing the

results of programming, as well as a code generator for downloading the code to the connected hardware (if available).
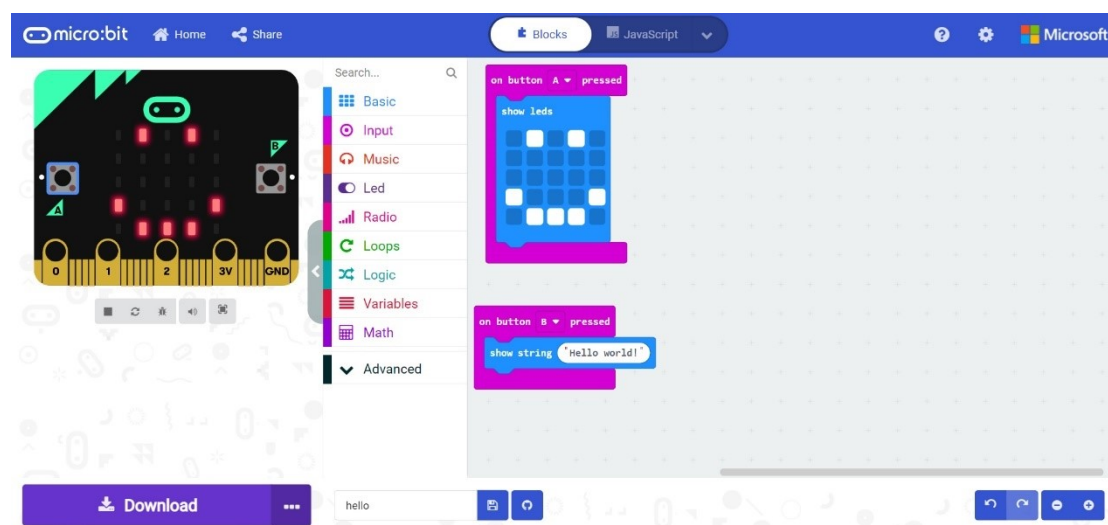
Figure 38: Screenshot of MakeCode environment while using micro:bit extension – Image captured and developed by the authors

- Tools for interactive simulations/representations in Maths and Science

Geogebra is a free interactive mathematics software, that accumulates geometry, algebra, spreadsheets, graphics, statistics and calculus in one digital place, providing a tool that is considered suitable for learning and teaching primarily mathematics and mathematical related subjects, in all educational levels (from primary school to university). Therefore, users can become familiar with basic to more complex mathematical concepts through designing geometric constructions, creating graphics through different types of input (i.e., inserting points, creating lines, typing etc.), turning conjugators into diagrams, creating physical simulations etc. (*Figure 39*). Given these features the tool can be also applied in the context of other subject areas i.e. Physics, Engineering. Moreover, Geogebra offers the possibility for sharing on-line projects and organizing them into lessons. Geogebra can also be integrated in online classrooms and/or in digital platforms for online education, and thus becoming a tool not only for online learning and teaching but also for online collaboration and communication.

Also, through the virtual platform GeoGebra Classroom teachers can: a) assign task for students, view up-to-date progress of students working on a specific assignment, b) see which tasks students are working on, c) pose questions to the entire class and have immediate feedback, while d) allowing them to create a GeoGebraBook, which is a pedagogical resource in the form of a digital book created and developed for free on the GeoGebra online page.

Figure 39: Example of using GeoGebra environment – image produced by the authors

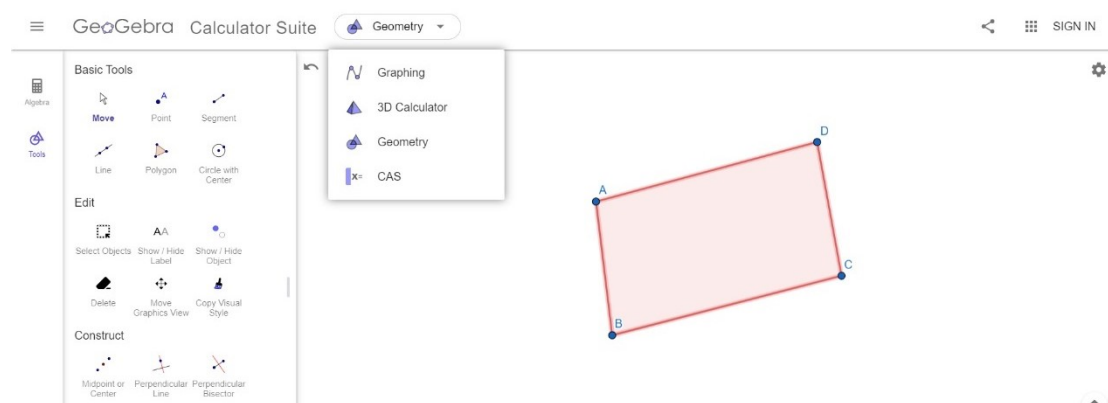**Free Math Apps** contains a number of interactive applications related to mathematical concepts (*Figure 40*), and is offered by the Math Learning Center (MLC), a nonprofit organization serving the education community by trying to boost the confidence and the abilities of students and teachers around mathematics. The applications are based on visual models included in "Bridges in Mathematics", a curriculum that contains methods and material revolving around the development of key skills and abilities on solving complex problems and eventually on gaining deep understandings of mathematical concepts. Apart from interacting with the different applications (concerning geometrical and algebraic concepts) teachers and students have also the opportunity to share content (i.e., teachers can share an activity with students, while students can share their thinking and inquiries with both teachers and their classmates).
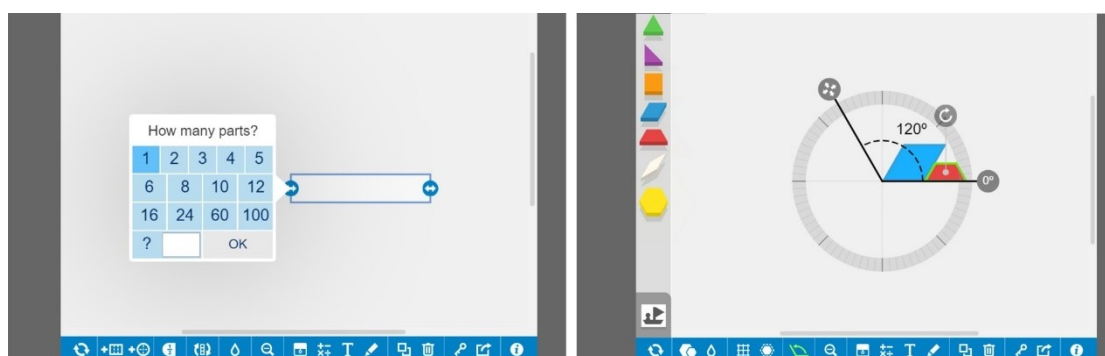
Figure 40: Examples of applications contained in Free Math Apps – Image produced by the authors

Another interesting online tool is **CanFigureIt**. CanFigureIt offers a number of interactive activities on Geometry that assist teaching and learning of geometric proofs. Students are encouraged to explore and test different ways in order to solve a given problem (e.g., check if two triangles are equal). Each activity has three levels of difficulty, functioning also as indicators of the progress of the student in each activity. Each activity can be solved through a number of hypotheses posed by the student, and through the justification of these hypothesis based on provided theorems and hints (*Figure 41*). After finishing an activity, students can submit it and send it to their teacher. They can also download it and keep it as a copy for their own library. Through the included activities, it is argued that students reinforce their logical thinking skills and develop problem solving skills. CanFigureIt is also considered a valuable tool for teachers since it can empower their learning methods by making their course more interacting and engaging.

Figure 41: example of using CanFigureIt - still from video tutorial retrieved from: https://youtu.be/feaqw4os_MQ

PhET Interactive Simulations is an open educational resource project, developed by the University of Colorado Boulder, that provides free interactive simulations on math and science topics for implementation in K-12 as well as college STEM education. PhET Interactive Simulations engage students in an intuitive environment where they learn through exploration and discovery, as well as through gaming.

Concerning mathematics, PhET enhances learning processes by offering students challenging activities regarding the exploration and test of different ways to solve a given problem. Some of the activities have different difficulty levels that can be chosen. For example, in the activity depicted in Figure 42, students can create rectangles of various sizes and use multiplication to calculate the area. Students can discover new strategies for multiplying algebraic expressions and can also use the game mode to test their multiplication and factoring skills.

Regarding Science, the main goal of the provided simulations is to represent scientific phenomena that normally are not visible and/or graspable, in an easier and comprehensible way. Therefore, through the use of graphics and interactive components (such as buttons, sliders etc.) and by turning them into interactive animations, abstract concepts such as electrical circuit are turn into a fun, perceptible and more intuitive process (*Figure 43*).
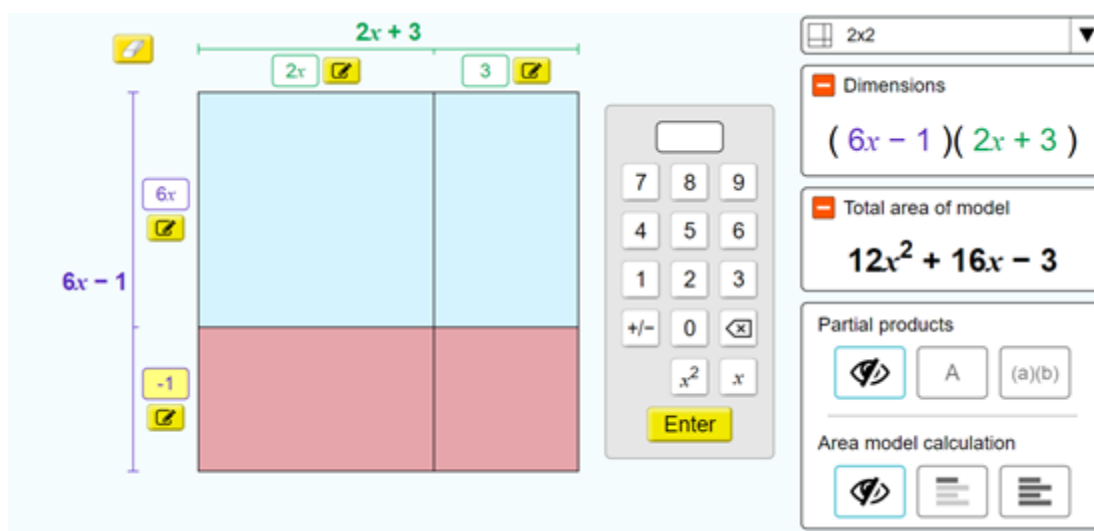
Figure 42: Example of activity regarding area calculation – Image produced by the authors
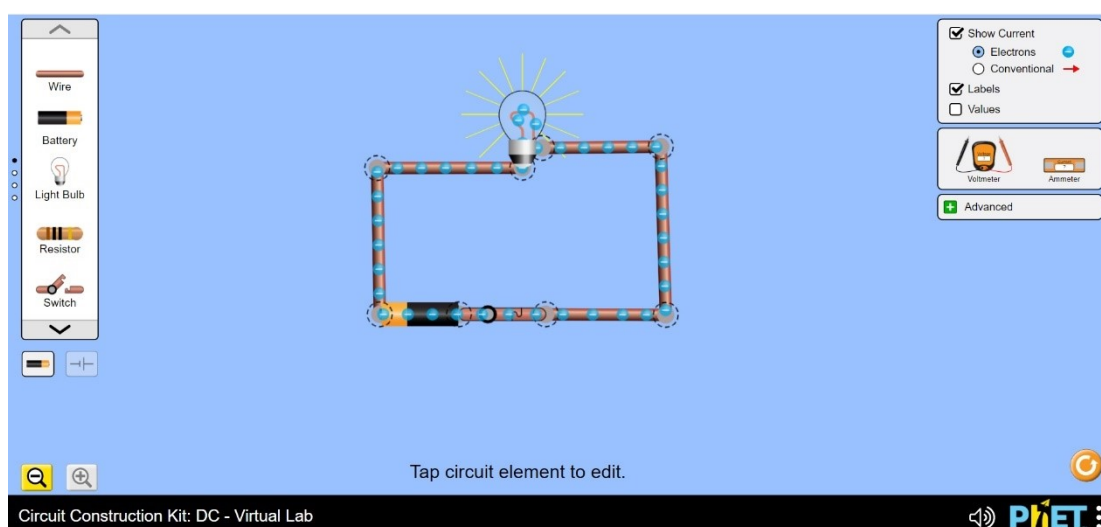
Figure 43: Example of circuit created in PhET Interactive Simulator – Image produced by the authors

Physics Interactives is a growing collection of interactive materials for allowing users to explore concepts related to physics. The included material is broadly divided in three categories, namely simulations, skill building exercises and game-like environment. Therefore, the nature of interactivity varies from more static (e.g., viewing a video and answering a question) to more dynamic (e.g., adding components to activate a simulation) (*Figure 44*). Apart from the interactive material the included learning activities are enhanced with text and diagrams that assist students towards the comprehension of the physical concepts.
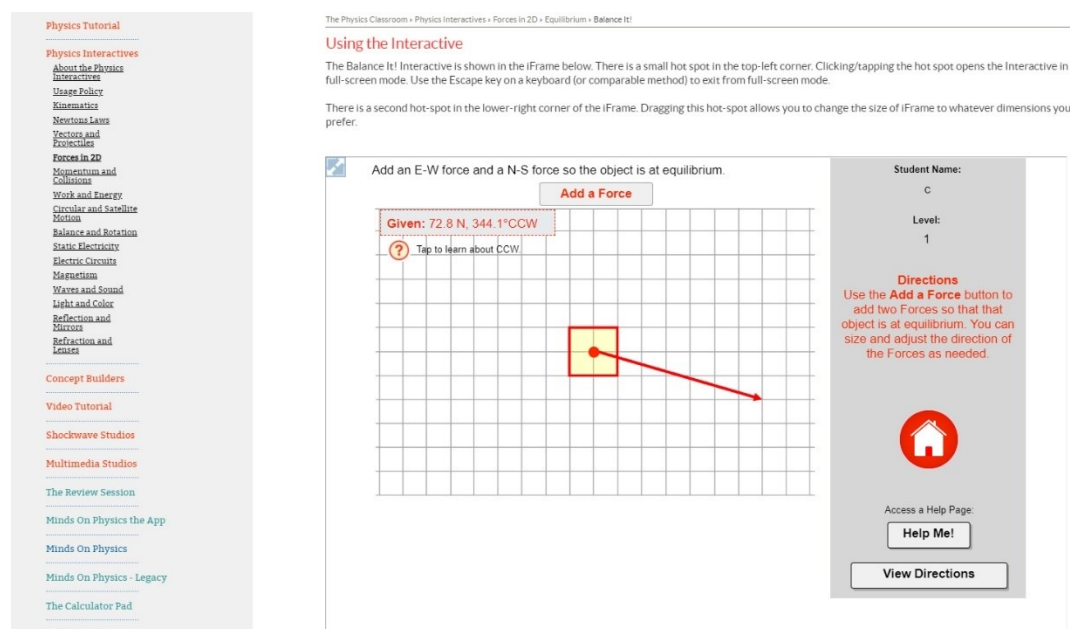
Figure 44: Example of activity in Physics Interactive – image produced by the authors

The **TEAL** (Technology Enabled Active Learning) Studio Project is an educational initiative of the MIT Department of Physics. A large part of this initiative is the release of a software (The TEAL Simulation Framework) enabling the development of simulations through a number of embedded services (i.e., real time 3D rendering, importing and exporting application components etc.) regarding phenomena in physics, mathematics. Users can download the software or they can download available simulations visualizing concepts from different sections such as Electrostatics, Magnetostatics and Faraday's Law (*Figure 45*).
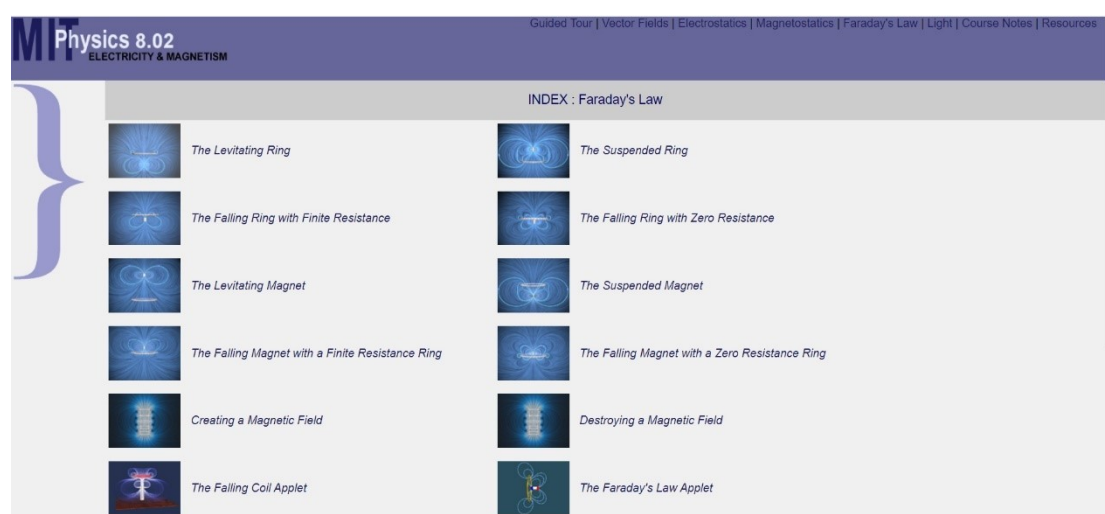
Figure 45: Screenshot depicting some of the available simulations in MIT Physics 8.02 – Image captured and produced by the authors

Biology Simulations is a website created by a high school biology teacher from Illinois, to explicate some of the main concepts related to Biology and their correlated data analysis. Towards this direction, the website provides a number of interactive simulations and games, accompanied with student's worksheets for facilitating the implementation of the former in the class. Students can experiment with the interactive material, gather data and analyze them according to the included (in the worksheets) activities. For example, by using the hematocrit simulation, students can record the different generated data and perform some calculations and a relevant diagnosis (*Figure 46*).
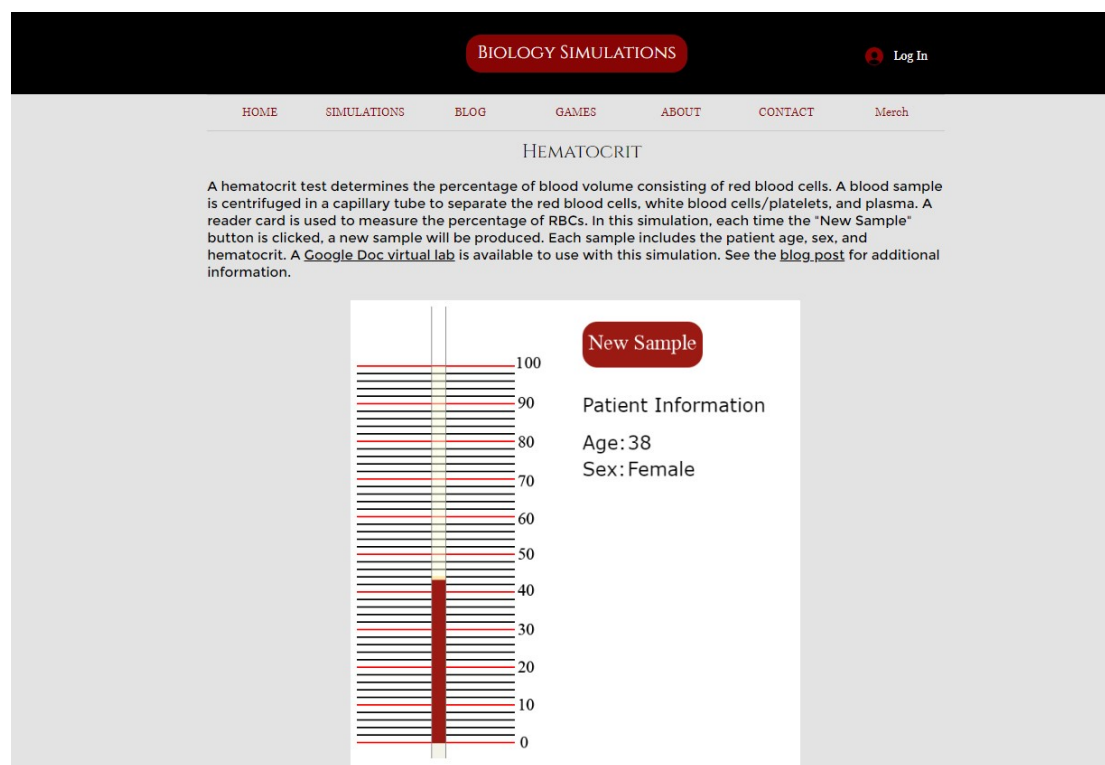
Figure 46: Screenshot from Hematocrit simulation included in Biology Simulations website – Image captured and produced by the authors

Virtual Labs are online educational websites hosting material and interactive activities that can turn STEM related disciplines and topics into more engaging and comprehensible learning experiences. In virtual labs, users can have access to simulations related to the explication of a scientific concept or phenomenon, or/and to the reproduction of lab experiments while getting acquainted with processes regarding lab technologies and scientific approaches. Virtual Labs by MERLOT skill commons and partners, is such an example, hosting virtual labs for exploring Biology, Chemistry, Physics, Maths as well as Engineering and Environmental Sciences. Virtual Labs by MERLOT are giving access to several simulations and other types of open educational resources while providing links to similar material offered by other sites and organizations (e.g., PhET simulations). Another example is Virtual Biology Lab, focusing on simulations regarding ecology and the natural world. Through the offered material, users can run some virtual experiments and realize how the natural environment can be effected by changing a number of parameters and conditions (e.g., how some parameters and conditions can effect the population of some species, *Figure 47*).

A slightly different paradigm is **LabXchange** which apart from hosting a library with several simulations, it also functions as a community offering space for sharing, discussing and exchanging ideas with others regarding scientific experiments and research experiences, getting inspiration from experts and exploring a rich repository of authentic scientific content (*Figure 48*). LabXchange can also be seen as a good practice example on how online learning

experiences in Science can be enriched and authentically and collaboratively constructed within a supportive learning community (*Figure 49*).

Figure 47: Screenshot of simulation hosted in Biology Virtual Lab regarding Biogeography – Image retrieved from: http://virtualbiologylab.org/ModelsHTML5/IslandBiogeography/IslandBiogeography.html

Figure 48: Screenshot of LabXchange library – Image captured and produced by the authors
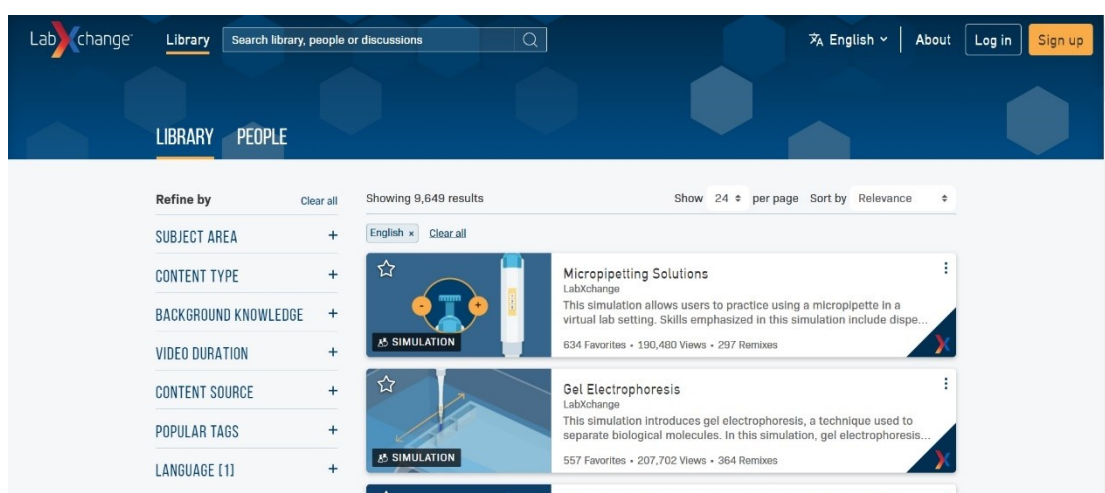

Figure 49: LabXechange as a supportive learning community – Image captured and produced by the authors

-Tools utilizing the concept of gamification

A concept that is introduced as a method for making learning activities more engaging is gamification. Gamification is the process of using gaming techniques to motivate consistent participation and long-term engagement. Games are "per se motivating" [18] and are inextricably related to the act of playing [21] [22]. In this sense, they should be also linked to the process of learning [20]. Games, such as video games and particularly those belonging to the field of "serious games", are "information-rich" interactive environments and therefore are considered as valuable tools for STE(A)M related learning activities since they are enhancing the acquisition of knowledge, while supporting behaviors of exploration, problem solving and team-building [18] [19]. In addition, they are having a positive impact on skills such as "communication, adaptability and resourcefulness" [17]. All these assets are not only related to the act of playing, but also to the act and process of designing. After all, a reason that we are playing games is to make sense of the possibilities lying behind them and think of their implications in our daily life [23]. Moreover, designing and using games (and particularly serious games) are highly interrelated to constructivist learning theories about the creation of knowledge through the experience of "exploring the world and performing activities" [18].

With this as a solid base, a number of tools emphasizing on the concept of gamification are presented. **Cells Alive** for example is a site utilizing gamification as a process and method for engaging students to concepts related to biology. Through a number of quizzes, puzzles, and other interactive games, Cells Alive students can explore different phenomena such as genetics, immune response and microbes (*Figure 50, left*). Another example is **Socrative**. Through the tools of Socrative, teachers can create interactive and fun quizzes in order to evaluate and monitor the level of understanding of their students. In this way they are making the learning activities more engaging, while they are receiving instant feedback for the progress of their students. A similar to Socrative example is **Kahoot!**. Kahoot! is a game-based learning platform that allows the creation of quizzes in multiple subjects (*Figure 50, right*). It is a rather popular platform with a positive impact on students' learning performance [24]. Kahoot! is available in multiple languages, and therefore is a widely accessible tool. Similar to Kahoot! platform, as far as the educational method is concerned, is **Quizizz**. In both platforms, the user can select among pre-made quizzes or can create her/his own based on her/his needs. The questions type included in a quiz can vary from multiple-choice to true-false, or from answering by selecting an image (a method that is also appropriate for pre-school students) to answering through typing (i.e., filling blanks, answering to an open-ending question etc.)[1]. Polls, slides adding more information regarding context and puzzles are also provided[2]. The quizzes can be played individually or in teams, making the entire process more entertaining and engaging. Both platforms can also support asynchronous teaching since they permit extracurricular assignments.
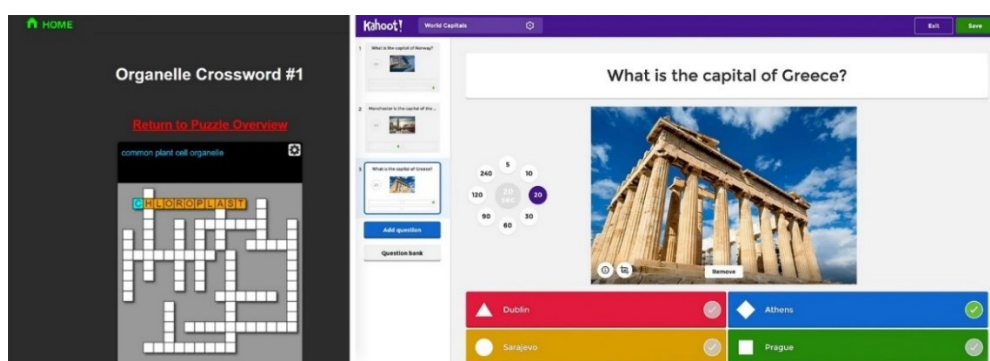
Figure 50: Examples of educational games contained in Cells Alive (left) and Kahoot! (right) – Images captured from the official sites and produced by the authors

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[1] In Kahoot, this option is available only for pro or premium subscriptions

[2] In Kahoot, all these features are available only for pro or premium users. Quizizz does not support puzzles.

Figure 51: Screenshot of the creation of a quiz in Quizizz for testing equations – Image captured and produced by the authors

-Tools for producing 3D virtual experiences

During the last years, virtual reality and tools for creating virtual environments have become present in fields related to education. These kind of tools and environments are introduced in order to enhance the learning ability of students towards a specific subject through producing lived embodied experiences [43] [44] [45] [46]. By producing instant and multisensory feedback, virtual environments can easier trigger students' interest and engage them to meaningful interactive learning processes. In such environments students are able to interact and experiment with content and information that could not be accessible or available in real life (e.g., visiting a museum located in another country, running experiments in virtual labs, visiting a virtual historical building that does not exist at present etc.). Moreover, it is argued that virtual environments and tools can also support theories of constructivism, especially in cases that students are able to design their own (virtual) content and experiences, thus offering opportunities for learning, making meaning and exploring concepts while engaging in meaningful and challenging creations [44]. Some tools that can support the creation of 3D virtual experiences are Artsteps and CoSpaces Edu.

-CoSpaces Edu

CoSpaces Edu is a web-based platform that allows users to create their own 3D virtual spaces or interact with 3D environments designed by other users (*Figure 52*). By using the available tools students can create their own 3D models, add interaction with block-based coding or more advanced methods of scripting, and collaborate in real-time. They can also explore the work of other students which can be presented in a virtual or augmented form. Through CoSpaces Edu, students can imagine and develop their own stories, games, exhibitions or/and simulations. It is compatible with any device but the free license is limited since it permits the use of basic features and it allows the creation of up 2 CoSpaces.
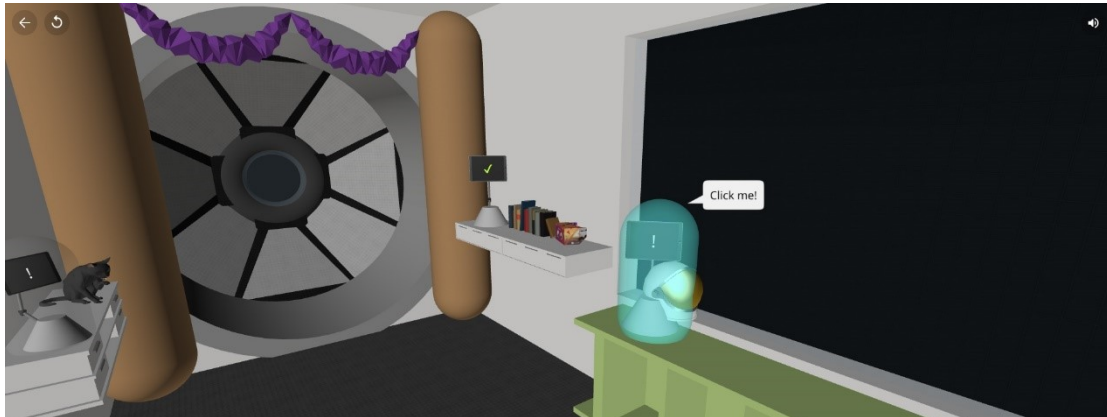
Figure 52: An example of an interactive 3D game produced in CoSpaces Edu – image retrieved by https://edu.cospaces.io/TBK-SAG

-Artsteps

Artsteps (*Figure 53*) is a web-based software that allows users to create their own virtual gallery by using prebuilt templates or by designing their own 3D spatial configuration. There they can add their own exhibits in the form of images, videos or/and 3D objects and even plan a guide thus creating a specific narrative flow that visitors of the gallery will be able to follow. Even though it is primarily intended for artists, Artsteps is considered as a powerful tool that can be used by anyone who wants to create 3D narrative experiences and share content with a broader audience. And since there is no restriction on the content of the gallery, Artsteps can be a useful tool for both teachers and students. The former can use ArtSteps to introduce students to a specific topic (e.g., the life and the work of a famous scientist) and the latter can use it to make a presentation on a specific topic (e.g., present their research on the life of a famous scientist, present artefacts created in their makerspace etc.). The software provides an unlimited free version that can be used after creating a personal account on the ArtSteps platform.
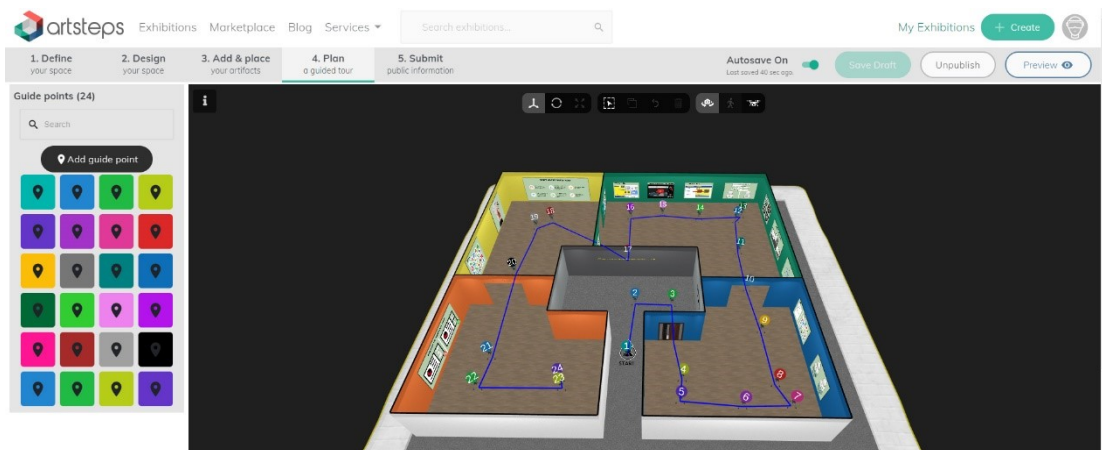
Figure 53: Example of a virtual gallery created in ArtSteps – image produced by the authors

-Multipurpose / Multitasking tools

Explain everything is a multitasking whiteboard digital platform offering among others the feature of sharing. Through Explain everything users can create content by combining sketches, images, documents and videos, enhance their notes through "on-fly" recorded audiovisual material in order to better communicate their ideas, and share their projects, as video links, by uploading them on the cloud (*Figure 54*). In this way they can share their ideas, as well as develop their own video libraries and channels. Explain Everything also offers a digital canvas in which users can collaborate by sharing their thoughts and actively participate to the development of an idea or a project. Explain everything provides, among others, a fee-free license for both teachers and students with a limitation to the number of projects (i.e., up to three projects working in parallel) as well as the number of slides that can be used (i.e., one slide per project).
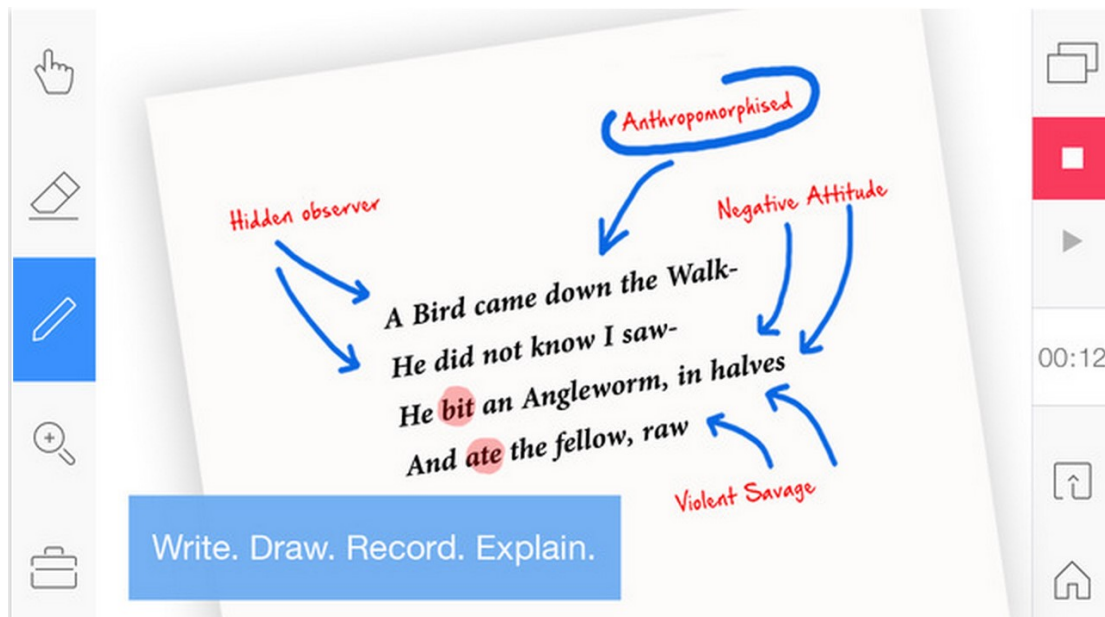
Figure 54: Example of using the Explain Everything platform – Image retrieved from: https://www.educatorstechnology.com/2015/08/the-new-explain-everything-30-offers-math-features-for-teachers.html

Padlet is a multitasking digital pinboard that allows users to share content and collaborate by uploading different types of information such as texts, images, videos and audio files. It provides different templates (e.g., wall, canvas, grid etc.) which allow different type of activities (e.g., In the wall template users can pin a message, a sketch etc. in a brick-like layout, while in the canvas template users can scatter and make connections among the uploaded content), and therefore it can support different learning stages such as collaboration and brainstorming (*Figure 55*). It can also support the stage of sharing since it allows users to share content with certain users, or with a broader audience via social media platforms (i.e., Facebook, Twitter etc.). One of Padlet's drawbacks is the limited license, since its free license permits the development of up to 3 projects per time.
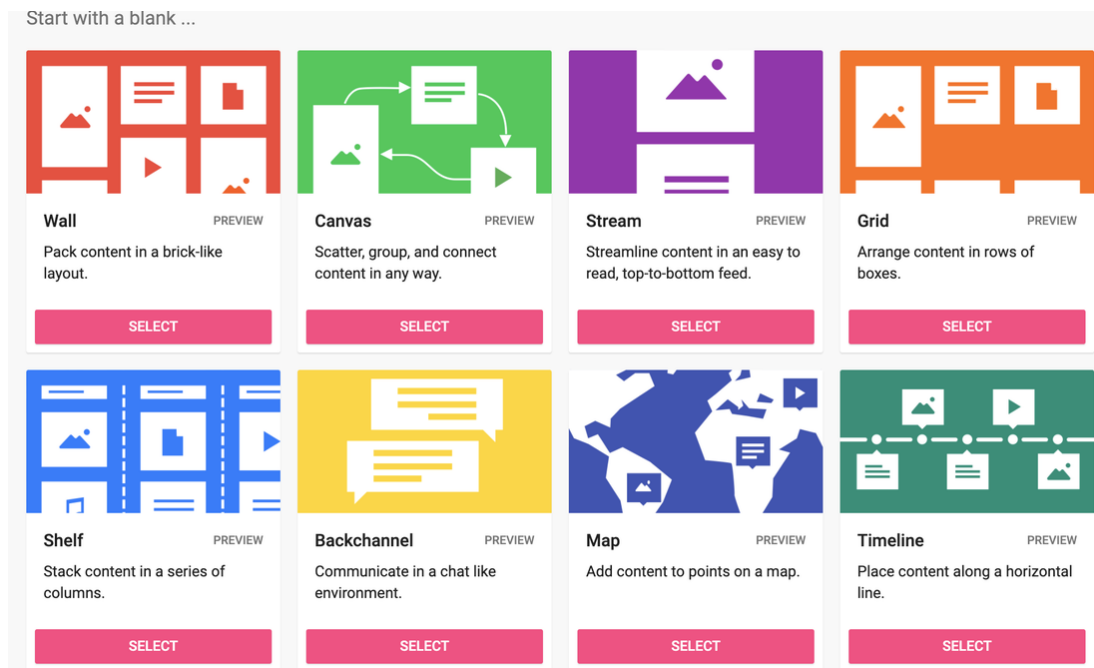
Figure 55: Preview of the Padlet environment – Image retrieved from: https://www.writecenter.org/blog/use-padlet-to-assist-students-process-based-writing

Nearpod is a free cross-platform application containing features and toolkits that allow teachers to turn their lessons into interactive and engaging learning experiences. Through the teaching mode "Live participation" it enables students to join the class through their devices, have access to the content of the lesson and participate in class. NEARPOD has several features, allowing teachers to incorporate content of different types. For instance, they can upload their own resources and notes (i.e., powerpoint files, videos, google slides etc.) and enhance them with interactive elements or they can choose from a library where pre-made lessons and videos are hosted, coming from rather popular sources such as PhET, VR Field Trip and BBC and customize them based on their needs (*Figure 56*). Then, they can create a number of different, and in case collaborative, activities by embedding playful and interactive methods such as quizzes, polls, virtual reality, simulations and open-ended questions.
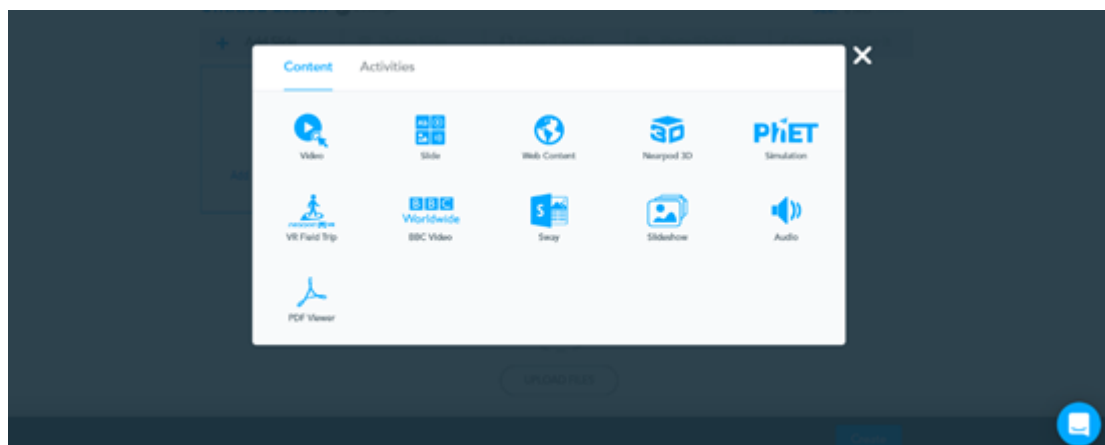
Figure 56: Screenshot of NEARPOD included features – Image captured and produced by the authors

An interesting tool embedded in Nearpod is **Nearpod's Draw It**. Draw It can be used as a sketch pad, in which students can create a quick sketch, a diagram, etc. as a response to a question posed by the teacher, as a text box, in which students can type anything relevant to a given task, or as an editor, in which students can make changes over an uploaded file (i.e., highlight specific parts of an uploaded document by using circles, lines etc., erase or annotate parts of an uploaded image etc.). Due to this feature (i.e., Draw It), Nearpod can be a very useful tool for Maths and Science turning the learning process into an engaging and collaborating experience (e.g., labeling a diagram, recreating geometrical related problems, sketching a circuit etc.) (*Figure 57*).
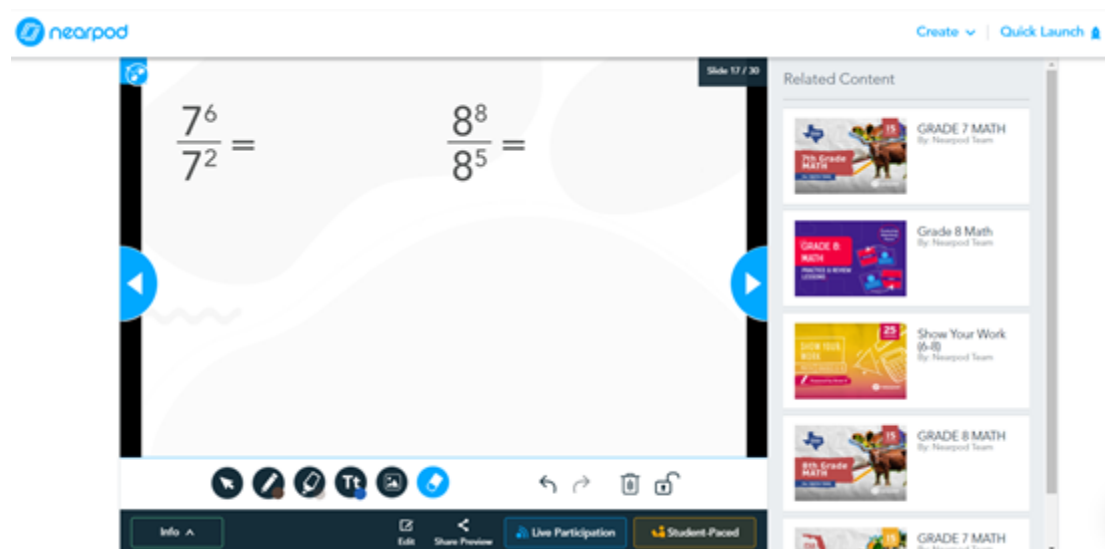
Figure 57: Using Nearpod Draw It to create an activity in Maths – image created by the authors

Note: Among the tools that are frequently used in the context of online STEM education are those that enable the creation of audiovisual material for pedagogical purposes. The section below presents an extended presentation of tools that support the creation and use of audiovisual material bringing also forward pedagogical tips and guidelines for teachers.

Tools and pedagogical tips for creating and editing audiovisual material

The vast entrance of technology in our daily life has created new needs in a variety of fields, including education. Nowadays, students belong to the so-called "Digital Generation", a generation that is surrounded and experiences the world mainly through the use of technology [27]. Due to this fact, digital generation students are fond of using their sensory system to come in grasp with their environment and therefore gaining knowledge through more interactive and intuitive processes coming from an active visual and kinesthetic exploration [27]. Therefore, it is an immanent need to enhance learning and teaching processes with digital technology, especially since the aforementioned qualities are not fostered in the existing traditional methods of education.

One of the primary senses that is stimulated through the implementation of digital technology is vision [28], and vision is considered as the igniter and the derivative point of all the other sensorimotor skills towards understanding and experiencing the world [29] [30]. And, as far as young learners are concerned, the fact that, from quite early stage, they "*live in a predominately visual world, exposed to the media, technology and an overabundance of digital stimuli*" [28] should be a critical parameter towards the enhancement of traditional learning and teaching processes with digital methods emphasizing on audiovisual aspects. In this sense, the production and the implementation of audiovisual material is really important. The amplification of existing learning activities with videos, animations, interactive presentations and audible material will not only create a more engaging educational content but will also enhance it with sensorimotor qualities [26]. Students can better follow instructions, concentrate and comprehend the presented/teaching concepts [31]. Additionally, the visualization of abstract concepts (i.e., Science or Mathematical concepts) can lead them to easier find solutions on a given problem [31]. However, it is highlighted that it is critical to employ audio visual aids in ways that are better aligned with the learning style of the students and reflect their learning needs [28].

-Tips for the pedagogical use of videos online

From a pedagogical aspect, the integration of videos to learning and teaching is considered as a rather beneficial strategy, since the audiovisual material has greater appeal to students by turning the entire educational process into a more engaging, entertaining and meaningful experience [26] [32]. Concerning online educational activities, video is often the main tool for teaching and delivering information [32]. However, the way that audiovisual/multimedia material will be produced and implemented will also determine the effectiveness and the impact on teaching and learning processes [26]. After all, the integration of multimedia materials in courses should serve the main purposes of a course by functioning as assistive and complementary tools. Therefore, there are some considerations that should be taken into account for avoiding malpractice. In fact, it is argued that there are three interrelated elements that can be taken into consideration, regarding video design and implementation, and these are a) cognitive load, b) students' engagement and c) active learning [32].

Cognitive load refers to the human's memory capacity of retrieving, processing and storing information [32]. Based on this, the incoming information is filtered in ways that allow the maximum storing of the desired learning outcome. Therefore, the educational material should be designed in ways that will turn the core subject into a meaningful and memorable network of ideas and concepts, able to be stored in the long-term memory. One method is the *"integration of new information into existing cognitive structures"* by enhancing learning through the creation of material that appeals to both working memory's channels, namely the visual and the auditory [32]. To do that a number of different practices can be adopted.

A good practice is the implementation of symbols and text for highlighting significant information and therefore drawing the attention of the viewer. This can be done by adding signs on the

video (i.e., arrows, circles etc.) to mark a specific area of the screen, or by modifying colors and contrasts to highlight a specific entity of the video.

Segmentation (i.e., cutting and/or separating the presented information in smaller pieces) is also a useful method. This can be done by adding chapters to a video, or by breaking a video to shorter. In this way, the presented information can be turned into a string of comprehensive and memorable steps, which can be easier grasped and stored in students' long-term memory.

Removing or avoiding adding unnecessary information (i.e., complex images for background, extra effects, irrelevant to the content music or/and audio etc.) is another good practice. Elements that are distracting can produce less engaging content as far as learning is concerned. However, there is a strong correlation on the needs and the level of the students and on what can be characterized as unnecessary information. Something that is significant for increasing the engagement of novices to the key points of the video, can be unnecessary and distracting for experts and vice versa.

The proper combination of provided information in ways that will successfully trigger both visual and auditory channels. For example, a video visualizing an abstract concept can have greater appeal to students if it is combined with a narration rather than with a written text, or a recorded lecture can have a greater impact if it is combined with a number of diagrams. Therefore, it is crucial to integrate videos to the teaching process in ways that will eventually lead to building dialogue with your students, turning the entire process into a lively and interactive discussion [31].

Apart from the aforementioned strategies that create engaging content from a cognitive point of view, there are more methods that can increase **the engagement of students** to the presented information.

A significant parameter is the duration of the video. Videos should be short. Depending on the presented content, 4 to 5 minutes might be enough for conveying the key concepts and avoiding having a boring or a distractive – from the principal topic – material.

As has already been mentioned, implementing audiovisual material can motivate the development of conversation between teachers and students. Therefore, the creation of videos that can trigger communication through posing or/and promoting the formation of questions, is also considered a good practice. In this way, apart from turning teaching and learning into a more interactive process, a "*sense of social partnership*" [32] is also developed.

All the aforementioned tips and strategies can also promote **active learning** by cultivating a sense of critical thinking and eventually active participation. By following such mechanisms and methods, the implementation of audiovisual material can turn the entire learning process into an intuitive and lively procedure in which the acquisition of information happens through a progressive cognitive binding of the viewer with the presented content. This can be enhanced, especially in online education, by adding features that allow students – to a certain extent - taking control of the presented content (i.e., including annotations, allowing skipping parts or/and moving forward etc.).

In previous sections a number of tools for producing 2d or 3d graphical content were presented. This section is gathering some tools that can assist teachers to produce their own audiovisual material, based on their teaching needs. There are several software for video production and editing. Here are some examples for beginners and intermediate users, as well as suggestions of tools for the creation of storyboard, an important technique prior to the production of audiovisual material.

-FilmForth

FilmForth is an intuitive video editor and a movie maker software for beginners (*Figure 58*). It allows users to combine video clips, images, text and audio for producing their own movies. The embedded toolkit provides some basic but rather useful features such as split, rotate, join,

for both video and audio files, as well as some transition effects for better results from an aesthetic point of view. FilmForth is a free software, producing material deprived of watermark (following FilmForth on social media is required) and is offered to any user with an account on Microsoft.
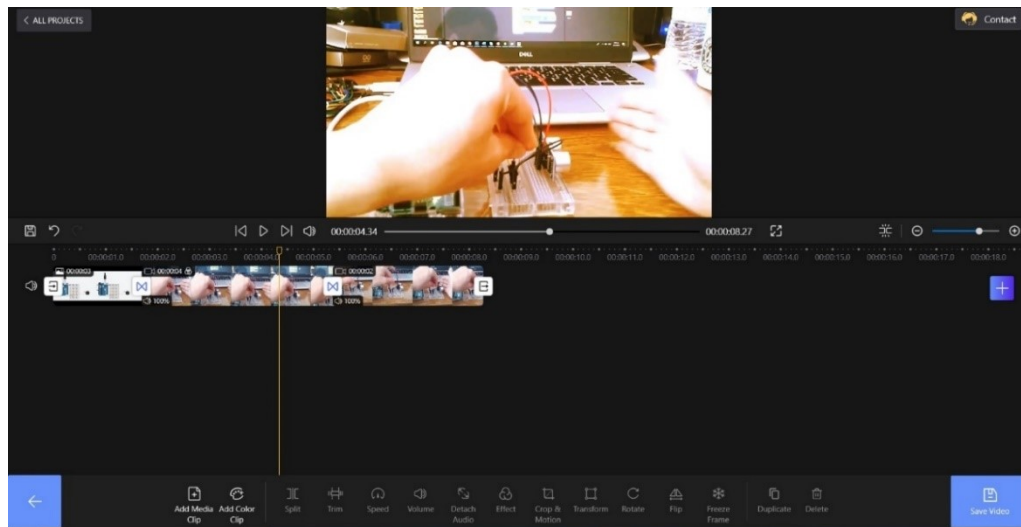
Figure 58: Screenshot of the FilmForth environment – image produced by the authors

-Adobe Spark video

Adobe Spark is an online service comprising three different design applications, namely Spark Page, Spark Post and Spark Video. Through Spark Video users can create short videos from scratch or based on specific templates. The timeline consists of distinctive parts/chapters (i.e., About me, What it is, Why etc.), a useful feature for beginners who need some guidance on how to organize and assemble their footage or their material (*Figure 59*). Apart from that Spark Video contains useful tools for trimming, color correcting, displaying and/or adding text and audio to the produced movie. It is an easy to use and rather intuitive tool, but it has a limited for-free with limited features.
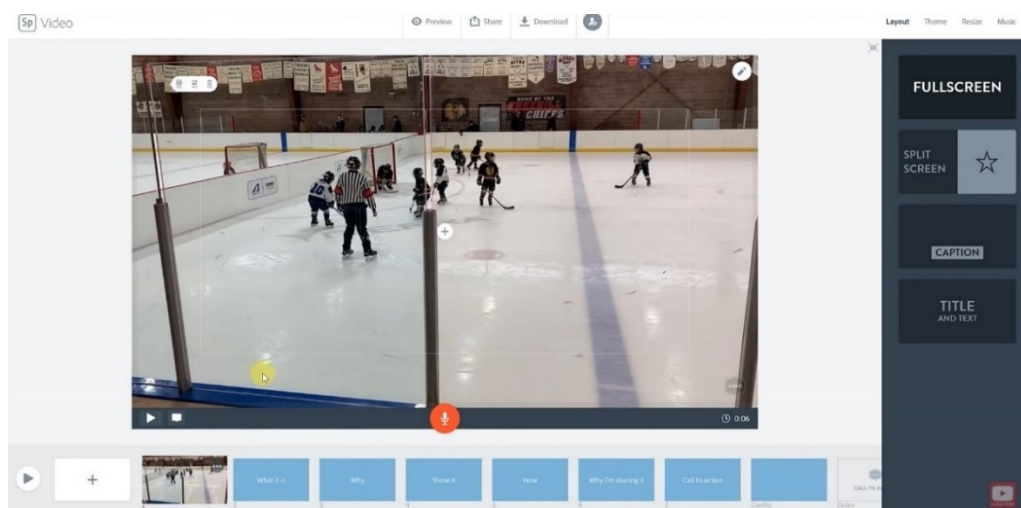
Figure 59: Preview of Adobe's Spark video environment – Image retrieved from:
https://www.youtube.com/watch?v=3zH5LNt8dH8

-Animoto

Animoto is a free and easy-to-use video maker that allows for the creation and sharing of short videos, without the need of extensive technological or video editing skills. Therefore, it is considered a proper tool for beginners. Also, due to the fact that is cloud-based and browser-

accessible, it is a convenient solution as far as system supporting and accessibility are concerned. With Animoto, users can import and combine video clips, images and audio files and turn them into video slideshows, or they can use pre-made templates and simply drag-and-drop the content therein (*Figure 60*). The result can be easily shared through social media accounts or through teaching and learning platforms such as Google Classroom, Edmodo, and more. Apart from paid licenses, it also offers a free-user license with the Animoto branding stamp on the produced file.
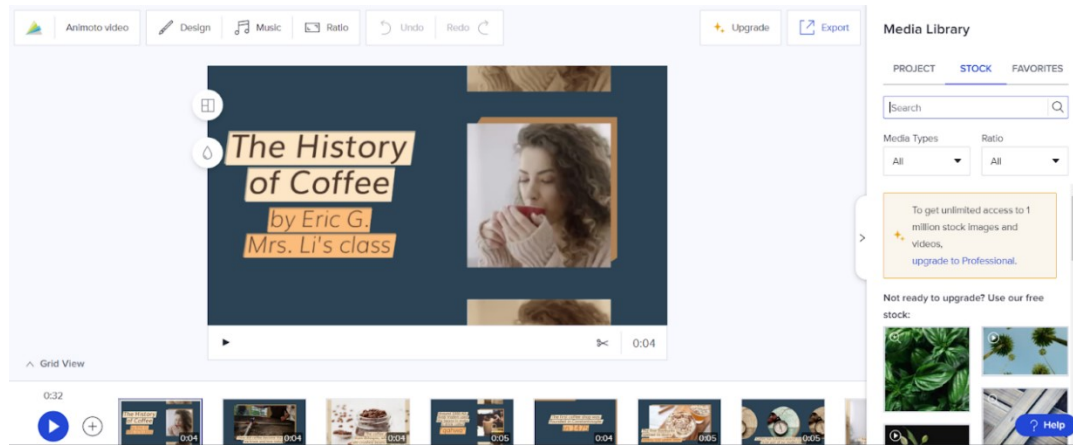
Figure 60: The Animoto environment – Image retrieved from: https://animoto.com/

-DaVinci Resolve

Davinci resolve is a video editing software that permits the creation of a video by cutting sequences, applying visual effects, correcting color as well as by adding and mixing audible files (*Figure 61*). It is a non-linear video editing software (meaning that editing doesn't affect the source-video, preventing the original source from destruction) which can be used as a standalone tool, or as an intermediary between other software. It's a free software and the exported material is deprived of watermark. Davinci resolve can be used by beginners but it might be more intuitive for intermediate users due to the variety of tools and features contained therein; a parameter that might be destructing and stressing for beginners.
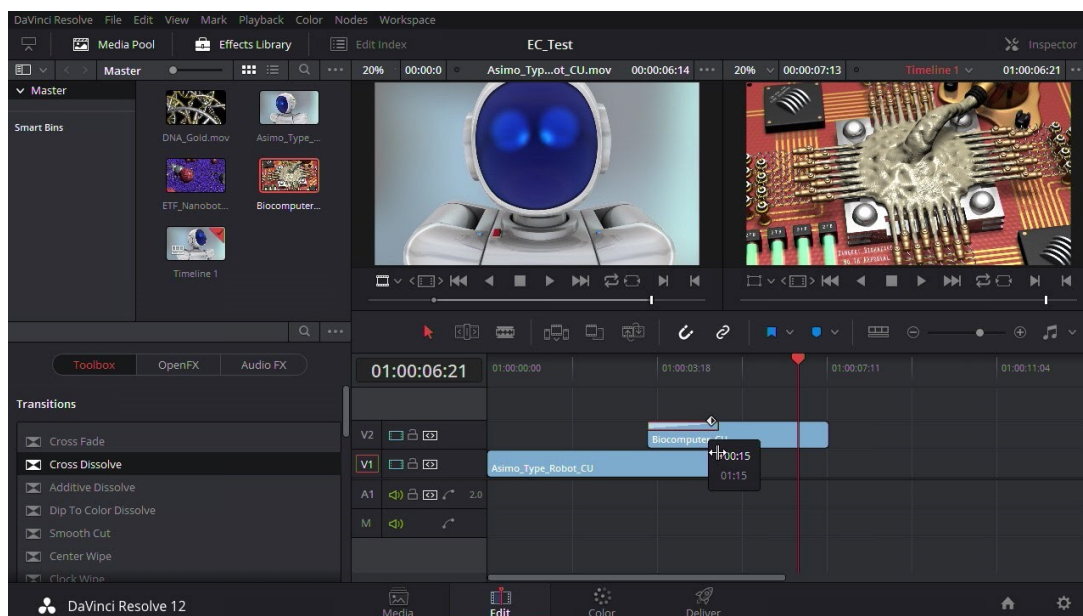
Figure 61: DaVinci resolve environment - image retrieved from: https://renewle355.weebly.com/davinci-resolve-free-download-for-mac.html

-Audacity

The majority of the aforementioned tools include features that allow editing sound. However, there are also software that are exclusively for editing and recording audio. One of the most popular is Audacity, a free and open-source digital audio editor and recording application software (*Figure 62*). Through the embedded tools, the users can modify audio files in multiple ways (e.g., cut and paste a part of the audio file, mixing more than one files, adding effects etc.). They can also export the produced files in several formats (WAV, MP3, FLAC etc.) compatible with other software and applications. The environment is rather intuitive and therefore user-friendly to several age groups. Regarding teaching it can be a very helpful tool, especially for the creation of podcasts or for editing an interview. It could be also used as an information visualization tool as far as spectrum analysis and the presentation of physics behind the sound are concerned.
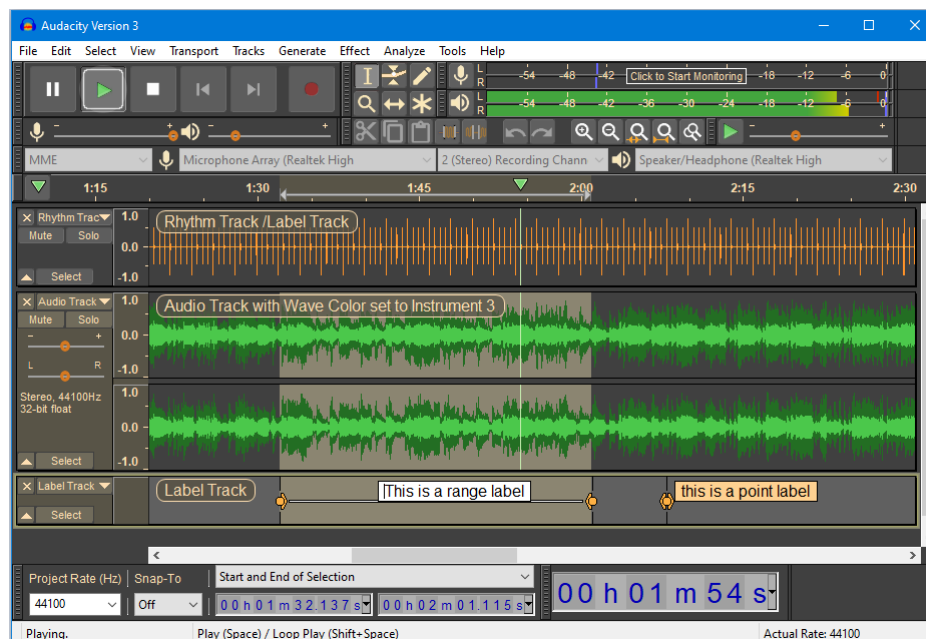
Figure 62: Audacity environment – Image retrieved from:
https://en.wikipedia.org/wiki/Audacity_(audio_editor)#/media/File:Audacity_Version_3_in_Dark_Theme.png

-Storyboard

Storyboard is a useful process towards creating a video. As storyboard is defined a number of consecutively drawings (enhanced with narration) pre-visualizing critical scenes of a video, an animation or an interactive media [25]. Through storyboard, a creator can better organize the sequence and the content of the scenes of his/her produced (audio)visual material.

An online tool that can support the creation of a storyboard is Storyboard That. Storyboard That enables users to easily create storyboards by dragging-and-dropping different items (i.e., background, characters, text bubbles etc.) on a canvas of sequential cells (*Figure 63*). It is offered for individual use as well as for educational and business purposes. Through Storyboard That teachers can enhance the content of a worksheet or an assignment by creating graphic novels, character maps, timelines etc. Storyboard That can be also a valuable tool for applying the concept of storytelling to learning activities. The full version of Storyboard That is available only under a paid license, by there is an option of a limited for-free version.
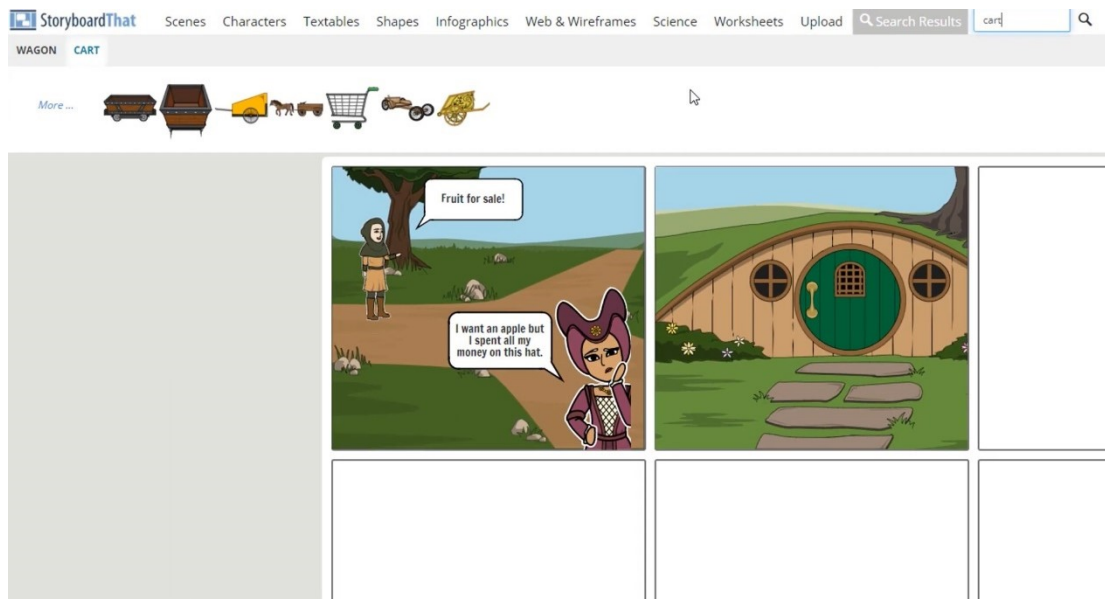
Figure 63: Still from "How to use Storyboard That" video: https://www.youtube.com/watch?v=sC0yg5k1RqY

Implementation example:

Lena is a junior high school teacher, introducing the Lighthouse project to her students. During the stage of ideation and brainstorming, she is encouraging her students to find alternative ways of representing their ideas by using a number of available online tools that facilitate graphic representation content. One of the teams decides to use Storyboard That in order to represent the concept behind the operation of their lighthouse. They are creating a number of rather humorous strips depicting the conversation between an elder and a younger person (*Figure 64*). In their story, the elder person is worried because it is getting dark and no one shows up to turn on the lighthouse but the younger person calms him down by informing him that the lighthouse is able to detect the level of ambient light and will automatically turn on when dark will fall. Lena not only approves the idea of the team but she is also encouraging her students to create a video at the end of the project which will record the entire process, beginning with this sequence of strips and ending with a demonstration of the created model.

Figure 64: Humorous strip for representing the concept of the Lighthouse project

Combining videos with online tools for making courses more interactive

-EDpuzzle

As mentioned, regarding online educational activities, video is considered as a main tool for teaching and delivering information. Apart from tools that can assist teachers to create their own videos, there are also tools that can help them to make their own videos – or videos found on internet (i.e., videos in YouTube channels) – interactive, thus making their content more engaging for students. Such tool is EDpuzzle (*Figure 65*). EDpuzzle is a free web-based teaching tool designed for adding interactive content to videos. This can be done by adding multitype questions (i.e., multiple choice, open-ended etc.) to critical part of the video, thus engaging students to critical thinking and checking their comprehension regarding the presented content. EDpuzzle offers also a recording tool that facilitates the creation of videos through educator's computer camera. In this way educators can instantly create a video covering the needs of their students, narrated by a familiar face. Moreover, through EDpuzzle's analytics, the educator can check and evaluate the progress of their students. Additionally, teachers can get inspired or use pre-existing interactive videos that have been created by other teachers of the EDpuzzle community. However, each teacher can store to her/his account up to 20 interactive videos. A significant disadvantage of EDpuzzle is that students should have a reliable internet connection in order to be able to interact with the uploaded audiovisual content.
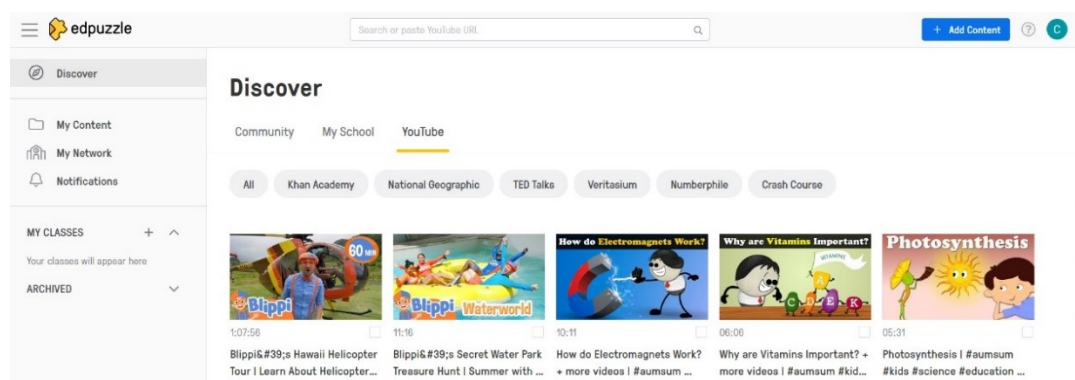
Figure 65: The EDpuzzle environment – Image captured by the authors

-Tracker

Tracker (*Figure 66*) is a powerful free video analysis and modeling tool provided by *Open Source Physics*. It is designed to be used in physics education in order to introduce students to dynamic particle modelling and basic physics law (such as Newton's second law) in an appealing way. Students can upload a video showcasing a dynamic movement (e.g., the movement of a pendulum), and by using a dynamic model track combined with inserted values and expressions, they can record (manually or automatically) among others the object's position, velocity, acceleration, and line profiles on every frame. In this way they are building a dynamic model simulation comprised by particles which imitates the behavior of the real-world motion. The data of this model are displayed in plots and tables and can be used for further analysis and measures. Through tracker's output students can focus on how forces are affecting motion and interpret the result in a more intuitive way. Tracker tool can be used online or it can be downloaded locally to a personal computer, for offline use.
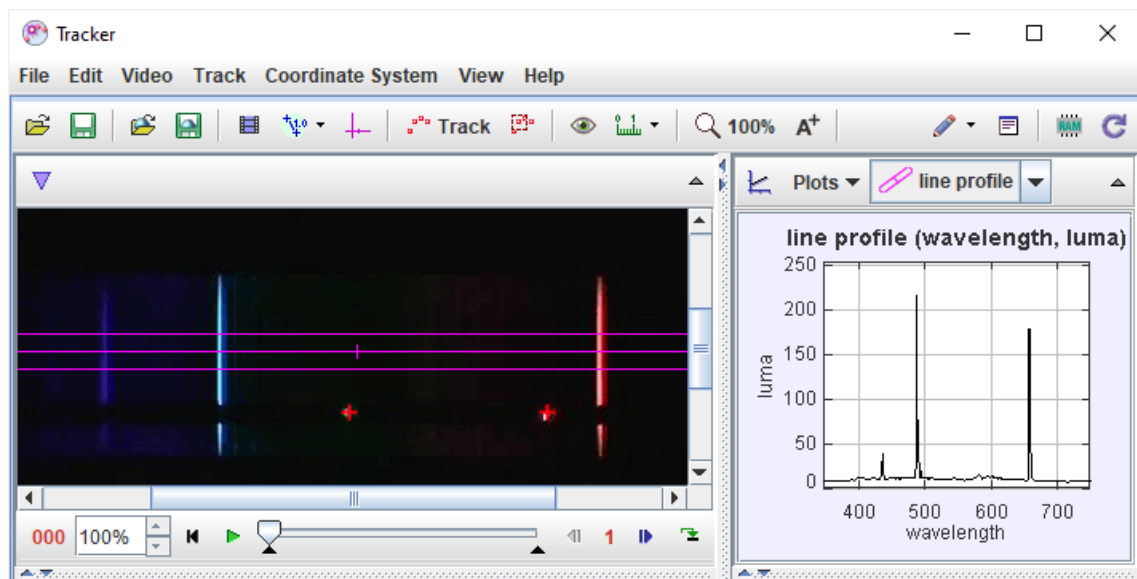
Figure 66: Tracker tool -mage retrieved by: https://physlets.org/tracker/help/frameset.html

Online tools and/or services for supporting the stage of sharing

Sharing is considered as an equally important aspect in project-based learning, reflecting one of the fundamental dimensions of maker movement [38]. By tools and services for sharing we are referring to any online/digital means that allow students and teachers to share their projects with others, to present the current status of their work, to showcase their work in the wider public, as well as to share ideas, thoughts, solutions and consequently share experiences.

On the one hand, sharing of experience can be proved very fruitful for school community members since it provides opportunities for exchanging ideas and good practices with other schools or other educational communities, which eventually can lead to building synergies and the establishing networks of communication [16]. On the other hand, sharing of work and projects can have a great impact on students, since it can lead to enhancing their educational experience and increasing their sense of awareness concerning their future educational choices and consequently their professional orientation [16]. Also, receiving positive feedback can boost their confidence, while the entire process (i.e., presenting their own work, interacting with other people from the educational community) can enhance their social skills as well as a sense of ownership (i.e., the feeling of presenting something that was developed by them and by their own hands), progressively forming a feeling of wholeness [38]. Moreover, sharing can boost interdisciplinarity and interculturalism, leading to broadening the horizons of both teachers and students.

Through this lens – and in the context of the present project – a number of online tools and services that can support the stage of sharing are recorded. Some of the gathered paradigms are social media (e.g., Facebook, Instagram, Youtube etc.), blogs and wikis, as well as platforms offering space for sharing (e.g., Instructables, Frontier for Young Minds etc.). The suggested tools encourage the online exchanging of ideas, while facilitating communication by providing tools for commenting and chatting.

-Social media

Social media, like Facebook, Instagram, Twitter and Youtube, are platforms or/and applications offering multiple and rather easy and intuitive ways of communication and sharing information (*Figure 67*). Users can share content as individuals, or through a specific-topic-related page and/or group, targeting a particular audience. Users can upload content of different and multiple format (i.e., images, text, video), organize the content by hashtags and geographical tagging, publish stories and videos, expand their network by following and be followed by other users and/or groups, as well as communicate through public comment sectors or individual chat rooms. In this way they can reach multiple and different kinds of audience and on a global scale. However, due to the tremendous amount of content that is uploaded on a daily basis, the shared information on social media might not have the expected correspondence and impact. Also, another major drawback is the existence of fake profiles with malicious behavior or ambivalent intentions.
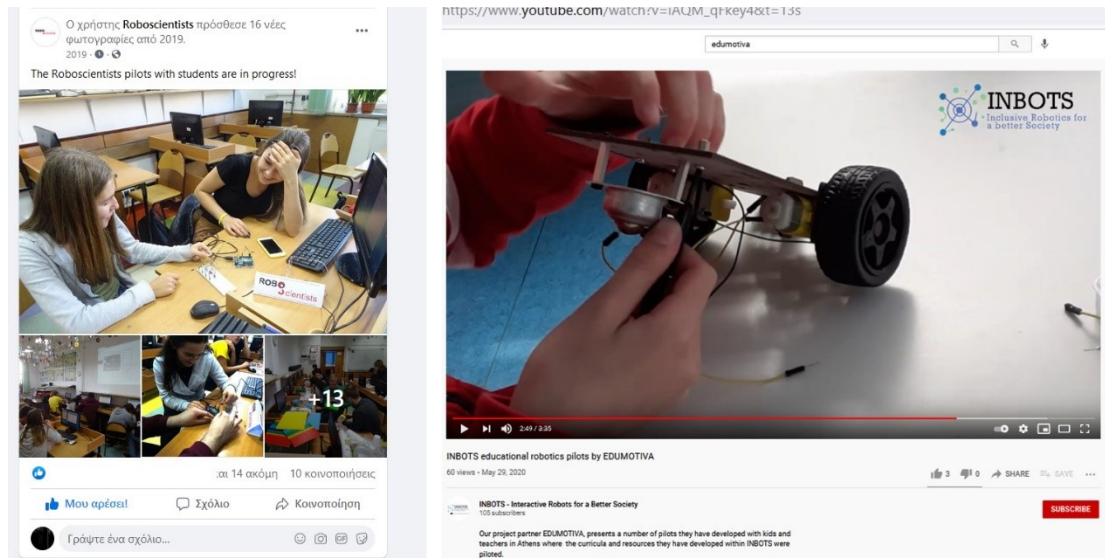
Figure 67: Example of sharing through Facebook posts (left) and Youtube channel (right) – Image produced by the authors

-Blogs and Wikis

Blogs serve as a personal space for users to upload, organize and share information. Based on users' interests, a blog can have a more or less formal content (i.e., containing elaborated information around a specific topic or personal diary-like notes). A blog can contain texts, images, videos and links, while providing space for public commentary. Therefore, a blog can be an important digital space for sharing and exchanging knowledge. In education, blogs can function as a place for sharing resources. These types of blogs are referred to as edublogs (*Figure 68*). An edublog is a blog for sharing educational related content that permits educators (teachers and students) to create their own free blog by using blogging features and tools (text editor, image and video uploader etc.) and therefore, sharing information and tips among community (i.e. blogs written as learning journal, blogs created to keep in contact with student's parents etc.). Educational blogs can also be used as an engagement and reflective assessment tool.

Figure 68: Screenshot from the edublogger site captured and produced by the authors

-Online communities of practice and sharing platforms

Instructables is a website – owned by Autodesk – that allows users to upload projects oriented towards and inspired by the DIY (do-it-yourself) culture (*Figure 69*). Users/Members of the Instructables community can upload a description of their project, step-by-step guidelines as well as visual material, such as images and/or videos. They can also share files containing programming solutions, or other material that want to accompany their projects (e.g., slideshows). Each member of the community can post or receive comments and questions, ask other members for help, and/or discuss their ideas about an upcoming project. Members can also take part in contests that are held from time to time, and therefore can have the opportunity to be evaluated and voted for their ideas. All these features make Instructables a valuable place not only for sharing but also for helping teachers and students to draw inspiration for their own DIY projects.
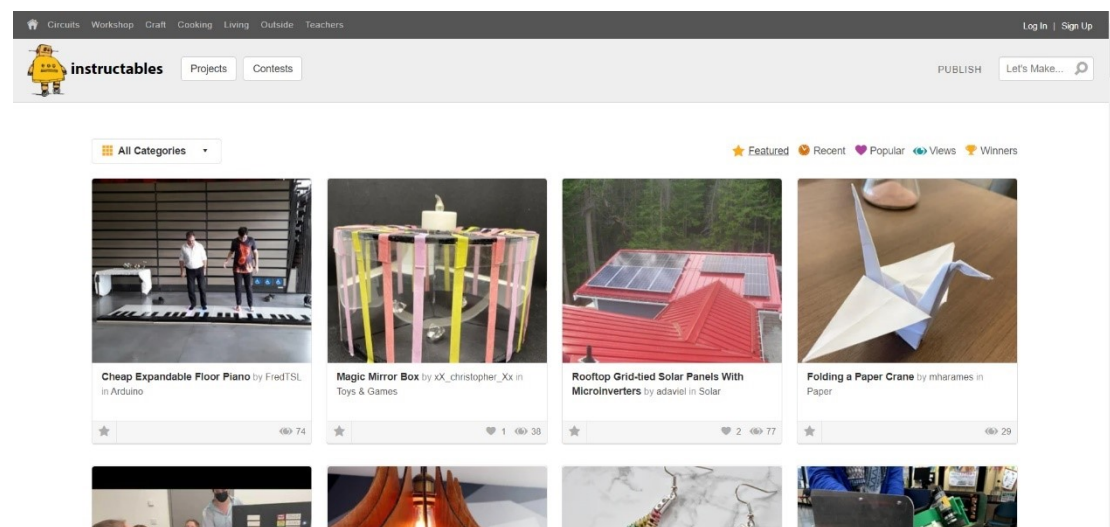
Figure 69: Screenshot from the Instructables site captured and produced by the authors

GrabCAD is a free cloud-based collaboration environment for professional designers, engineers, manufacturers, and students, that brings together resources and material for CAD-based projects (*Figure 70*). Registered to the community users can upload and/or download CAD drawings and models from a free CAD library, find tutorials developed by engineers and designers, connect with other engineers and exchange information and inquiries, as well as participate in challenges. All these features make GrabCAD a really useful sharing platform for a specific audience, including students and educators from engineering and designing faculties.
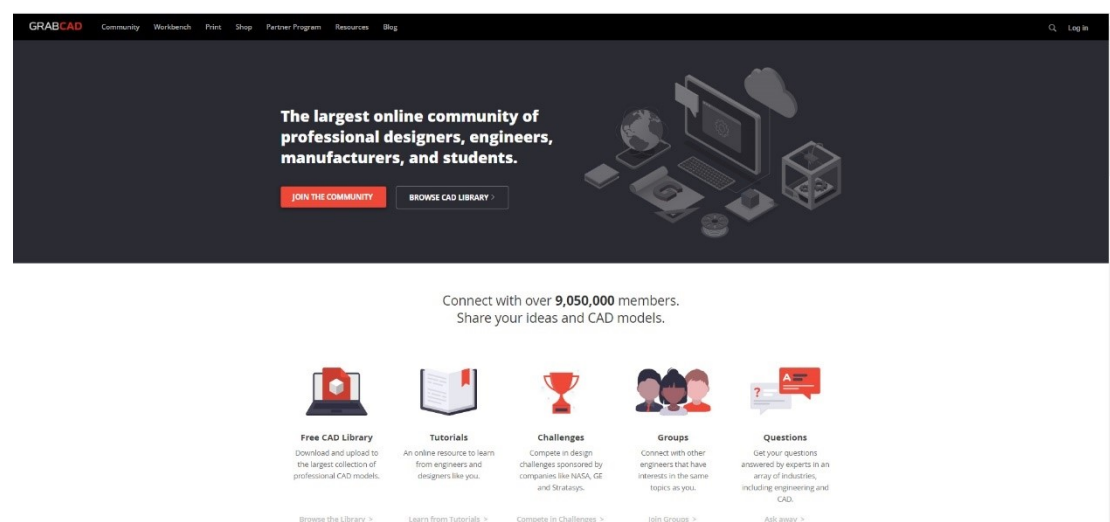
Figure 70: Screenshot from the GrabCAD site, captured and produced by the authors

There are also websites and platforms that share content but they do not support a two-way sharing. They do offer open resources that users can share with other users, but, apart from the owners of the website, no one else has the right to upload content. **NRICH** for example – a website with an extensive number of resources on mathematics for ages 5 to 19 created by the Faculties of Mathematics and Education of the University of Cambridge – shares valuable material revolved around supporting teachers and encouraging students to learn mathematics through exploration and discussion. The provided resources are designed to develop subject knowledge, problem-solving, and mathematical thinking skills assisting students to think about math in new ways. However, this material can be only uploaded by the researchers belonging to the specific faculties (*Figure 71*).

Figure 71: Screenshot from the NRICH site, captured and produced by the authors

Scratch community

Scratch community is an online community where users of Scratch tool can share their projects, work, communicate and interact with other users as well as ask for advice and/or solutions regarding coding (*Figure 72*). It encourages the development of fruitful dialogue between the members of the community as well as the intermixing of different ideas and cultures. Scratch community is open for everyone who is interested in creating, sharing or simply learning and broadening her/his horizons regarding block-based programming, since s/he respects some rules related to proper behavior. To become a member of scratch community, each user needs to create an account by simply providing a nickname, and a password. For safety reasons Scratch advises the future users to avoid using their real name and/or sharing any personal information that might reveal their identity.
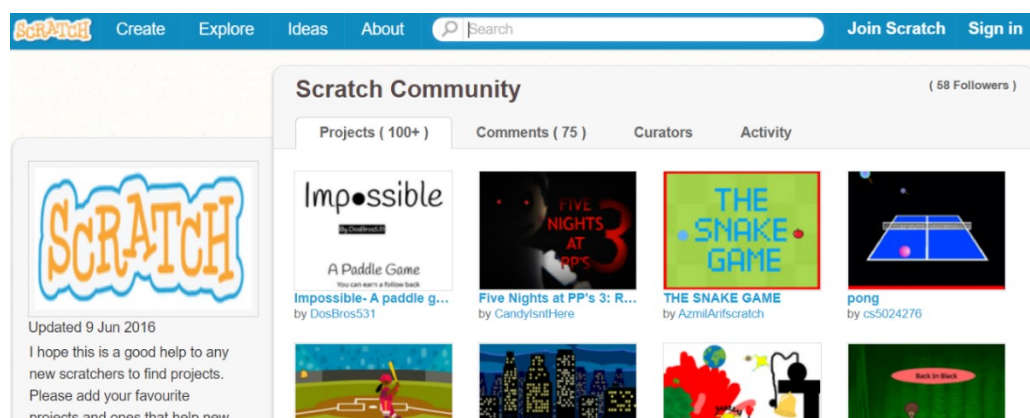
Figure 72: Screenshot of Scratch community main page – Image captured and produced by the authors

Arduino project hub

Arduino project hub is an online and open-source electronics prototyping platform hosting a number of projects created (and shared) by users/makers all over the world through the implementation of Arduino hardware (*Figure 73*). Users can share their project by providing some information regarding the implementation of the project (i.e., short description, circuitry, coding, audiovisual material etc.), comment or/and ask advice from other users/makers and vote on the uploaded projects. The projects are sorted to different categories based on the level of difficulty, the type of the hardware, the category that the project belongs to (i.e., Motors & Robotics, IoT, Audio & Sound etc.), the type of the provided material (i.e., tutorial, work in progress) as well as the trending concerning the popularity of each project.
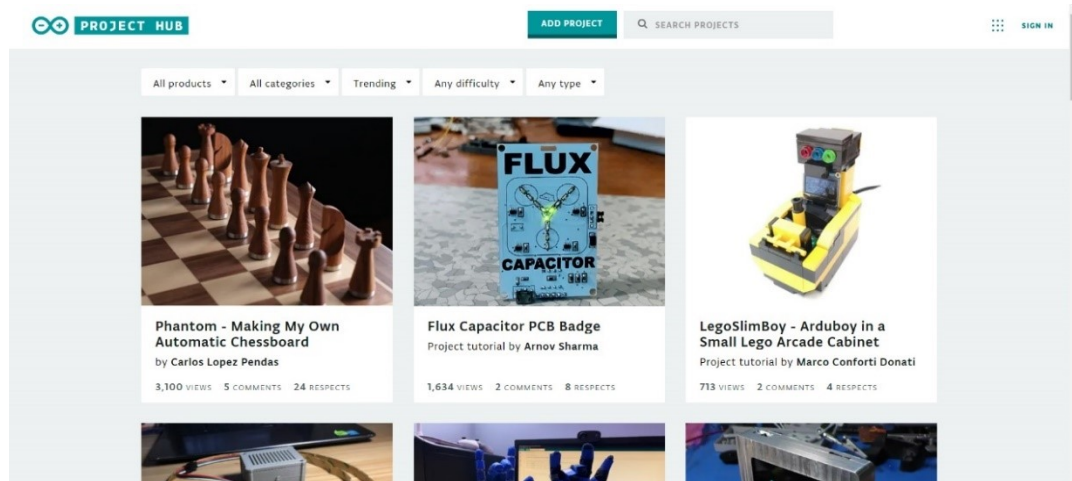
Figure 73: Screenshot of Arduino Project hub page – Image captured and created by the authors

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Implementation example:

Maria's students are disappointed. This year's Robotics Festival was cancelled due to covid-19 pandemic. All of them had enthusiastically reacted to the idea of presenting their robotic projects there. They had even made early plans on how to organize the showcase of their projects in the booth. Maria comes up with an alternative idea: what about presenting your projects on the school's Facebook page? She plans the steps that should be undertaken; she encourages her students to collaboratively create short videos where they demonstrate their projects, prepare short descriptive text and collect representative pictures. She then works with each group towards finalizing the content and takes care of the upload on the Facebook page (Figure 74). At the same time, she contacts her fellows, the Parent Club of the school and representatives of the local community to further promote these posts through their social media accounts. A fellow comes up with a new idea; why not share your students' work in the Instructables platform so as to inspire more young makers? Maria embraced the idea;it could be a good opportunity for her students to reflect upon their learning by explaining step-by-step how they construct their robotic artefacts. It could also be great for other young makers interested in robotics to build on her students' work, to draw some inspiration and give new shape to the projects!
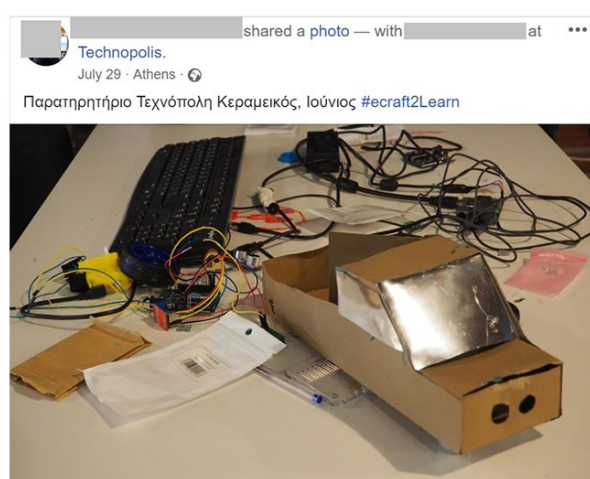
Figure 74: Examples of the online sharing process

- Tools for presentation

Under certain circumstances, sharing needs to be done in a specific format and timeframe. In these cases, the shared content should be meaningfully organized in a presentation. Nowadays, there are several different presentation tools are available that can support this process and help both educators and students to create a narration consisted of the material they want to share (images, videos, thoughts, ideas, data etc.).

Microsoft PowerPoint (*Figure 75*) is one of the most well-known tools for creating presentations. It is an offline tool that enables creators to produce presentations consisted of a number of slides. Slides can contain multiple type of information such as text, images, videos, diagrams and more enhanced with a number of features that add interactivity to the content (i.e., animations, links that re-direct presentation to other slides or files etc.). In this way creators can meaningfully visualize the information they want to convey, thus better engaging their audience. Even though, the offline version of PowerPoint is available under payment, there is a web-based version which is free but with limited features.
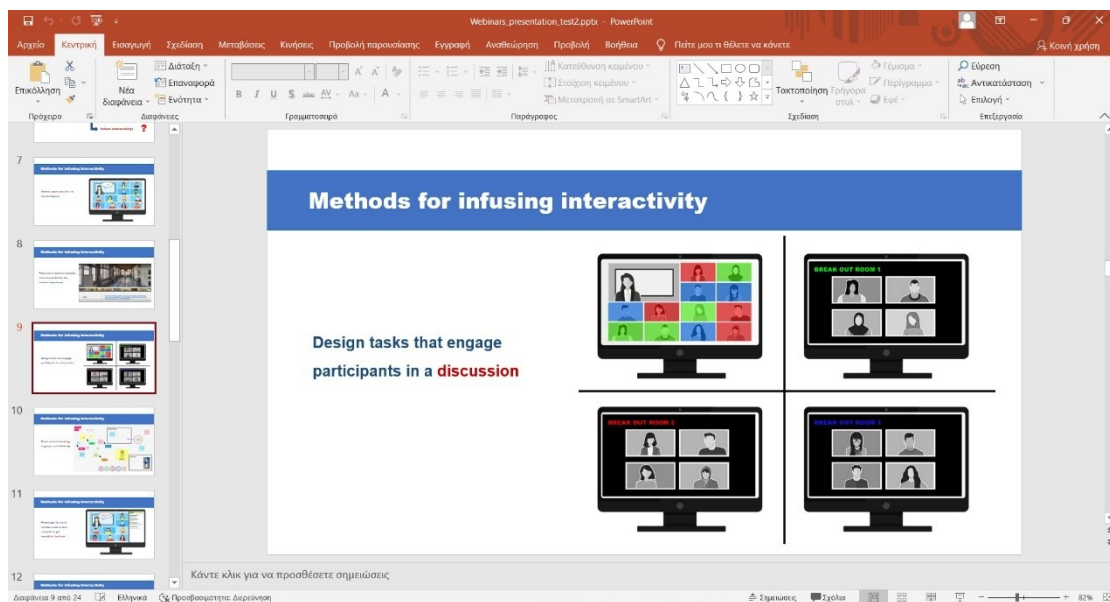
Figure 75: Example of a presentation created in PowerPoint

A similar to PowerPoint tool is **Google Slides** (*Figure 76*). Google Slides is a web-based tool included in the Google Suite, and can be freely accessed through a google account. Like PowerPoint, the creator can use a number of slides to add the material s/he wants to share, and develop a meaningful presentation. One of the advantages of Google Slides is that it can support real-time online collaboration making easier for teams to instantly work on the same presentation and making edits, suggestions and comments. Google Slides offer also an easier way for embedding videos (especially from YouTube) or maps. However, there are limitations on the available features for transition and animation, as well as some advanced characteristics such as image editing, creation of unique objects and shapes, and use of grids to better align the included information (i.e., text, images etc.).
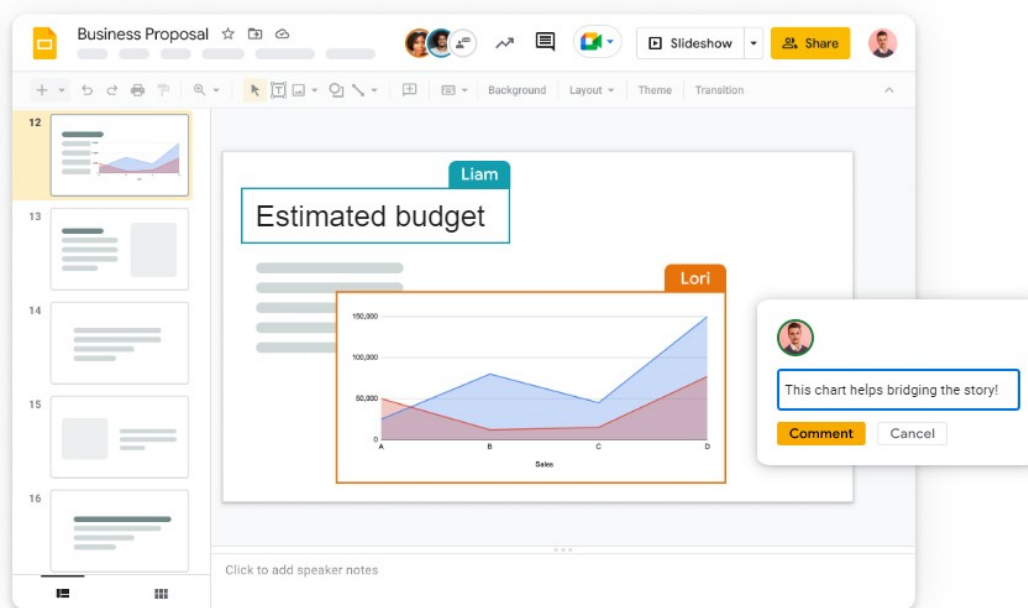
Figure 76: Schematical example of a presentation in Google Slides – Image retrieved by Google Slides site

Another interesting tool for creating engaging presentations is **Mentimeter** (*Figure 77*). Apart from providing templates for creating a slideshow, Mentimeter provides tools for creating interactive presentations. The creator can add questions, quizzes or polls to her/his slideshow and then ask from the audience to interact in real time with these items through their smartphone. The responses are instantly visualized thus turning the entire process into a more engaging and collective experience. Mentimeter offers a limited free edition with up to 2 question slides and up to 5 quizzes slides, while there are special prices educational purposes.
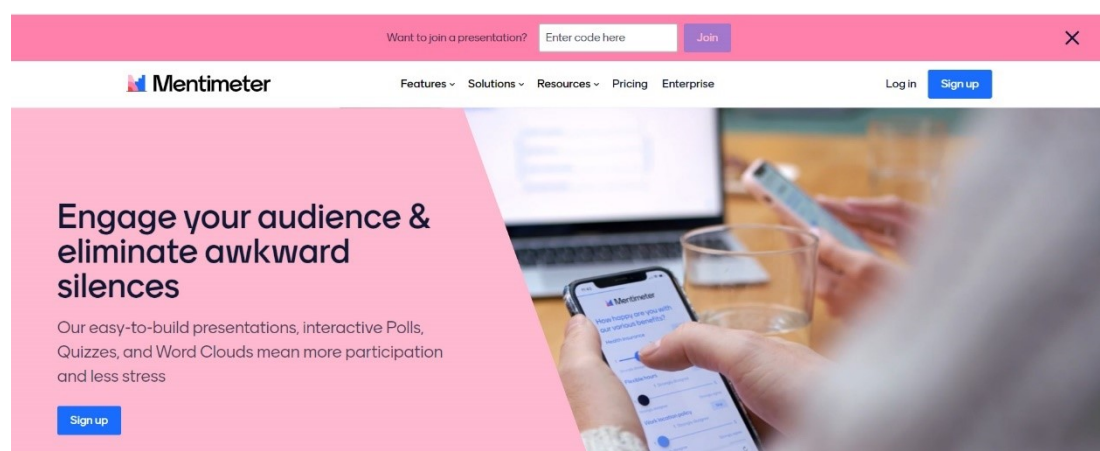
Figure 77: Still from Mentimeter site – Image captured and produced by the authors

Tip: Keep in mind that many other tools can be used for presentation purposes. As mentioned earlier in this handbook, and based on the content that someone wants to share, tools such as Canva, ArtSteps and Edpuzzle can be also used for creating highly engaging and interactive presentations.

Learning from others: good practices and inspiring strategies

"We teachers are standing on the shoulders of giants before us who have developed tried-and-true strategies by testing them out, reflecting on the outcomes, and honing those strategies over decades or longer. And they work; they get results." [34]

Good practice or best practice is defined as a strategy/technique or a combination of methods that has been proven to work well and produce optimal results. It is promising, and can be recommended as a model with an added-value or with "*a high level of widely-agreed effectiveness*" [33] [34].

Good practices are inspiring stories that can boost teachers' confidence regarding the implementation of a new method, tool, strategy etc. since they present successful stories based on years of experience or reliable research data. In this sense, good practices should also function as a starting and challenging point not only for employing new methods but also for evolving them through the lens of personal needs and experience as far as teaching and learning are concerned [34].

In the context of BeReady, we are seeking for examples of already existing digital communities boosting or/and practicing online education, as well as strategies and methods that have already been applied regarding online teaching and learning.

Inspiring digital communities

In this section we present online communities and platforms that can enrich the learning experiences and act as sources of support, guidance and inspiration. In the traditional class, teachers and educational advisors often seek opportunities to widen the classroom's walls by offering students opportunities to interact with experts, professionals, other school community members and more. The question that is raised is the following: How can this aspect be reflected in the online classroom as well? Below we present several online solutions that aim at broadening the learning experiences and have been well received by the school community worldwide. The presented solutions are indicative; many more exist. While reviewing them, it is worth considering how these can be better integrated in the online learning experience for supporting students implementing their STEM projects, draw inspiration, receive guidance, boost their self-confidence and/or simply enhance their sense of belonging in an educational community where their work and ideas are valued and discussed.

-iCouldBe

iCouldBe (https://www.icouldbe.org/) is an online community of professional mentors that aims to inspire and empower high school students to stay in school, plot career pathways and succeed in life. In this community, the mentees (i.e., the students) who are seeking of advices are creating a profile in which they are adding information about themselves regarding their educational goals, their career interests and their milestones, as well as some self-reflective information (i.e., what they admire most to themselves, what are they proud of etc.)[3]. Based on the uploaded information, each mentee is assigned to a mentor. The mentor will initially try to inspire the mentee through sharing activities that will initiate brainstorming and a self-reflective conversation (e.g., the mentor shares a video or/and a quote presenting a real's person perspective on a topic, and then asks the mentee if and how s/he correlates to this, based on her/his background). Then, again by sharing real-life paradigms, the mentor tries to assist the

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[3] Trying to create a safe and secure environment for both mentors and mentees, the iCouldBe platform does not ask participants to share any personal information that would reveal their identity (i.e., last name, address, social media accounts etc.). For this reason, the communication is strictly text-based. No video calls, or voice calls are allowed, while there are filters that monitor the conversation between mentors and mentees (or between mentees) prohibiting any action that is against the iCouldBe rules.

mentee on planning her/his own career path by providing a number of strategies that s/he can adopt and by illuminating the skills that need to obtain to follow this pathway (e.g., what studies should be done to become a computer engineer, what skills should develop and what are the best ways to do that). The mentee can pose questions and thoughts and ask for advice about best practices that can s/he follow. Then the mentor will try to put things in perspective as well as boost her/his confidence towards the acquisition of the mentee's goal. The iCouldBe platform uses an asynchronous method, therefore the interaction is not necessarily taking place in real-time.

iCouldBe is a rather successful initiative with important recorded outcomes as far as mentees achievements are concerned, since 87% of the past users recommend this program and consequently approve the adopted strategies and methods.

iCouldBe platform is not oriented towards distance teaching and learning per se, but the methods and mechanisms that are applied could be beneficial for online education. The steps towards the guidance of a mentee and the experience of e-mentoring can inspire and enhance the online learning and teaching progress. In this way, they can turn the learning activities into more engaging and self-reflective experiences. For example, teachers can think of using inspiring stories and/or quotes towards the initiation of dialogue and the sharing of ideas regarding a specific topic. They can also draw inspiration from the flow charts used in e-mentoring to set the key-points of the learning activities and pave the way towards the successful realization of an online lesson.

-The Tipping Point

> *"Through Tipping Point we believe we will give our students one more tool and more knowledge and experience, is that they can make the best decision for themselves. The program is now considered an important part of the educational process by all members of the educational community (students-teachers – parents and guardians).*
>
> *Educator, Junior and High School of Agios Georgios, Livadia*

The Tipping Point (*https://www.thetippingpoint.org.gr/en/*) is a non-profit organization in Greece that aims to build bridges between students from all over Greece and model figures around the world, in order to inform the former about the opportunities in a number of educational and professional fields and inspire them to pursue their dreams regarding an educational or professional career. The vision of the Tipping Point is to offer the chance to every student – even in the most remote places in Greece – to multiply the people acting as a role model and thus having access to real stories and examples as far as the different options and pathways they can follow towards their future careers are concerned. Also, with the support from public and private partners, The Tipping Point implements projects for groups of students regarding the development of different skills such as entrepreneurship, digital and soft skills of the 21st century, environmental sustainability etc.

Like iCouldBe platform, The Tipping Point initiative is not focused on providing an environment for distance teaching and learning, but the general concept (i.e., inviting an expert to share knowledge, present real-life paradigms and answer students' questions) can be beneficial for online education and ideally in line with project-based learning.

- Frontiers for Young Minds

Frontiers for Young Minds (https://kids.frontiersin.org/) is an online and open access academic journal providing a collection of freely available STEM related scientific articles written by distinguished scientists in a language that is appropriate for younger audiences (*Figure 71*). To succeed that, apart from using age-appropriate glossary and key words, they are also receiving constructive feedback and critical questions from peer students, aged from 8 to 15 years old, regarding the clarity and comprehensibility of the article. The website that hosts the published articles is also easy navigable and kid friendly since it is enhanced with colorful sketches and audiovisual material. However, since one of the main goals of the journal is to invite and "place

kids and teens in the role of the reviewer", it does not accept young children – including high school students - as co-authors.

Frontier for Young Minds initiative is considered as a good practice due to the fostered methods regarding the implementation of age-appropriate language and audiovisual material towards creating a comprehensible, engaging and wider accessible content. Educators can be inspired on how to enhance their projects and activities with age-appropriate methods or simply find resources for boosting the content of curriculum activities.
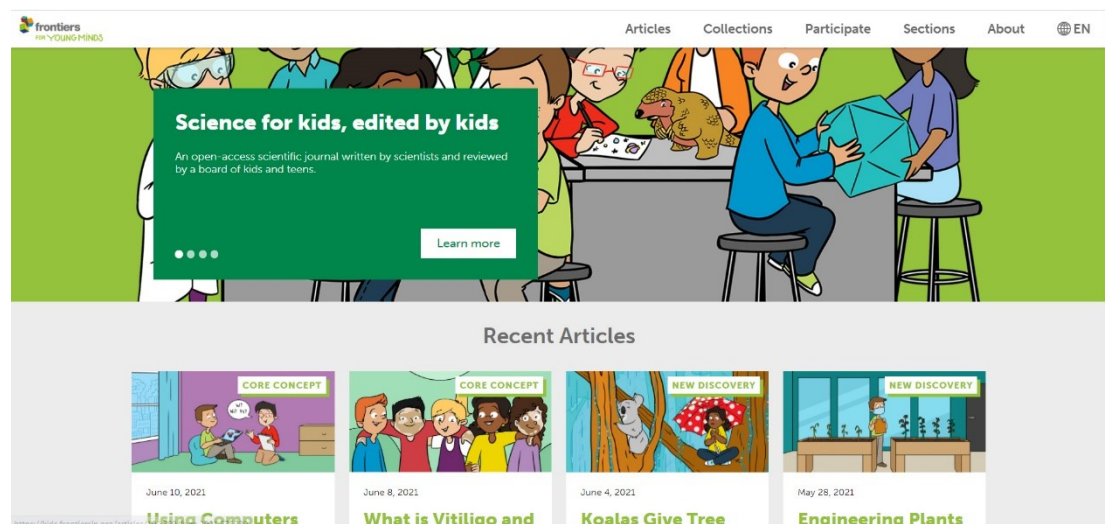
Figure 78: Screenshot from the site of Frontiers for Young Minds, captured and produced by the authors

Inspiring methods and strategies for online education

One of the trickiest and rather difficult tasks in a live class is participation and methods for encouraging students to become part of the discussion regarding assigned activities. Digital learning increases this problem since it adds new communication barriers (i.e., students don't know when is the right time to speak, cameras are turned off leading to disembodied presences deprived of facial or/and embodied expressions etc.). This problem was magnified during the pandemic. To overcome this difficulty, Edutopia site gathers and proposes eight strategies for improving participation in virtual classroom, based on real examples and experiences that were shared by over 20 educators (https://www.edutopia.org/article/8-strategies-improve-participation-your-virtual-classroom).

-Adopting think-pair-strateegy via Zoom and Google docs

One of them – that can be applicable to secondary education – is the adoption of the think-pair-share strategy (TPS). TPS is a learning strategy promoting the collaboration among students towards solving a problem or answering a question regarding an allocated activity [35]. TPS is based on two fundamental steps, namely a. thinking individually the allocated activity and the ways that can be solved or answered and b. sharing the outcomes of this individual process with classmates. This second step leads to the development of discussions around the assignment and eventually to increased participation as well as engagement and deeper understanding of the topic.

One of the teachers, adapted this strategy through the implementation of Zoom. After allocated an activity, students were split in groups and placed into breakout rooms. Each group was asked to discuss the topic and record their answers on a shared Google doc. In this way students were able to reflect their ideas both verbally and written. After that, all teams were gathered back to the class and a representative from each team shared their answers with the

plenary. For the teacher, the ultimate goal was to grant a degree of autonomy to his students over the allocated activity and eventually encourage discussions to be carried out.

-Adopting carousel brainstorming activity via Google docs/slides

Another strategy that was adopted in a virtual classroom, in order to boost participation, was the implementation of carousel or station brainstorming activities. In carousel or station brainstorming activities, the teacher sets up a number of stations where a different question, that needs to be answered, is written [36]. Then the students, divided in groups, move around and answer the questions. This method promotes active learning as well as group skills including brainstorming, communicating information and discussion. To perform this technique online, the teacher created a number of shared Google docs/slides with different questions. Then the students were split in groups and were asked not only to write their thought under each question, but also to comment on other groups' responses, preserving a sense of classroom community. This activity took place in an asynchronous environment, since the teacher believes that in this way more students can be engaged in the entire process (even the students who feel less comfortable participating in a physical classroom).

-Virtual gallery walks

The same teacher adopted a similar method for boosting discussion among students by creating a virtual "gallery walks" that hosted students' projects. The students were asked to give feedback to at least two projects created and presented by their colleagues through Google Sheets and by answering a number of questions such as "What's something new I learned about this topic?", "What's something that surprised me about this topic" etc. In this way students had the opportunity to view their classmates' work and learn from each other.

A closer look into implementation through learning scenarios

Scenario 1: Creating a virtual gallery

Who	George (ICT teacher)
Students	15 students/ 13 years old
The topic	Project in programming with references to Arts
The tools	Zoom and breakout rooms, Google docs, Scratch, GIMP, Blog, online community
Pedagogical considerations and good practices	Interdisciplinary learning, encouraging brainstorming & planning, teamwork, opening up the classroom walls to experts/**professionals**. scaffolding, sharing

The full scenario:

George is an ICT teacher in a secondary school in Greece. This year he works with 13 years old students. Covid-19 situation forced him into online teaching and challenged the realization of STEM projects. He is currently considering how to contextually introduce students into programming tasks. He imagines a virtual gallery created in Scratch. His idea is while the user is navigating in the virtual gallery to get information about the artworks included therein. He communicates with his students through Zoom. His idea is to group them into teams of three.

In the first session he presents the project idea to the students. He has invited the Art director/Curator of a local gallery who presents some artworks from different art movements, providing key information about the depicted content and the artists. The invited speaker also releases information on how an exhibition in a gallery is organized, emphasizing on the fact that an exhibition is normally oriented towards the work of a specific artist or a specific art movement. Then George calls them to think aloud in Zoom around the project and the possible challenges trying to answer their queries and provide clarifications. George has created one Google Doc for each team.
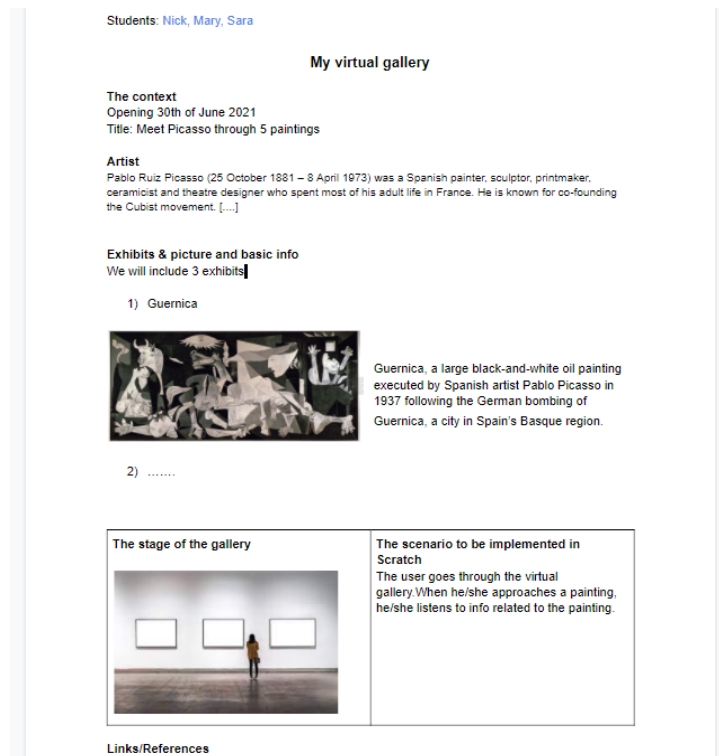
Figure 79: Work in progress on Google doc for Team 1

He provides some time to the students to individually think around the project and review the google doc files. Then he calls them in teams to discuss practicalities of the project in Zoom breakout rooms. He goes from one room to the other to ensure that the discussion is progressing well. He expects that in the breakout rooms the students will make key decisions about the virtual gallery (if their exhibition will be oriented towards the work of a particular artist or towards a particular art movement and eventually the exhibits to be showcased, the stage of the virtual gallery and other key components). He also encourages them to create a draft plan of their virtual gallery (for example a simple sketch indicating how the gallery will look like and where the artworks will be placed). The outcomes of the discussion will be documented in the Google doc by a representative of each team.

Having set the framework of the project and the key components it is time for implementation. George has created in Scratch his one virtual gallery which is rather "poor", as it includes only 1 exhibit. He shares his screen through zoom and presents his gallery to the students. He provides key explanations of his idea. He shares the stage of Scratch and demonstrates how he inserted each object and how he breathed some life into them.
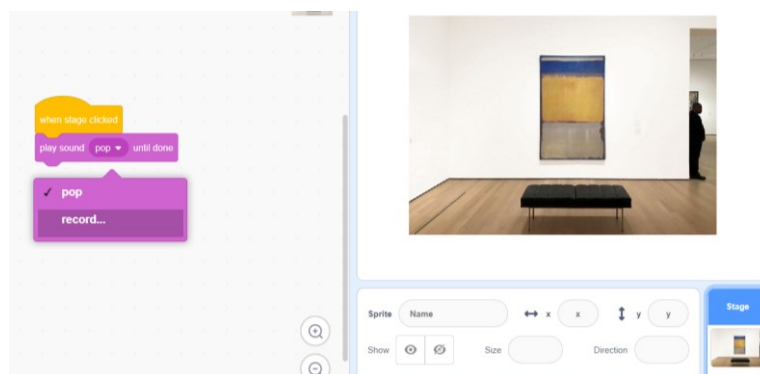
Figure 80: George's virtual gallery in Scratch

Apart from the example that he presented, he encourages his students to think out of the box and find ways to make their own gallery more interactive. For example, apart from placing the artworks in the virtual gallery, they can create a sprite that walks around the gallery and each time it approaches an artwork, an information appears or sounds. The sprite can represent a visitor or even the artist. Based on these ideas, George calls the students to finalize their scenarios in the Google docs. He reviews once more and then activates the implementation period.

As Scratch does not allow working simultaneously, George randomly decides which team member is going to first place an artwork and move forward with the coding process. After 3 days of coding efforts, the 1st programmer notes down what remains to be done and invites his/her fellow team member to continue programming by sending over the scratch file.

However, if a team has decided to enrich the interactivity of their gallery with a moving sprite (i.e., the avatar of a visitor, or the avatar of an artist), George proposes to work in parallel. In this case, one of the members of the team can work on GIMP in order to produce an avatar, one of the members can experiment in a different Scratch file to find how the movement of the sprite should be coded, and the third member of the team can start setting up the virtual gallery.

George estimates that this particular STEM project will be completed within two months. While the students are working on the projects George is in constant communication with them. They meet once a week in Zoom and they share the progress that they have made, demonstrating the current status of work and getting feedback and support.

At a later stage George calls the students to upload their projects in the Scratch community. He collects the links and uses the blog of the school to showcase their work as well.

Scenario 2: The Lighthouse project

Who	Lena (ICT teacher)
The topic	STEM project (with a focus on crafting, programming and circuitry)
Students	12 students / 14-15 years old
The tools	Miro, Zoom, TinkerCAD Circuits, OpenRoberta, Youtube
Pedagogical considerations and good educational practices	Focus on brainstorming online

The full scenario:

Lena is an ICT teacher in junior high school. She is planning to introduce the lighthouse project to her 14 years old students. The lighthouse project revolves around the development of the model of a lighthouse that blinks at dark and/or when a ship is approaching. The project introduces young students to crafting processes, electrical circuit making and programming. Covid-19 pandemic challenges the implementation of the project and Lena is considering how to meaningfully release the project entirely online using the available web and digital tools to boost collaboration and online practical activity. The class consists of 12 students which have been given the necessary equipment for electrical circuit making (wires, electrical components, Arduino).

In order to engage her students in this project, she is initially asking them to record their ideas based on their experiences, on their knowledge and on short research over the internet about lighthouses, how they were working in the past, who was operating them etc. Currently, she is teaching through the school's e-learning platform. Therefore, she needs to find a solution on how to recreate the ideation/brainstorming stage via the internet. She decides to use Miro. an online visual collaboration platform. She splits the students into groups, and creates a template for each one of them. After briefly introducing them to the tool, she is giving time to the teams to collaborate through the template by noting down their ideas to sticky notes, creating sketches, uploading images and sharing links. When everyone is ready, she is giving the floor to each one of them to present their ideas in the (virtual) plenary by sharing their screen. The following image presents an example of the ideas that were recorded by Team A, consisting of Maria, John, Alex and Kate in Miro. After presenting their ideas, Lena is making some suggestions to help them better organize their notes.
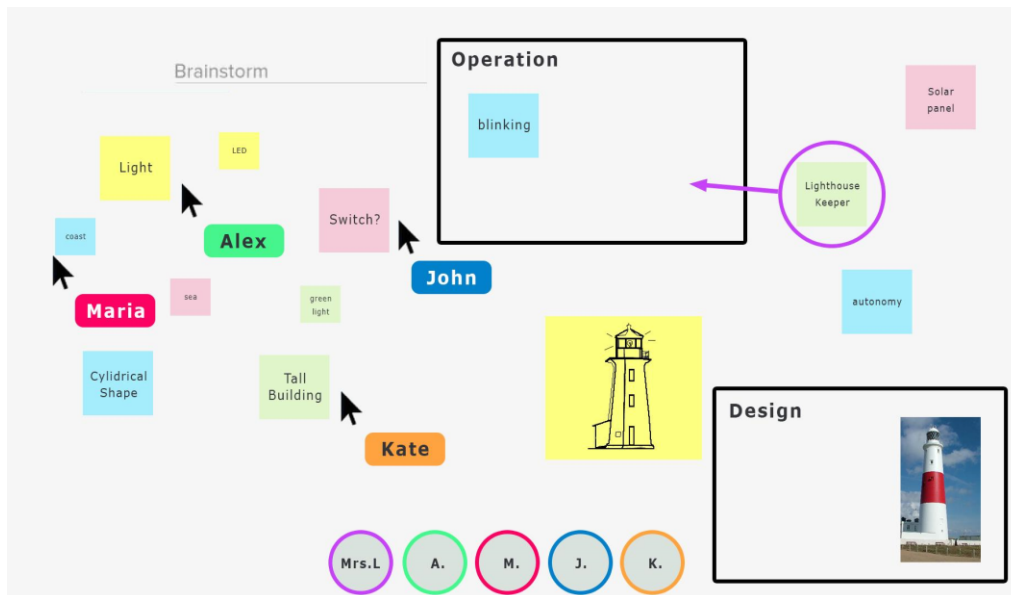
In a next stage, Lena invites the students in Zoom to summarise their ideas and she provides basic guidelines on how to proceed with the project. Her focus is on introducing them into electrical circuit making as some relevant questions have already been raised by the students. *How can we create the circuit of the lighthouse? How can we program the created circuit?* To respond to these questions Lena uses a number of tools that can facilitate students towards the stage of creation. To make the process more engaging she chooses to make a number of short demonstrations through TinkerCAD Circuits. First, she introduces TinkerCAD circuits through the creation of a simple circuit. The following image presents a snapshot of the demonstration. To make the entire process more interactive, Lena encourages her students to write their questions in the chat.
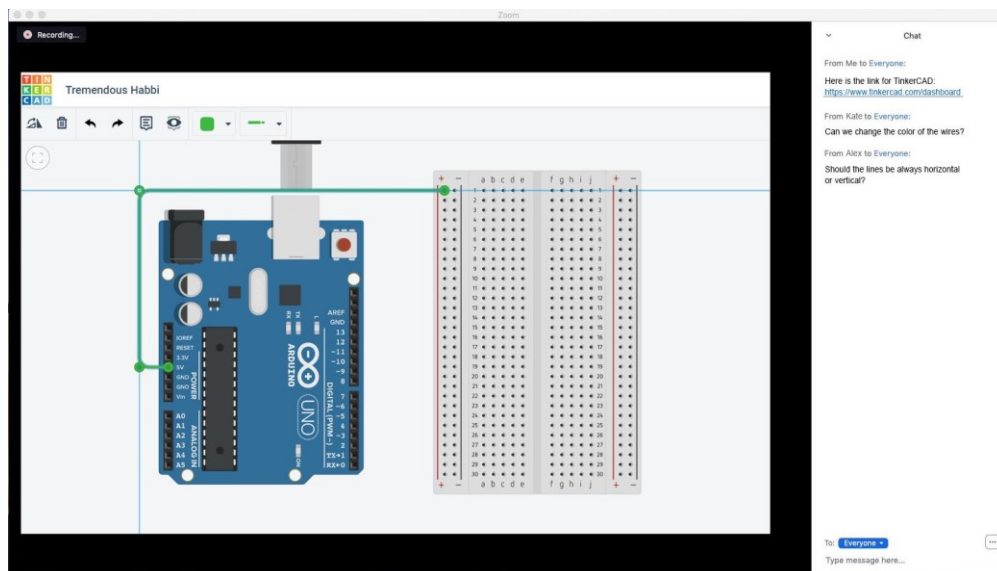
After creating the circuit, she is introducing them to the simulation process and consequently to block-based programming. Apart from the live demonstration, she is also sharing some notes with her students as well as some links with alternative tools and solutions (e.g., Open Roberta Lab). After these short demonstrations – and until the next session - she suggests that they should spend some time experimenting with the presented tools and – if they feel confident – to "jump into" the realization of the project. Lena encourages the students to start working using the actual material (Arduino, wires and electrical components) and considering the crafting process as well. She estimates that this stage may last 3 weeks and she is prepared to provide

support through Zoom three times a week through scheduled meetings. In each of these sessions, Lena asks the students to present the current state of their project. Although the students implement the project individually (something that would be different if they did not have face to face restrictions), she highly encourages the exchange of ideas and knowledge through these meetings.

Last, she encourages students to create very short video recordings of their final artefact- the lighthouses in action. Her plan is to upload these videos on the Youtube channel of the school together with a short note by the young makers and share the artefacts with as many school community members as possible.
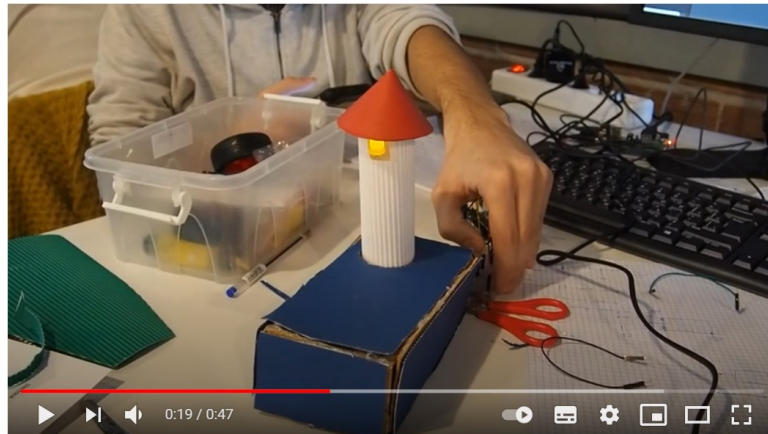
Figure 81: Paul's lighthouse available on Youtube

Scenario 3: The Egg Drop Challenge

Who	
The topic	Project based learning in general The Egg Drop Challenge
Students	
The tools	MS Teams, YouTube, Canva, Tracker
Pedagogical considerations and good educational practices	design/prototyping/testing/refinements, gamification

The full scenario:

Julia is a physics teacher in primary school. Usually, physics is introduced in Poland in 7th and 8th grade but she convinced her school administration that it would be helpful to start lessons in 6th grade - spending additional time not constrained with mandatory topics on having a "fun" out of physics. Without stress of marks and exams students should be able to be more open, creative and collaborative, which will be beneficial during "regular" learning.

One of her favorite school projects was always "The Egg Drop Challenge". The task is to throw a raw egg out of a window - and ensure its safe landing. To introduce topic to her students in the introductory lesson she played a video from YouTube channel "Minute Physics" with cartoon-style animation that stresses how hard it it to land spacecrafts on Mars and describes different ideas about landing techniques

(https://www.youtube.com/watch?v=h2nqgKL2JQU).
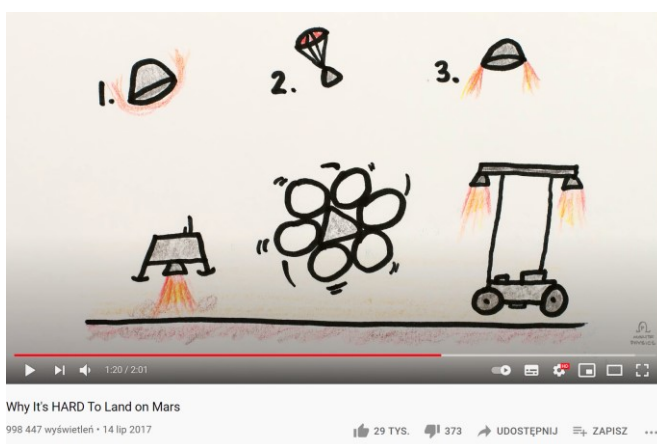
Afterwards she conducted group discussion to sum up new knowledge from

, mainly falling into two categories:

- decreasing speed (though reducing kinetic energy of impact), like parachutes or propellers with drag opposite to velocity, balloons with helium or hot air, use of wings, drones...

- Damping impact (absorbing or dissipating kinetic energy of impact), like strings, bubble foils, cotton, soft/spring/elastic materials as a padding...

Watched together during the on-line synchronous meeting on MS Teams

After on-line live discussion on different solutions, the teacher set the task: height of drop, time to put in and take out egg in/from students construction. Students divided into groups by MS Teams rooms work collaboratively on their projects: they decide what technology (or combination of technologies) will they use -> they make a conceptual project in graphic software -> they build physical model and make a series of test (that they record on put on YouTube do document mistakes or solved problems) -> on on-line meeting they show a movie of the test drop fulfilling project requirements -> using Tracker they determine velocity of they construction during the flight (showing if velocity is constant or increasing) and assessing total kinetic energy (and beginning potential energy)

https://www.youtube.com/watch?v=nsnyl8llfH4

Scenario 4: Scratch-ing Geometry

Who	Ana (Math Teacher)
The topic	The area of the circle
Students	18 students/12 years old
The tools	Zoom and breakout rooms, Geogebra Classroom, Scratch Online, Padlet
Pedagogical considerations and good educational practices	Interdisciplinary learning, encouraging brainstorming, planning, teamwork, collaboration, computational thinking, the area of the circle, Scratch programming, sharing

The full scenario:

Ana teaches Mathematics to 12-year-old students at a Portuguese school. This year, Ana had to teach online due to measures to mitigate the COVID-19 pandemic. The teacher plans to propose to students an interdisciplinary project between the subject of Mathematics and the subject of Information and Communication Technology. The project revolves around deducing the area of the circle by manipulating the Geogebra Classroom Applets. Later, Ana will create a project in Scratch to share the final students' projects on a Padlet wall. Ana, with design-based learning activities, particularly in Scratch programming and interactive media applets, will support the development of computational thinking in her students.

Ana provided informational documents in advance, which allowed students to review the concept of the perimeter of a circle. She starts by grouping teams made up of two students and explaining the project goal. Students communicate through Zoom and breakout rooms created for collaborative work between teams. The students begin by exploring a Geogebra Classroom activity consisting of an instructional video and an Applet where they can see a geometric demonstration of the area of the circle.
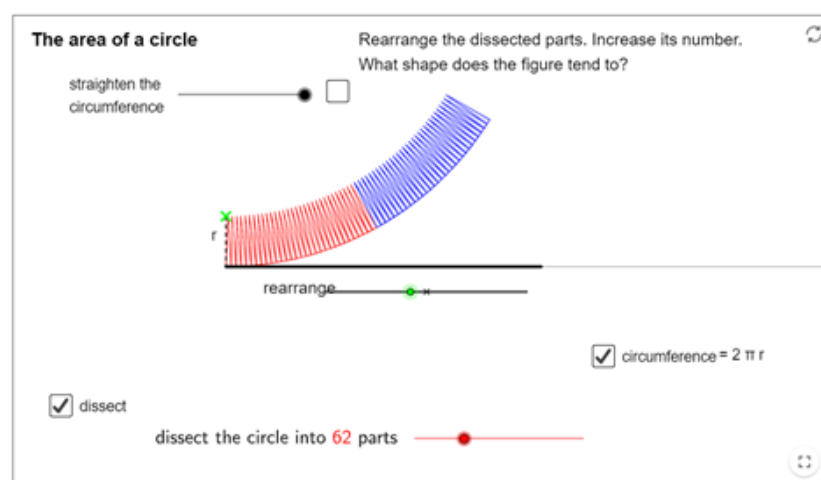
Figure 82: Applets on Geogebra Classroom

After exploring the Applet, each group will devise a Scratch project to explain how to calculate the area of the circle. Ana gives the students time to reflect on the development of the project in Zoom's breakout rooms. After this time, the teacher will go to each of the breakout rooms to

check the progress of the work, clarify doubts and guide the students' work. As teams are made up of two students and Scratch does not allow simultaneous work, one student shares the screen and the other does the necessary research.
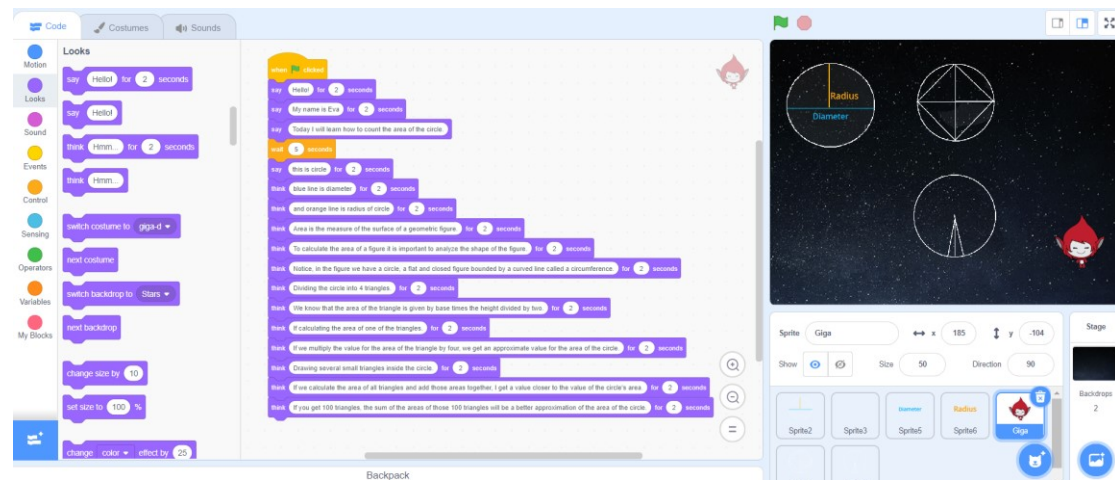
Figure 83: Work in progress on Scratch online for Team 3

After completing the creation of the project in Scratch, each team will present their work to other colleagues and share the work on a Padlet wall via a link. This Padlet mural will serve to share and publicize the work of this group of students. Afterwards, all students see each other's work and the teacher promotes a discussion around the projects created by each group. Finally, students complete the rule for calculating the circle area and record this conclusion in the Padlet.

Ana estimated 1 month for this work. During this time, the teacher monitors the work carried out, analyses the progress made by the students, communicates with the students, giving feedback, and clarifying any doubts that arise.

Scenario 5: The pendulum concept

Who	
The topic	Project with a focus on Physics
Students	
The tools	PHET pendulum lab, Geogebra, MS Teams, shared board
Pedagogical considerations and good educational practices	How to learn scientific method

The full scenario:

Franek is a physics teacher that always performed a lesson on a pendulum in a classical way: he derived a formula for pendulum period on a blackboard from force analysis, showing that period depends only on the length of pendulum. He found that students were much more interested during a demonstration of physical pendulum with use of a long rope and weight than during calculation, although they seem to appreciate conformity between theory and real measurement. The problem occured when students asked if they could try a bigger angle - and Franek was confused, knowing that during derivation of formula he assumed that angles are "small"... What's more he failed during an earlier attempt to prove that mass of weight is irrelevant to pendulum period - as it occurred to be relevant in experimental setup! During pandemic he came to idea that this is a chance to change his approach to topic of pendulums.

Instead of boring lecture with problematic demonstration with all the responsibility with set-up on him, he decided to leave a governance on experiment and change a bit of roles in the classroom. Boring lecture was turned into a great insight into how the science works - by setting and experimentally testing hypothesis.

The point is to show on live synchronous meeting on MS Teams a Phet simulation od pendulum (*https://phet.colorado.edu/sims/html/pendulum-lab/latest/pendulum-lab_en.html*), explaining what a pendulum period is and show (by changing parameters) that it can change. At on-line board we put ideas which parameter could be important (mass? Length? Amplitude?...) - that we split into groups that has to design virtual experiment in simulation that will test a particular hypothesis. After reconnecting together teams gives their answers with screen sharing of their substantiation. Finally on shared board we draw a table with yes/no for different parameters [but depending on air resistance on/off].

In next step every student has to build his own physical pendulum. Taking a picture or making a movie to show it's design (and the teacher could be surprised how creative this task could be!). Making a measurement of length and period and comparing this to simulation [putting numbers to table in shared Excel or in Geogebra spreadsheet] drives a discussion why some pendulums are in conformity with theory and others are not [air resistance, to low mass of pendulum in comparison to mass of thread/line on which it holds, movable place of attachment of line to support [experimental mistakes]]

Knowing the physics/math behind the phenomena, students create their own Geogebra-based simulation of pendulum.

Below there is a gallery of students' pendulums:
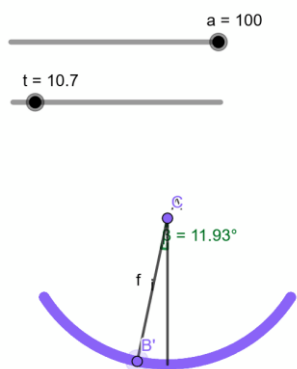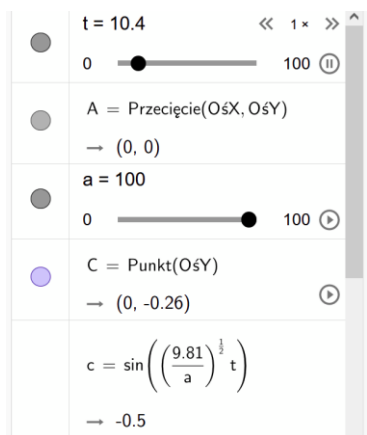
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Abbreviations and Glossary

LMSs = Learning Management Systems

VLEs = Virtual Learning Environments

SIS = Student Information Systems

STEM= Science Technology Engineering Maths

STEAM= Science Technology Engineering Arts Maths

synchronous learning = methods that reflect and simulate the dynamic of a live classroom where students learn simultaneously and collectively

asynchronous learning = methods that reflect and simulate the dynamic of a live classroom where students learn at their own pace

blended learning = an educational approach combining online educational materials and live interaction with traditional place-based classroom methods.

distance education = education of students that are not physically present at classroom

flipped classroom = a type of blended learning aiming to increase students engagement through methods that combine personal studying with live engagement in problem-solving concepts during class time and under the guidance of an educator.

Project-based learning = a dynamic methodology that organizes learning around projects.

Appendices

Examples of digital platforms

1. Blackboard: https://www.blackboard.com/en-eu

2. eClass: https://www.openeclass.org/en/platform/

3. Edmodo: https://new.edmodo.com/

4. Google Classroom: https://classroom.google.com

5. Google Workspace: https://workspace.google.com/intl/en/

6. Khan Academy: https://www.khanacademy.org/

7. Microsoft Teams: https://www.microsoft.com/it-it/microsoft-teams/group-chat-software

8. Moodle: https://moodle.org/?lang=en

9. Webex for Education: https://www.webex.com/industries/education.html

Examples of tools for online collaboration/communication

1. ClassDojo: https://www.classdojo.com/pt-pt/

2. Edmodo: : https://new.edmodo.com/

3. Google Classroom: https://classroom.google.com

4. Google Meet:

5. Skype: https://www.skype.com

6. WhatsApp: https://web.whatsapp.com/

7. Webex: https://www.webex.com/

8. Zoom: https://zoom.us/

Examples of online tools for supporting ideation/brainstorming

1. Goodnotes: https://www.goodnotes.com/

2. Google Docs: https://workspace.google.com/

3. Mindmaps: https://www.mindmaps.app/

4. MindMup: https://www.mindmup.com/

5. Miro: https://miro.com/

6. Mural: https://www.mural.co/

7. Padlet: https://padlet.com/

8. Word Cloud Generators (examples: Wordclouds: https://www.wordclouds.com/ , WorditOut, https://worditout.com/word-cloud/create)

Examples of online tools for supporting planning

1. Asana: https://asana.com/

2. OneNote: https://www.microsoft.com/en-us/microsoft-365/onenote/digital-note-taking-app

3. Todoist: https://www.educationalappstore.com/app/todoist-organize-your-life

4. Trello: https://trello.com/

Examples of online tools for supporting the stage of creation

Tools for 2d and 3d design and modelling

1. Autodesk AutoCAD: https://www.autodesk.com/products/autocad/overview

2. Autodesk 3dsmax: https://www.autodesk.com/products/3ds-max/overview

3. Canva: https://www.canva.com/

4. FreeCAD: https://www.freecadweb.org/

5. GIMP: https://www.gimp.org

6. Inkscape: https://inkscape.org/

7. Scribus: https://www.scribus.net/

8. Sketchbook: https://www.autodesk.com/products/sketchbook/overview

9. TinkerCAD 3d: https://www.tinkercad.com/

Tools for circuit making

1. Circuito: https://www.circuito.io/

2. Eagle: https://www.autodesk.com/products/eagle/overview

3. TinkerCAD circuits: https://www.tinkercad.com/

Tools for block-based programming

1. mBlock: https://mblock.makeblock.com/en-us/

2. Microsoft MakeCode: https://www.microsoft.com/en-us/makecode

3. Open Roberta Lab: https://lab.open-roberta.org/

4. Scratch: https://scratch.mit.edu/

5. Snap4Arduino: http://snap4arduino.rocks/

Tools for interactive simulations in Maths and Science

1. Canfigureit: https://www.canfigureit.com/

2. Free Math Apps: https://www.mathlearningcenter.org/apps

3. Geogebra: https://www.geogebra.org/

4. Physics Interactive: https://www.physicsclassroom.com/Physics-Interactives

5. PhET Interactive Simulations: https://www.colorado.edu/csl/programs/phet-interactive-simulations

6. TEALsim Project at MIT: http://web.mit.edu/viz/soft/visualizations/tealsim/index.html

7. TEAL simulations, Physics 8.02: http://web.mit.edu/8.02t/www/802TEAL3D/index.html

8. Biology Simulations: https://www.biologysimulations.com/

9. Virtual Biology Lab: http://virtualbiologylab.org/

10. Virtual Labs by MERLOT skill commons: https://virtuallabs.merlot.org/

11. LabXchange: https://www.labxchange.org/explore

Tools for creating 3D virtual experiences

1. CoSpaces Edu: https://cospaces.io/edu/

2. Artsteps: https://www.artsteps.com/

Tools for video and audio editing

1. Adobe Spark: https://www.adobe.com/express/

2. DaVinci Resolve: https://www.blackmagicdesign.com/products/davinciresolve/

3. FilmForth: https://www.microsoft.com/en-us/p/filmforth-video-editor-movie-maker/9nsf023x0mqs?activetab=pivot:overviewtab

4. Animoto: https://animoto.com/

5. Audacity: https://www.audacityteam.org/

6. Storyboard That: https://www.storyboardthat.com/

7. EDpuzzle: https://edpuzzle.com/

8. Tracker: https://physlets.org/tracker/

Tools for producing content based on the concept of gamification

1. Cells Alive: https://www.cellsalive.com/

2. Kahoot: https://kahoot.com/

3. Socrative: https://www.socrative.com/

4. Quizizz: https://quizizz.com/

Examples of tools for supporting the stage of sharing:

Social Media

1. Facebook: facebook.com

2. Instagram: https://www.instagram.com/

3. Youtube: https://www.youtube.com/

4. Twitter: https://twitter.com/

Platform offering space for sharing

1. theedubloggers: https://edublogs.org/

2. Explain Everything: https://explaineverything.com/

3. Grabcad: https://grabcad.com/

4. Instructables: https://www.instructables.com/

5. NRICH: https://nrich.maths.org/

6. Scratch community: https://scratch.mit.edu/studios/2050636/

7. Arduino project hub: https://create.arduino.cc/projecthub

Tools for presentation

1. PowerPoint: https://www.microsoft.com/en-us/microsoft-365/powerpoint

2. Google Slides: https://www.google.com/slides/about/

3. Mentimeter: https://www.mentimeter.com/

The form for feedback collection

Questions to retrieve feedback from partners for IO1 - The BeReady pedagogical handbook

The document aims at gathering input from partners which will be used in the context of IO1-*the BeReady pedagogical handbook*.

The document includes 7 questions. A table for inserting answers is available for each question and for each partner. You can use red (or other than black) colour to indicate work in progress. Please insert answers that are primarily relevant for secondary education.

Please notify us (ralimisi@gmail.com) when you finalise your contributions.

We welcome the documentation of **more examples/tools** per question than the ones indicated. Please have a look in the answers documented so far in order to avoid overlaps.

Deadline: 10 May 2021 *(in case you need more time, please let us know)*

Questions:

1. Please mention (up to 5) **digital platforms for online education** (preferably suitable for secondary education level) that you know or have used. For each platform provide the name, the relevant link and a short description (3-5 lines). Please number your answers.

    Digital platform: *A digital service that facilitates interactions between two or more distinct but interdependent sets of users who interact through the service via the internet. It can be described as a digital space to share information and educational content. It is intended for teachers and students.*

INPUT FROM EDUMOTIVA
1)
2)
3)
4)
5)

INPUT FROM University of Siena
1)
2)
3)
4)
5)

INPUT FROM UniMinho
1)
2)
3)
4)
5)

INPUT FROM WUT
1)
2)
3)
4)
5)

2. Please mention **tools** (up to 3) that can support **online collaboration/communication**. Please provide the name of the tool, a short description and the corresponding link.

INPUT FROM EDUMOTIVA
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INPUT FROM University of Siena
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INPUT FROM UniMinho
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INPUT FROM WUT
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3. Please mention (up to 3) **online tools** that can support **ideation/brainstorming**. Please provide the name of the tool, a short description (2-3 lines) and a corresponding link.

INPUT FROM EDUMOTIVA
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INPUT FROM WUT
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3)

INPUT FROM University of Siena
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INPUT FROM UniMinho
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4. Please mention at least one (1) **online tool** that can be used by students for doing the necessary **planning** in the context of their projects. Please provide the name of the tool, a short description and a corresponding link.

   Planning: *is the process of thinking about the activities (i.e. identifying key steps, setting deadlines, listing of materials needed and more) required to achieve a desired goal, in our case an online educational activity/project. The stage of planning is usually inherent in project-based learning practices.*

INPUT FROM EDUMOTIVA
1)
2)

5. Please mention **digital tools (preferably web based) (up to 5)** that can support the stage of **creation** (usually an important aspect in project-based learning).

Note: The tools can be used to create a digital artefact (i.e. a digital animation, a 3d model, a program, a simulation, a visual diagram, a video and many more). The tools are intended for use by the teachers (i.e. for preparing educational content) and/or by the students (i.e. for practicing their skills towards digital artefact creation). The tools can be of general scope or related to a specific subject area. Please provide the name of the tool and the link, a short description, the corresponding subject field and from whom they are supposed to be used.

We welcome the documentation of more than 5 tools, feel free to add rows in the table.

INPUT FROM EDUMOTIVA			
Name of the tool and link	**Short description**	**Subject**	**Main user (teacher/ student/ both)**

INPUT FROM SIENA			
Name of the tool and link	**Short description**	**Subject**	**Main user (teacher/ student/ both)**

INPUT FROM UniMinho			
Name of the tool and link	**Short description**	**Subject**	**Main user (teacher/ student/ both)**

INPUT FROM WUT			
Name of the tool and link	**Short description**	**Subject**	**Main user (teacher/ student/ both)**

6. Please mention **2 online tools and/or services** that can support the **stage of sharing** (usually an important aspect in project-based learning). Please provide the name of the tool, a short description (2-3 lines) and a corresponding link.

Note: By tools and services for sharing we are referring to any online/digital means that allow students and teachers to share their projects with others, to present the current status of their work, to showcase their work in the wider public, to share ideas, thoughts and solutions.
* free accessed tools are preferable

INPUT FROM EDUMOTIVA
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2)

INPUT FROM University of Siena
1)
2)

INPUT FROM UniMinho
1)
2)

INPUT FROM WUT
1)
2)

7. Please mention **3 good practice examples, strategies and/or inspiring stories** for enhancing learning experiences through and with the help of digital online technology.

Good practice: a practice/method/technique/combination of methods that has been proven to work well and produce good results and/or is promising, and can be recommended as a model or described as having an added-value.

INPUT FROM EDUMOTIVA
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INPUT FROM WUT
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INPUT FROM University of Siena
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INPUT FROM UniMinho
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