

INNOVATIVE DIGITAL SOLUTIONS TO ASSESS 21<sup>ST</sup> CENTURY SKILLS IN  
MAKERSPACES

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IO1

Assessment and tool design

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### Declaration

This report has been prepared in the context of the [ASSESSMAKE21](#) project. Where other published and unpublished source materials have been used, these have been acknowledged.

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### Funding Disclaimer

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## Table of Contents

|  |    |
|--|----|
| Executive summary .....  | 4  |
| Glossary .....   | 7  |
| O1_A1: Definitions of 21 <sup>st</sup> century skills for makerspace contexts..... | 8  |
| 1. Task description .....  | 8  |
| 2. Methodology .....   | 8  |
| 3. Findings.....   | 8  |
| 4. Defining the five 21 <sup>st</sup> century skills for ASSESSMAKE21 .....        | 13 |
| O1_A2: Technological Requirements and User Experience Design.....                  | 19 |
| 1. Task description .....  | 19 |
| 2. Methodology .....   | 20 |
| 3. Findings and design decisions .....   | 20 |
| 4. Technical and Functional Requirements.....                                      | 24 |
| O1_A3: Designing Pedagogical Framework .....                                       | 28 |
| 1. Task description .....  | 29 |
| 2. Methodology .....   | 29 |
| 3. Pedagogical framework.....  | 29 |
| References .....   | 56 |
| Appendix A - Innovative elements of ASSESSMAKE21 (vis-à-vis SkillTrack!).....      | 59 |
| Appendix B – Educators Tool Wireframe Annotations .....                            | 66 |
| Appendix C – Student Tool Wireframe Annotations.....                               | 67 |

## Executive summary

IO1 covers the design phase of the project. O1 allowed the partners to design a digital assessment tool for 21st C Skills that is dedicated to the learning context of makerspaces (either in Schools or nonformal). This tool was to be used by students (aged 12 -18) who engage in makerspace activities and supply information to their teachers and/or makerspace facilitators. This information was to assist in the validation that 21st C Skills that are promoted and developed through makerspace activities. The tool was to be based on the demonstrator already developed by Learnovate in their SkillTrack! research project, which was based on self-reflective practice in a formative assessment to increase student skill literacy, awareness and confidence and allow them to document examples of utilising these skills in a variety of contexts.

O1 gathered and analysed the specific needs and requirements of the students, teachers and facilitators operating in these contexts for this tool. The process involved co-creation activities with representatives of user groups and utilised Design Thinking methodology and tools to ensure that design met user needs and facilitated highest usage and best user experience. Also, O1 determined the specific subset of 21st century skills to be assessed, developed a pedagogical framework that defined the structured and scaffolded experience for the student-user as they built awareness and literacy of each skill and document its application through activities. O1 was organised in three tasks: O1\_A1 Definition of skills to be assessed (a subset of 21st century skills), O1\_A2 Determining technological requirements and Designing the User Experience, and O1\_A3 Designing pedagogical framework. O1 tasks were lead by CIL with input from all other partners.

The design thinking workshops and interviews aimed to address the following questions: (i) to what extent do makerspace practitioners and educators draw from 21st-century skills frameworks in their maker contexts? (ii) what 21st-century skills do makerspace practitioners and educators consider important during the implementation of making activities? (iii) how do makerspace practitioners and educators consider 21st-century skills as part of their practice? Participants in the design thinking workshops were members of the consortium of partners (total of 13 participants) and seven makerspace educators/facilitators from the local (Cyprus) context. Participants in the interviews were 13 educators or makerspace facilitators coming from the four countries of the consortium (non-consortium-members). Out of the 13 participants, two of them were educators operating makerspaces within primary and secondary public schools (i.e., formal setting) while the rest (11 participants) were educators or makerspace facilitators working in non-formal setting i.e., public or private makerspaces or fablabs for children and adolescents to engage as an extracurricular activity. These participants were selected to provide rich information about the topic, based on their experience (i.e.,

purposeful sampling). The participants in workshops and interviews identified 15 skills that they consider important in maker contexts and linked some of the skills to their practice. Among the wide range of 21st-century skills which were incorporated into their practice, the majority of participants commonly referred to five skills: Collaboration, Creativity, Communication, Life/Social skills, and Problem-solving. These skills were therefore agreed by the consortium to be designed into the Assessmake21 tool.

The co-design process involved all project partners and external collaborators who shared their insights and expertise in the areas of education, makerspaces, 21st-century skills (assessment), and software development for educational technology. The codesign and co-creation started with Skilltrack! exploration (previous work of Learnovate on which this project was based and expanded) and considered all the input from the stakeholders as gathered in the design thinking phase. The main phases of the realization of the tool design included exploration, analysis, design, prototyping, evaluation, and integration. We followed an iterative design, which is at the heart of UX. Our interaction of design needs and requirements resulted to the following goals about the Assessmake21 tool design: (1) the tool should allow students to detect the skill they perceive to use/develop through their making activities through easy selection i.e., by ‘tapping’, (2) the tool should provide both formative and summative ways to record the students’ development of skill(s), (3) the tool should offer flexibility in selecting an integration plan to appropriate different classroom/makerspace contexts and needs, (4) the tool should facilitate an overview of students’ progress and reward students for their achievements (i.e., gamification), (5) the tool should support the educator with learning-management actions and access to learning analytics (i.e., educator dashboard).

The design of the pedagogical framework was based on the five commonly referred skills: Collaboration, Creativity, Communication, Life/Social skills, and Problem-solving. The pedagogical framework defined the structured and scaffolded experience for the student-user as they build awareness and literacy of each skill and documents its application through activities. Questions and activities were fully scripted to form self-reflective practice. As envisioned in the proposal of this project, the tool was designed to support gamification (e.g., reward students for their achievements) to increase motivation for engagement and progression for the students.

CIL and Learnovate worked closely together on the UX design outputs (e.g., Wireframes) to ensure that the level of detail was as required to progress tool development in IO2. In the overlap of IO1 and IO2, the goals and requirements for the tool were prioritised to align with the project objectives as well as feasibility for delivery on time and in budget. The resulting tool design of IO1 (and development of IO2) was innovative in being designed specifically for the context of makerspaces

and in its use of self-reflective practice as part of self-assessment. The learnings from IO1 were regarding the most relevant 21stC Skills for makerspaces and requirements for digital tools and technologies for assessment in this context. IO1 report covers the details design phase of the project. It covers the data collection and analysis processes corresponding to each of the tasks A1-A3. A comprehensive list of appendixes accompanies IO1, addressing the cycles of design and refinement of the tool.

## **Glossary**

### **21<sup>st</sup> century skills**

21<sup>st</sup> century skills are considered the essential skills necessary in the workplace of the 21<sup>st</sup> century. When referring to 21<sup>st</sup> century skills, bear in mind that the following skills are included but not constrained to these. A list of these skills includes: Citizenship, Collaboration, Communication, Creativity, Critical Thinking, Global Awareness, ICT literacy, Personal and Social Responsibility, and Problem Solving. For this project, we focused on the five skills most often identified in the context of makerspaces (either in schools or nonformal) as identified by teachers and/or makerspace facilitators.

### **Elements**

When referring to elements in this project, we consider the main categories a 21<sup>st</sup> century skill is being divided. Each 21<sup>st</sup> century skill has been divided in 3 or 4 elements that exemplifies the essence of the skill. To identify the elements of each skill, we reviewed the most well-known frameworks for 21<sup>st</sup> century skills. Through this literature review, we conducted a list of elements for each 21<sup>st</sup> century skill included in this project.

### **Learning Outcomes**

When referring to learning outcomes in this project, we consider the major indicators/behaviours that derive from each element. Each learning outcome is based on thorough literature review of the most well-known theoretical frameworks for 21<sup>st</sup> century skills. These act as indicators for learners when developing each 21<sup>st</sup> century skill.

### **Digital self-assessment tool**

The digital self-assessment tool is named ASSESSMAKE21. This tool will be used by students (aged 12 -18) to reflect on their development of 21<sup>st</sup> century skills in makerspace contexts. The tool includes five levels of reflection on each selected 21<sup>st</sup> century skill (one being infinite level). The students' progress through levels as they tap on skills and reflect on challenges specifically designed to enact their metacognitive thinking during the making activities. When referring to the ASSESSMAKE21 tool in this report, we consider it to be the final digital tool that is going to be used in the pilots in making contexts.

### **Educator's Dashboard**

The Educator's Dashboard is the online platform designed for the management of students by the teacher. The teacher is the only person having access to this platform and can review the overall progress of the class as well as review an individual's progress. The Educator's Dashboard provides several functions to the teacher such as to create a class, add students, manage students (group, reorder, colour code), take notes, select language, select approach, select duration of levels, etc.

## **O1\_A1: Definitions of 21<sup>st</sup> century skills for makerspace contexts**

### **1. Task description**

The first task of IO1 called on our team to determine which skills, out of the long list of 21<sup>st</sup> century skills, are the most relevant to makerspaces and their participants - teachers and students.

### **2. Methodology**

The subset of 21<sup>st</sup> century skills included in the design of ASSESSMAKE21 were based on data collection and analysis as follows.

- Design thinking workshops
- Semi-structured interviews
- Literature review

A triangulation of findings from the above informed the design of ASSESSMAKE21.

### **3. Findings**

#### ***Initial findings from the literature review***

There is a demand for individuals to acquire a set of skills for life and for the workspace in the 21<sup>st</sup> century (NCCA, 2009). Students of today must become the skilful workers of tomorrow with the ability to apply their knowledge and skills in newfound situations therefore educational systems all over the world should prepare the learners of the 21<sup>st</sup> century to acquire the necessary skills for their future jobs (Kjällander et al., 2018).

With the maker movement increasingly adopted across K-12 schools and non-formal makerspaces, students are being given more opportunities to engage in making activities using tools such as robots, electronics, arts, and crafts. In the research years, making activities have played a prominent role in the transformation of various formal and non-formal education settings, such as school or non-school spaces, makerspaces, or maker camps (Timotheou & Ioannou, 2019a,2019b). Making activities are said to help students develop 21<sup>st</sup> century skills such as collaboration, critical thinking, creativity, problem-solving communication, and collaboration. Understanding how students develop these skills and locating assessment tools with applicability in making contexts has proven challenging. ASSESSMAKE21 aims to assist in the validation that 21<sup>st</sup> century skills are promoted and developed through makerspace activities.

#### ***The 21st century skills***

A set of essential skills for the successful journey of learners in today's world have been recognised through numerous frameworks to date. These skills are a blend of specific skills, expertise and literacies that are necessary for learners to succeed in work and in life (P21, 2015). The following skills include, but not limited to: *Citizenship, Collaboration, Communication, Creativity, Critical Thinking, Global Awareness, ICT literacy, Personal and Social Responsibility, and Problem Solving*. They are considered “transversal, have mobility, adaptability and accessibility across subject matters without being directly linked to a content base” (Kipp, Kapros & O’Keeffe, 2018, p. 42). These skills



should be used throughout the curriculum, repetitively from early childhood education to tertiary education and across all disciplines.

Challenges arise when educators aim to integrate the development of 21<sup>st</sup> century skills in teaching and learning in formal and non-formal learning settings. The reason why this happens is primarily because these skills are not sufficiently defined, they lack distinction between them, they lack indicators of success in most national curriculums from the partner countries and are not perceived clearly by students/learners or educators.

The purpose of the first task of IO1 is to identify which 21<sup>st</sup> century skills are most frequently used in makerspace settings and can be developed through makerspace activities. A definition is presented for each skill together with a breakdown of what each skill is comprised of (referred to as “elements”).

### ***Maker education***

A makerspace is a hands-on learning environment where learners explore project-based learning and participate in learn-by-doing lessons as well as develop new innovations (Pepper-Kittredge & DeVoe, 2016). These spaces were built for exploration of the learners’ skills, for sharing ideas, tinkering, creating and remaking products as well as investigating the mechanisms of objects and creating a sense of ownership and meaning making in the world (Timotheou & Ioannou, 2021; Wohlwend, 2018). Sheridan et al. (2014) described makerspaces as learning environments that “*are comprised of participants of different ages and levels of experience who work with varied media, but a commonality is that these spaces all involve making: developing an idea and constructing it into some physical or digital form*” (Sheridan, et al., 2014, p.507). In addition to this definition, maker learning contexts welcome practices that facilitate interdisciplinary learning and ensure that Science, Technology, Engineering and Mathematics (STEM) subjects are supported in such diverse environments and are taught in such ways that are enjoyable and meaningful (Marsh, Arnseth & Kumpulainen, 2018).

In makerspaces or makerspace learning contexts learners take part in non-traditional methods of learning, therefore modern skills are required by the students, such as creativity, problem-solving, productive participation in teamwork and the flexible use of information and communications technology (Häkkinen et al., 2017). In the end, learners are expected to work individually or in groups and be able to produce digital and/or tangible products.

### ***Initial findings from the design thinking workshops***

The design thinking workshops and interviews aimed to address the following questions: (i) to what extent do makerspace practitioners and educators draw from 21<sup>st</sup>-century skills frameworks in their maker contexts? (ii) what 21<sup>st</sup>-century skills do makerspace practitioners and educators consider important during the implementation of making activities? (iii) how do makerspace practitioners and educators consider 21<sup>st</sup>-century skills as part of their practice?

Participants in the design thinking workshops were members of the consortium of partners (total of 13 participants) and seven makerspace educators/facilitators from the local (Cyprus) context. The design thinking workshops were conducted on three different days with a small number of participants each time to ensure that all members would have enough time to share their thoughts:

- Workshop with 8 partners
- Workshop with 5 partners
- Workshop with 7 local (Cyprus) experts

Design thinking is an iterative process in which teams seek to understand users, re-think assumptions, and redefine problems to figure out alternative strategies or solutions. It is acknowledged as a way of thinking, working and methods collection. Design thinking includes five phases which are: 'Empathize with users', 'Define their needs/ problems and producer's insights', 'Ideate by generating new ideas', 'Prototype to start creating solutions' and 'Test solutions'. Last but not least, design thinking is considered a non-linear process where phases may not come in order, and they can occur in parallel or repeat iteratively in order to tackle problems that are ill-defined or unknown (Dam & Siang, 2020).

The design thinking workshops were focused specifically on:

- identifying what 21<sup>st</sup> century skills are the most relevant in makerspaces based on the experiences of the participants
- defending these skills
- voting on the most relevant skills for ASSESSMAKE21
- identifying potential features of the digital tool for the assessment of 21<sup>st</sup> century skills
- design a learner's journey on the use of the digital assessment tool in a makerspace context

The results showed that 3 skills were of great consideration – Creativity, Problem Solving, Communication, followed by social skills, technical skills, collaboration, and critical thinking. Some of these skills were elaborated in terms of what they meant for the workshop participants, for example:

- Creativity was explained as innovation, self-expression, curiosity, tinkering, making.
- Problem solving was explained as working on real-world problems, being effective and generating new ideas.
- Collaboration was explained as teamwork, learn from others and work with others.
- Communication was explained as sharing achievements and communicate ideas effectively.
- Social skills were explained as taking initiative, intentionality, taking responsibility, learning to learn, persistence, build confidence, resilience, and self-direction.
- Critical thinking was explained as making informed decisions.
- Technical skills were explained as computational thinking, programming, ICT and digital/information skills.

It is important to mention that not all of these skills are considered 21<sup>st</sup> century skills as such, but we are reporting the findings from the design thinking workshops and what participants felt important to mention.

### ***Initial findings from the interviews***

Participants in the interviews were 13 educators or makerspace facilitators coming from the four countries of the consortium (non-consortium-members). Out of the 13 participants, two of them were educators operating makerspaces within primary and secondary public schools (i.e., formal setting) while the rest (11 participants) were educators or makerspace facilitators working in non-formal setting i.e., public or private makerspaces or fablabs for children and adolescents to engage as an extracurricular activity. These participants were selected to provide rich information about the topic, based on their experience (i.e., purposeful sampling). The participants in workshops and interviews identified 15 skills that they consider important in maker contexts and linked some of the skills to their practice. Among the wide range of 21st-century skills which were incorporated into their practice, the majority of participants commonly referred to five skills: Collaboration, Creativity, Communication, Life/Social skills, and Problem-solving. These skills were therefore agreed by the consortium to be designed into the Assessmake21 tool. The Design phase work is presented in IO1. The semi-structured interviews aimed at understanding 1) the educators' and makerspace facilitators' needs in their operating contexts and 2) the 21<sup>st</sup> century skills that are more frequently used in makerspaces, based on their experience. The interviewees were/are the potential end-users in the projects' upcoming pilot studies. Specifically, the interviewees were asked to share their practices and examples of learning activities around the development of 21st century skills especially in makerspace contexts and to discuss challenges they experience in assessing those skills. The practitioners also shared examples of 21st century skills most frequently used in their local makerspace settings and gave specific examples of experience. The interviews helped to clarify the needs of the end-users with respect to the digital assessment tool ASSESSMAKE21.

The partner countries (Ireland, Sweden, Greece and Cyprus) share some commonalities in the way makerspaces operate in their educational system. Most importantly though, there are differences among them that require adaptation of ASSESSMAKE21, so that students and educators can include the tool in their lessons/maker sessions, without having to make significant changes in the learning process. The tool is intended to be integrated in typical lessons and procedures, not obstructing the learning process. Moreover, the digital assessment tool should be designed to support with the needs, practices, tools and materials (technological equipment) each class has available. For instance, some schools that will potentially participate in the pilot studies do not have a permanent makerspace incorporated in their school space/premises. Therefore, these teachers will have to operate in a normal classroom and use limited equipment and materials. In other cases, a makerspace is placed in the school and the teachers has direct access to a variety of tools. This exemplifies the different modes

of learning that are going to happen in the current project, while this project is exploring the issue of raising awareness of 21st century skills in makerspaces.

In terms of the participants' thoughts about skills, we found general overall consensus on their thinking.

-*Communication* was described as “*Communication of ideas, thoughts, space for brainstorming, ideation*” as well as a mean to present the current state of the learners' work. Interviewees consider it important that the student should communicate effectively with his/her peers when building the project as well as address the facilitator or turn to the person next to them and communicate with them.

- *Collaboration* was one of the top skills for learners to develop. The participants explained that “*the class is designed in a student-centred way, that allows students to collaborate*” where others describe that the ideology and the purpose of the makerspace is to develop 21<sup>st</sup> century skills and particularly collaboration, where learners create together. It is important for them to promote this kind of mindset where learners learn from each other and work together whilst having a common goal to succeed. Students are encouraged to “*make a plan, set goals and collaboratively find a way to reach the goals.*”

- *Problem solving* is included in the design of the maker activities, so that students follow a series of steps to discover learning by themselves. They need to explore, search, investigate, find evidence, and solve the problem, using the design process in all the artefacts. In other cases, depending on the age group, students ought to plan what is essential for their solution in terms of tools and materials and think ahead about what is needed to solve the problem that is emerging. Another typical example of problem solving is when students are assigned a specific project, which they have absolute liberty of making it their own. This would entail coming up with the ideas, the design, and the prototype, as well as making decisions with partial or ambiguous information available. Typically, as the participants explain, this type of situation in the beginning is chaotic, but when students start implementing problem solving skill and technical principles from other domains, they manage to achieve their goal.

- *Life/Social skills* was referred to as traits that characterize the essence of the whole. Some mentioned it as excitement of students, since they enjoy learning, others as self-confidence, taking responsibility of their actions signifies the sense of ownership they feel afterwards and finally others mentioned a number of traits under this category such as leadership, taking initiative, productivity. Per participants, these traits that belong under Life/Social skills can be developed inside makerspaces and allow learners to have a better experience and provide them with assets to enjoy learning.

- *Creativity* is developed when students get to create their own projects, use their imagination, and think of alternative ways of creating an artefact. Other cases show that creative thinking still emerges, despite having the same project for all the groups. Different approaches get

developed by the groups, displaying their own view and expressing themselves through their artefact. Students are also part of the creative process when they generate new ideas, explore their options and creative side through multiple interventions and finally select the best idea and elaborate on it. Moreover, it is considered of high importance for students to explore, make mistakes and discuss what went wrong and what could be done differently. Through these practices, students explore and learn individually and/or with others. Students learn first-hand that *“it is good that you tried this, now that it doesn’t work, it is ok, because this is part of life, when something does not work, we try it in a different way”*. Therefore, they get to view failure as an opportunity to learn, since creativity and innovation is a long-term process that involves a lot of try-outs, small successes, and frequent mistakes.

#### 4. Defining the five 21<sup>st</sup> century skills for ASSESSMAKE21

Taking into consideration all the input from the design thinking workshops and interviews, together with literature review findings, we concluded to proceed with the following five skills in the digital assessment tool:

1. *Collaboration*
2. *Creativity*
3. *Problem solving*
4. *Social skills*
5. *Communication*

Below, the reader can find a definition and a set of attributes for each skill.

| Collaboration                  | Creativity      | Problem solving  | Social skills                   | Communication   |
|--------------------------------|-----------------|--|---------------------------------|---|
| Develop shared understanding   | Generate ideas  | Cultivate a problem-solving mindset  | Initiative and self-direction   | Express opinions, speculate, discuss, reason, and engage in debate and argument |
| Contribute collectively        | Experiment      | Observe, think, analyse, design, and synthesize components in ways that lead to insightful problem interventions | Flexibility and adaptability    | Engage in dialogue  |
| Regulate the work of the group | Implement ideas | Solve problems   | Productivity and accountability | Presentation  |

|   |  |  |                               |  |
|---|--|--|-------------------------------|--|
| Develop good relationships with others and a sense of well-being in a group |  |  | Leadership and responsibility |  |
|---|--|--|-------------------------------|--|

### ***Collaboration***

Collaborative learning is an active form of learning between two or more individuals that work together in a physical or virtual environment (Kirschner, et al., 2018). Roschelle and Teasley (1995) defined collaboration as a “coordinated, synchronous activity that results of a continued attempt to construct and maintain a shared conception of a problem”. It is noteworthy mentioning that learners who belong to the same group should be able to reach a “shared understanding” or “common ground” to concepts that are open to interpretation prior and during the learning process (Stahl, 2003). This collaborative learning situation derives from a specific set of interactions among individuals which would trigger learning mechanisms (Dillenbourg, 1999). Such interactions may include working together, working in multidisciplinary teams, understanding each other, creating solutions for complex problems together, sharing ideas, interpreting other people’s ideas, etc. Another important aspect is the collaborative construction of knowledge; this is linked to learners’ belief that the creation of new knowledge is meaningful to them and useful to their community (Scardamalia & Bereiter, 2006). Genuine collaborators share these attributes when taking part in projects that require construction of socially shared meaning. These attributes include:

#### **A. Develop shared understanding**

- Identify, evaluate and achieve joint goals
- Establish practices associated with different roles in a group (e.g., leader, team member)
- Gather together relevant resources and information

#### **B. Contribute collectively**

- Perform with others in various contexts with divergent goals and purposes
- Work in effective and respectful manner when taking part in diverse groups
- Learn together and from each other
- Include group contributions and feedback into the group work
- Adopt shared responsibility for collaborative work

#### **C. Regulate the work of the group**

- Review the work of the group
- Resolve conflict through explicit discussion with the group members to the extent needed to restore a sense of shared understanding
- Provide frequent feedback in the group through subtle word choices, inflections, gaze, body language

- Reflect on your own contribution

#### **D. Develop good relationships with others and a sense of well-being in a group**

- Appreciate individual contributions made by each team member
- Recognise what behaviour is appropriate in a given situation and act accordingly
- Be flexible and willing to help when it is needed to make compromises, to achieve a common goal
- Have an unbiased and accepting attitude towards new and diverse perspectives of group members

#### ***Creativity***

Creativity is considered one of the key skills for learners who prepare for complex life and work environments in the 21<sup>st</sup> century (Partnership for 21<sup>st</sup> Century Skills, 2009). Creative thinking is an individual or collaborative reflective iterative process whose goal is to design a new, relevant, and innovative method to answer to a challenge that is valued by the community (Boden, 2004). Creativity in educational contexts is equally represented between three types of thinking: divergent, convergent, and associative thinking. Through the trajectory of the creative process, the learner explores various new solutions to a given challenge, uses inspirational work of others to direct his/her own thinking and eventually chooses a solution, while in fact the learner is taking into consideration the context of the problematic situation (Lille & Romero, 2017). According to Gauntlett and Thomsen (2013) the creative process includes five phases through which the creative individual goes through to develop ideas or artefacts in not such a straightforward route. These phases are:

- Preparation: the individual becomes immersed in a challenge that is interesting and triggers one's curiosity
- Incubation: Ideas swirl in one's mind with a slight hint of consciousness
- Insight or illumination: the moment where the creator finds light in the darkness and knows how to start (Aha! moment)
- Evaluation or verification: the individual decides whether the insight is valuable and worth pursuing
- Elaboration: the individual works on the insight and display it as final work

Hennessey (2013) referred to individuals and learners who approach the world with curiosity, questions, and a desire to play, make and share as personalities with a creative mindset. These individuals view life from a different perspective than most, share a playful attitude with the world and have a strong will to take risks in their lives. The creative mindset of these individuals is particularly an attitude to the world which is often reduced or even lost in the school communities and work environments. The challenge to sustain the creative mindset in learners is sincere, thus in order to develop learners as creative thinkers, opportunities to create and the demand for

stimulating environments and engaging tools and materials is needed now more than ever (Gauntlett et al., 2010). Learners with a creative mindset share these attributes when taking part in individual or group projects.

These attributes include:

#### **A. Generate ideas**

- Generate new ideas and develop them in practice
- Utilise a broad range of idea creation techniques (e.g., brainstorming, online tools, etc.)
- Note down various ideas (number and range)
- Implement iteration to re-frame problems in order to enable new, surprising, and valuable ideas or artefacts to emerge

#### **B. Experiment**

- Generate several alternative interventions
- Observe patterns and recognise connections
- Demonstrate originality and inventiveness in your work
- Cultivate the relevant mindset behind optimal learning and creativity
- Create a profound understanding of the topic you are dealing as well as making it meaningful through investing the self while making it
- Master a tool to have the skills and confidence to express and communicate your ideas

#### **C. Implement ideas**

- Elaborate, refine, analyse, and evaluate your own ideas to improve and maximise creative efforts for a specific purpose
- Recognise the real-world limits to adopting new ideas
- Act on creative ideas to make a tangible and useful contribution to the field in which the innovation will occur
- View failure as an opportunity to learn; understand that creativity and innovation is a long-term, cyclical process of small successes and frequent mistakes

#### ***Problem Solving***

Problem-solving tasks that are ill- defined and ill-structured are provided to students to develop a set of 21<sup>st</sup> century skills, including creativity and critical thinking (Lai & Viering 2012). During the learning process of an ill-structured problem, students often get involved in a challenge where the information that is required to solve the problem is not complete in the problem statement. This allows learners to select from several solution pathways to follow, since steps are not clearly defined. This learning task leads learners to consider various ideas and constructive conflict among group members which is often obligatory for creating the solution to the problem. Such learning situations recall dialectical aspects of conventional and innovative analysing, where learners engage in productive discourse which ultimately deepens knowledge co-construction



and creation of a solution (Tan et al., 2014). Learners engage in a regulatory dialogue that involves discussion about planning, monitoring and regulation. They share their understanding towards the definition and the analysis of the problem to reach a mutual understanding with each other. When the solution is ready, learners evaluate it in the end of the project by examining, analysing, and judging the final outcome with the use of argumentative discussion. Last, learners take part in a discussion about their shared understanding with the use of affective and cohesive on-task talk (Tan et al., 2014). Learners who actively participate in problem-solving tasks develop attributes of problem-solving skills. These attributes include:

**A. Cultivate a problem-solving mindset**

- Explore open-ended problems in conventional and innovative ways to generate multiple solutions
- Define open-ended problems and reshape them to fit my skills

**B. Observe, think, analyse, design, and synthesise components in ways that lead to insightful problem interventions**

- Describe and explain different problem-solving strategies
- Assemble, test and progressively refine prototypes that illustrate the value of my idea
- Design and initiate innovative processes to create value
- Prepare a vision statement for my (or my team's) value creating activity that guides internal decision-making throughout the whole process of creating value

**C. Solve problems**

- Create (alone or with others) products or services that solve my problems and my needs
- Experiment with different techniques to generate alternative solutions to problems, using available resources in an effective way
- Actively search for new solutions that improve the value-creating process
- Act and work independently to achieve goals
- Set long-, medium- and short-term goals
- Define priorities and action plans
- Make decisions when the result of that decision is uncertain, when the information available is partial or ambiguous, or when there is a risk of unintended outcome

***Life/Social skills***

The combination of having complex situations in your personal life along with stressful working environments builds the need for the development and growth of skills that are beyond content and thinking skills. This requires the knowhow to navigate through the personal and working life and staying on top of things. Having the key life/social skills pays off in the fast-paced life (Partnership for 21<sup>st</sup> Century Skills, 2009). It can be rather challenging to try and include all possible social skills that are under this category. For this reason, the skills that are mentioning in this sector are

specifically the ones that can be developed in the maker learning contexts and are a combination of a number of frameworks (Partnership for 21<sup>st</sup> Century Skills, 2009; McCallum, et al., 2018; Kipp, et al., 2018; Scoular, et al., 2020). Learners who have these life/social skills developed, share the following attributes:

#### **A. Initiative and self-direction**

- Acquire more than the basic set of skills and/or curriculum to explore and expand one's own learning and opportunities to gain expertise
- Demonstrate commitment to learning as a lifelong process
- Be determined to turn ideas into action and satisfy your need to succeed
- Be resilient under pressure, adversity, and temporary failure to achieve your long-term individual or group aims

#### **B. Flexibility and adaptability**

- Adapt to number of roles, job responsibilities, schedules, and contexts
- Deal positively with praise, setbacks and criticism and incorporate feedback effectively
- Understand, negotiate, and balance diverse views and beliefs to reach workable solutions, particularly in multi-cultural environments

#### **C. Productivity and accountability**

- Set goals with tangible and intangible success criteria and balance short-terms and long-term goals
- Utilise time and manage workload efficiently
- Monitor, define, prioritise, and complete tasks without direct oversight
- Work independently
- Set and meet goals, even in the face of obstacles and competing pressures
- Prioritise, plan, and manage work to achieve the intended result

#### **D. Leadership and responsibility**

- Be accountable for results
- Participate actively, as well as be reliable and punctual
- Leverage strengths of others to accomplish a common goal
- Inspire others to reach their very best via example and selflessness
- Demonstrate integrity and ethical behaviour in using influence and power

### ***Communication***

Communication is considered as one of the key skills for learners in the 21<sup>st</sup> century. This is apparent from the continuous mentions of communication in the numerous frameworks for 21<sup>st</sup> century skills as seen in Lai and Viering (2012). Communication is included in the interpersonal skills, along with social skills, teamwork, cultural sensitivity, and diversity. This categorization shows that elements of communication may intertwine with elements of other skills that belong in

the same category as communication. Learners who have good communication skills, share the following attributes:

**A. Express opinions, speculate, discuss, reason and engage in debate and argument**

- Articulate thoughts and ideas effectively using oral, written and nonverbal communication skills in a variety of forms and contexts
- Listen effectively to decipher meaning, including knowledge, values, attitudes, and intentions
- Use communication for a range of purposes (e.g., to inform, instruct, motivate, and persuade)

**B. Engage in dialogue**

- Engage in dialogue, listen attentively, and elicit opinions, views and emotions (evoke or draw out)
- Communicate effectively in diverse environments (including multi-lingual)
- Get the support needed to achieve valuable outcomes
- Demonstrate effective communication, persuasion, negotiation and leadership

**C. Presentation**

- Utilise multiple media and technologies, and know how to judge their effectiveness a priori as well as assess their impact
- Present using a wide range of media
- Inspire and enthuse others

**O1\_A2: Technological Requirements and User Experience Design**

Aside from the lead research team (CIL), the co-design process involved all project partners and external collaborators who shared their insights and expertise in the areas of education, makerspaces, 21st-century skills (assessment), and software development for educational technology. The codesign and co-creation started with Skilltrack! exploration (previous work of Learnovate on which this project was based and expanded) and considered all the input from the stakeholders as gathered in the design thinking phase. The main phases of the realization of the tool design included exploration, analysis, design, prototyping, evaluation, and integration. For the technical and functional requirements Appendix A's table fully records what are the innovative elements brought to the tool through this process and project and what elements of the SkillTrack! design were validated as they remained.

**1. Task description**

O1\_A2 aimed to design the digital assessment solution (ASSESSMAKE21) tool to be used by the students as a self-assessment and self-reflect tool for them to learn and develop their 21<sup>st</sup> century skills during their maker activities. Additionally, the tool should be accompanied by a dashboard to be used by the educators.

ASSESSMAKE21 was to be based on the outputs of a research project conducted by the Learnovate Centre, Trinity College Dublin in the area of 21<sup>st</sup> century skills assessment - SkillTrack!. The project resulted in the development of a technical demonstrator of a learning application that supports the practice, development, and self-assessment of 21<sup>st</sup> century or Transversal Skills (e.g. collaboration, communication, creativity, problem-solving). This brings together innovative pedagogy and supportive technology and addresses the assessment challenge by cultivating skill literacy, cognition and reflection while creating an explicit, gamified context for use. SkillTrack! is not summative in its experience or assessment, the design allows for an assisted continuous practice and development of skills meant to promote metacognitive and deep learning while providing the user an opportunity to grow in skill understanding and usage. In Appendix A, the report highlights major changes and innovations of the ASSESSMAKE21 solution in relation to SkillTrack!.

## **2. Methodology**

The development of the ASSESSMAKE21 solution was based on previous work on SkillTrack!. In terms of the user requirements gathering methodology, SkillTrack! was shown to the participants, and therefore served as the reference point for them. The overall methodology draws on User Experience (UX) methods such as mapping, interviews, surveys, co-design facilitated sessions.

- The requirements analysis for the digital assessment tool has started with the design thinking workshop (see O1\_A1) involving all the partners.
- Some co-design sessions involved local teachers/facilitators from the context of Cyprus; these sessions engaged local teachers in the design process.
- Interviews with local teachers/facilitators from the partner countries were also utilised to inform the UX design of the tool.

This process was to ensure that the prototype for pilots will be developed to meet the user and project needs and requirements and to facilitate highest usage and best user experience. All partners had input to the requirements.

## **3. Findings and design decisions**

We have a lot of variables in this design task such as

- duration and number of making sessions in a typical learning experience in the country's makerspace context
- teaching philosophy/approach of the educator
- teaching setting e.g., groups vs single users
- number of devices in class
- local language

The ideal design solution should be adaptable during the creation of the "class" choosing the parameters of the class and making it flexible as much as possible. These parameters should be

accessible via the educator's platform that accompany the ASSESSMAKE21 tool. The educators should be able to decide the approach that they want to follow in using ASSESSMAKE21 e.g.,

- using it parallel with the making activities and completing challenges
- using it parallel with the making activities but only completing challenges at the end
- using it entirely at the end of the classroom session

Additionally, the educators should be able to choose between three duration options (further information at page 29)

- Short duration
- Medium duration
- Long duration

and they should be able to decide how many challenges they want to give to their students as the time and duration of each school, classroom, and makerspace varies.

Overall, the goal was to create an adaptable and flexible tool as possible for the approach and the duration of the experience. With that in mind, we should also be able to solve certain issues that come up in outlier cases (where classrooms don't have enough devices for example).

### ***Student's Tool***

The students are expected to input which skills they feel that they are using during their making activities. The way that they input varies from the approach that the educator decides to take. The tool itself then challenges the students with activities based on the skills that they students are using. By completing the activities, the students can progress through 4 levels. With each level the students can request a badge for successfully completing a level and be rewarded with it from the educator (which they can do from the educator's dashboard). After the 4 levels the students enter in the Infinite level. This level is always available to the students to self-assess and develop their skills; it gives the possibility to the students to have a tool of a never-ending use and thus be able to develop and self-reflect and assess their 21st century skills in a never-ending cycle. The use of the first 4 levels adds linearity and the satisfaction of progression for the users especially in cases where the making activities are not as frequent (something that enables us to keep the students engaged with the tool).

The design of the tool includes a set of features consisting of:

- **“Tapping a skill”**: This feature allows the students to register in the tool which of the 5 21<sup>st</sup> century skills (Collaboration, Creativity, Problem-solving, Life/Social Skills, Communication) are using during their making activities. By doing so, they trigger challenges associated with the skill they recognize that they use. By completing the given challenges, the students can progress through the levels.
- **“Levels”**: The tool has 5 levels (4 + “infinite level”). Each level has its own challenges and with the completion of each challenge the students can request the badge of the level

they have completed. The educators can then award the digital badge via their “Assessmake21 Dashboard”. Each skill can be progressed separately as different “making activities” need different amounts of skills. The “infinite level” recycles the challenges of the previous levels allowing the student to always self-assess, reflect and develop their 21<sup>st</sup> century skills forever.

- **“Badges”**: The tool includes 24 digital badges, one for each level and each skill. These badges can be collected by the students and awarded by the educators for successfully completing the levels of each skill. These badges can also be viewed from the “My Badges” page where they are presented for each skill and are ranked based on the level (Bronze, Silver, Gold, Platinum).
- **“Visual Examples”**: Alongside the activities of each skill the students can also progress through the levels by taking visual examples. The examples can consist of any pictures that show the use of 21<sup>st</sup> century skills or an artifact of an outcome of a making session that a skill was used for. Additionally, the students are expected to reflect on their visual examples. At the same time this enables the students to capture their progress of their development of 21<sup>st</sup> century skills visually and additionally to create a “Visual Portfolio” that can be seen in the “My portfolio” page. These portfolios and visual examples are also available to the educators to see via their dashboard.

To avoid any abuse of the usage of this feature (for example students trying to progress through levels by only taking pictures or students trying to progress without taking any pictures) each level requires a set number of visual examples. These visual examples can be taken / uploaded at any point that the students feel confident enough that they have something to show.

Visual examples activities are also included in the sequence of the challenges of each level. The visual example challenges that are given through the sequence of the activities are not forced as students might prefer to switch their visual example challenge with a different challenge (for example a multiple-choice question). This is aimed to make sure that the students have indeed a visual example to show and not force them to make one to progress. If the students are not taking any visual examples and are swapping the visual examples challenges with other challenges constantly then the feature of “swap” that enables them to change the visual example activity is disabled. Additionally, if the students have taken the maximum number of visual examples that they need already in each level, then the “Visual Example” button becomes inactive. These visual examples can be taken with the device’s camera or be uploaded from the device.

In addition, the tool includes an “Examples” page where students can find two visual examples of each skill alongside their context. They can also find the definition of that skill so they can associate it with the example and have an overall better understanding of the visual examples for

the 21<sup>st</sup> century skills. This allows the students to learn how a visual example of a given skill can be visualised and explained, making them more confident to take visual examples.

- **“Show me around”**: This feature aims to welcome the students and give a guided tour on how to use the tool and explain how each element in the tool works. This is expected to be used mainly for the first times of usage of the tool to make the students more familiar with the tool and the interface itself.
- **“Definitions”**: The tool has a “Definitions” page where the students can find various information for each skill like definitions, dimensions and their outcomes of each skill. These are also information that can be used in the challenges of each level. The main aim of these features is to familiarize the students with the 21<sup>st</sup> century skills and make them more confident with them, especially in the cases where students don't feel confident for a certain skill. Also, these features can be utilized by the educators to prompt the students to check them out when the deem necessary.

### ***Educator’s Dashboard***

The main functions of the dashboard can be categorized as follows:

- 1) Setting up the classroom
- 2) Getting an overview insight of the classroom / students
- 3) Managing the classroom

With the educator’s dashboard the educators can register their students for ASSESSMAKE21 generating a unique login-code for each student. Educators can either print them or share them with their students. At the same time the educators can choose between certain options. For example, they can choose the approach that they would like to incorporate the ASSESSMAKE21 tool in their classroom and the number of challenges for each skill. This enables them to use the tool as they believe is suitable for their own classroom e.g., students use the tool and reflect on challenges during their making sessions, students use the tool during the making sessions but only reflect on challenges at the end of the session or just using the tool only at the end of the session.

Additionally, educators can choose the number of challenges between each level from a set of 3 options (short/medium/long). This enables them to adapt the experience duration of the tool based on the time that the students spent in making sessions and makerspaces.

Moreover, the educators can choose the language that they want to use as well as what technologies that are planning to be used in the making sessions, making the challenges of the ASSESSMAKE21 student tool feel more unique for each classroom.

At the same time, the educator’s dashboard enables the educators to see how their classrooms perform with the development and the self-assessment of their 21<sup>st</sup> century skills. They can see which students are inactive or which students have completed a level on a certain skill and are now

requesting a badge. More information and graphs can be found for each student separately as well as for the entire classroom. The educators are also able to award their students the various badges via the educator's platform and see each answer and each visual example that their students upload. The educator's dashboard features several tools that help the educators to manage their classroom better. The educators can create custom "tags" for their students enabling them to mark them with certain keywords that can help them identify their strengths or weaknesses, especially in cases that the educator would like to group their students together. Additionally, they have the option to keep notes for each student.

Another feature is the ability to group the students together. We all know that there are a lot of cases where students must work together as teams. Educators can group their students together and see an overview of the development and the self-assessment of the 21<sup>st</sup> century skills for each student group separately or compared.

#### **4. Technical and Functional Requirements**

For the technical and functional requirements Appendix A's table fully records what are the innovative elements brought to the tool through this process and project as well as what elements of the SkillTrack! design were validated as they remained.

##### ***Student tool - Technical requirements***

###### *Technical requirement 1:*

Many schools / Makerspaces have different operating systems (Windows / iOS / MacOS / Android etc.)

The most efficient way to have a multiplatform tool is to be a browser-based solution.

###### *Technical requirement 2:*

Many schools / Makerspaces have different devices (Tablets / Desktops / Laptops) The most efficient way to have students use this tool for self-assessment and skills development and reflection is to have it running on a tablet or laptop (devices which have integrated cameras - in cases that they use devices with no camera like a desktop, the students will be able to still take pictures and upload them to the device).

###### *Technical requirement 3:*

Students don't express themselves comfortably in another language.

We need to have flexibility in languages with options like (English / Greek / Swedish). This can be done only if the partners are willing to localize the tool and put the time to translate the content. Yet, the design and development of the tool can make less use of images and more use of text which can be quickly replaced in other languages via an xls translation.

###### *Technical requirement 4:*



Many educators have different styles and approaches when it comes to engaging students in makerspace-type of activities and in self-assessment and reflection around 21<sup>st</sup> century skills. We need to have a flexible design approach that suits all styles, namely:

First Approach (Parallel Approach): Have the students input what skills they are using and complete activities during the maker sessions in class

Second Approach (Parallel input / Activities at the End): Have the students input what skills they are using during the making sessions and have them complete activities only at the end (based on what their input the entire time in classroom)

Third Approach (At the End): Students rate (on a Marzano scale) at the end of the maker session which skills and in what extent they used them during the making activities and present activities based on their input at the end.

\*Note that the educators will be able to switch between approaches based on the classroom needs (this only affects the way that the students interact making it intrusive)

#### *Technical requirement 5:*

Many educators have different approaches when it comes to the duration and number of sessions of a makerspace projects/activity.

The educators can choose between three duration approaches that they can pre-select during the setup of the classroom in the educator's platform. This gives the flexibility for the tool to be used in three different duration options as it reduces or increases the number of activities and thus the entire experience of the tool for the optimal progress satisfaction for the students in all cases.

Short Duration: 5 Activities (4 challenges + 1 Picture taking of example) in each level

Medium Duration: 8 Activities (6 challenges + 2 Picture taking examples) in each level

Long Duration: 12 Activities (8 challenges + 4 Picture taking examples) in each level

\*Note that the educators after choosing which length of duration they can choose will not be able to change it (as changing it meanwhile the students are progressing will alter the learning experience of the students)

### ***Student tool - Functional requirements***

#### *Functional requirement 1:*

The students need to be able to input which skill they feel that they are using during their making activities. This can be done by clicking / tapping the associated button or using the associated scale (based on the approach that they are using).

#### *Functional requirement 2:*

The students need to be able to capture their progress of developing their 21<sup>st</sup> century skills through their artifacts and projects in their making activities. The tool then can create a personal portfolio where each student can see pictures of their projects and the entire process (this can also be accessed

by the educator from the educator's platform). At the same time this enables us to have an insight on how the students work and progress their 21st century skills allowing them also to reflect on them. In outlier cases where the device has no camera (like a desktop) or if students want to upload a screenshot of their device showcasing their work, they will be also able to upload them instead of using the device's camera.

*Functional requirement 3:*

If students do not feel confident about a 21<sup>st</sup> century skill or the educator realizes that the tool needs to be able and offer insight on each 21<sup>st</sup> century skill.

This is achieved by a dedicated page of the tool giving information about every skill like definition, dimensions and outputs, all crucial parts for developing and self-assessing their 21<sup>st</sup> century skills and of course completing their activities.

*Functional requirement 4:*

If students do not feel confident on how an artifact of their project can showcase the use of a 21<sup>st</sup> century skill, the tool needs to be able and offer examples of images and content showing how a picture of an artifact during the making activities can showcase a 21<sup>st</sup> century skill.

This is achieved by a dedicated page of the tool giving 2 examples of images and context about every skill that the tool uses. Additionally, a fast preview of the definition of each skill is provided there to support the image and help students understand the context of the image.

*Functional requirement 5:*

The students need to be rewarded to be engaged with the tool. The tool needs to offer rewards for successfully completing each level of skill. This is achieved by rewarding the student a digital badge for successfully completing each level of each skill. As soon as the students complete a level, then they can request a digital badge from the educator. The educator will then be able to award them the badge through the educator's platform and allow the student to continue progressing to the next level. Each skill has its own badge, and each level has its own ranking (Level 1 - Bronze, Level 2 - Silver, Level 3 - Gold, Level 4 - Platinum).

The students are also able to see their collection of badges as the tool offers a dedicated page "My badges" where the students can see which badges, they have successfully collected and which not.

\*It's up to the educators how they would like to translate these digital badges in real world rewards.

*Functional requirement 6:*

The students need to be familiar with what this tool does and how they can use it. This is achieved by the top banner in the header of the tool. The student by clicking "Show me around" takes a brief tour of the tool learning what each element does and how it works.

*Functional requirement 7:*

Students need to have access to this tool with some form of credentials.

To avoid the usage of school / personal emails of the students and any privacy policies, the tool uses a unique 6-digit code for each student to use as their login credential.

These login codes are unique for each student and can be used as their key to login in the tool. The codes are generated by the educator's platform when the educator registers the students. In case a student forgets their code, the educator can simply retrieve it from the educator's platform (the codes can be given printed on a paper).

### ***Educator's Dashboard - Technical requirements***

#### *Technical requirement 1:*

Many educators have different operating systems (Windows / iOS / MacOS / Android etc.)

The most efficient way to have a multiplatform tool is to be a browser-based solution.

#### *Technical requirement 2:*

Many educators have different devices (Tablets / Desktops / Laptops)

The most efficient way to have educators use this tool for setting-up classrooms, managing and gaining an insight with data is to be used on a tablet or laptop /desktop where the displays are large enough to present a certain amount of information as clearly as possible.

#### *Technical requirement 3:*

The tool needs to be able to transform CSV documents to a list of students' names and then generate a unique login code / account for each student.

#### *Technical requirement 4:*

The tool needs to be able to access information from the ASSESSMAKE21 student's tool and present insightful data regarding the answers, visual examples and what skills they students are using.

#### *Technical requirement 5:*

The tool needs to access information from the ASSESSMAKE21 student's tool regarding the badge's requests or the inactivity of the students.

### ***Educator's Dashboard - Functional requirements***

#### *Functional requirement 1:*

The educator's dashboard needs to be able to have a login / register and forget password feature that enables educators to login or create accounts with their emails. Login credentials will be their email and their password.

#### *Functional requirement 2:*

The educator's dashboard needs to present multiple classrooms to their dashboards in cases that an educator has multiple makerspaces / classes with making activities.

#### *Functional requirement 3:*

The dashboard needs to be able to register each student either manually, or via copy paste list or generate a list using a CSV file that is going to be uploaded by the educators. Additionally, the list

with the names needs to be presented (with the option to remove a student) and also present each unique login code for the students.

*Functional requirement 4:*

The tool needs to have certain options for the educators during the creation of the classrooms like: Approaches, durations, language, technologies / tools and give a name to the classroom.

*Functional requirement 5:*

The tool needs to notify in the dashboard which students have requested a badge and which students are inactive.

*Functional requirement 6:*

All options selected during the creation of the classroom need to be accessible to change at any point (except the duration as this will lead to progress problems with the levels of the students).

*Functional requirement 7:*

The tool needs to be able to delete students or add new ones as well as overall classrooms.

*Functional requirement 8:*

The tool needs to present which students are in each classroom as well as overall data about the development of the 21<sup>st</sup> century skills of the entire classroom.

*Functional requirement 9:*

The tool needs to also be able to present information about the development and self-assessment of the 21<sup>st</sup> century skills for each student separately, as well as to show what the student has been answering during the assessment activities and what visual examples the students have been uploading.

*Functional requirement 10:*

The tool needs to be able to have the option for the educator to custom create tags for each student, create notes for each student or group students together (in cases that the classroom is working with groups)

*Functional requirement 11:*

The tool needs to be able to present data about the development and self-reflect of the 21<sup>st</sup> century skills of the students as groups. These groups need to also be able to disassemble at any point.

### **O1\_A3: Designing Pedagogical Framework**

The design of the pedagogical framework was based on the five commonly referred skills: Collaboration, Creativity, Communication, Life/Social skills, and Problem-solving. The pedagogical framework defined the structured and scaffolded experience for the student-user as they build awareness and literacy of each skill and documents its application through activities. Questions and activities were fully scripted to form self-reflective practice. As envisioned in the proposal of this

project, the tool was designed to support gamification (e.g. reward students for their achievements) to increase motivation for engagement and progression for the students.

### **1. Task description**

The design of the pedagogical framework in this task is based on the defined skills of O1\_A1. The pedagogical framework below defines the structured and scaffolded experience for the student-user as they build awareness and literacy of each skill and documents its application through activities. Questions and activities were scripted to form self-reflective practice. Per proposal the tool was expected to have a level of gamification (such as badging) to increase motivation for engagement and progression for the students.

### **2. Methodology**

The design of the pedagogical framework has drawn on data from the design thinking workshops, interviews, facilitated sessions, and the literature review.

- The pedagogical framework was informed by data extracted from the design thinking workshop (see O1\_A1) involving all the partners.
- Some co-design sessions involved local teachers/facilitators from the context of Cyprus; these sessions informed the pedagogical framework in the sense of understanding how the tool could be designed and used in a makerspace.
- Interviews with local teachers/facilitators from the partner countries were also utilised to inform the pedagogical framework.

This process was to ensure that the design of the tool was grounded in established theory and pedagogies as well as the realities of the local contexts. All partners had input to the requirements.

### **3. Pedagogical framework**

The pedagogical framework for the design of the digital self-assessment tool seeks to present a theoretical grounding for the various decisions made in the design process. In addition, the pedagogical framework will serve as supporting material for teachers/educators (see also IO3) who are looking for more information on how to integrate self-assessment methods for 21<sup>st</sup> century skills development in their class or makerspace. Finally, this framework contributes to the limited information available in literature related to the design of digital self-assessment tools, that aim to help students raise awareness of their development of 21<sup>st</sup> century skills in makerspace contexts. The design of ASSESSMAKE21 digital self-assessment tool lies on the foundations of the following theory and pedagogy:

- Constructionism
- Self-reflection
- Gamification
- Bloom's taxonomy
- Maker education and makerspaces

- 21<sup>st</sup> century skills

The framework of the design of the digital solution is being analysed below, illustrating actual examples taken from the potential use of the tool.

### ***Constructionism***

Papert (1980) raised the issue of correlating construction, in the physical or digital sense of an artefact, a product or even a computer program, with the mental interaction of the learner with the individuals around him. This close examination of constructing an artefact along with the encouragement to discuss, question, critique or admire that product, exemplifies the strong relationship between making and learning. According to Blikstein (2013) “Papert’s Constructionism builds upon Piaget’s Constructivism” that underlines the significance of constructing knowledge particularly well when learners “build, make and publicly share objects” (p.5).

Constructionism can be seen as a composition of elements that distinguish this learning theory from others. Firstly, students should be actively engaged in learning so that they achieve improved learning outcomes. Being actively engaged reduces the possibility of losing momentum when taking part in a learning activity or losing interest in a project, and it is easier for students to return to the learning activity even when something unexpected happens (Papert, 1991).

Secondly, students' agency is another crucial factor when talking about constructionism. Students will take charge of their learning when a project is more meaningful and interesting to them. After all, when constructing artefacts that are of interest to them, learners pay more attention to detail and have higher expectations from themselves (Schad & Monty Jones, 2020). One could conclude that when students are engaged in activities, where they create a product that is valuable and meaningful to them, they cultivate a growth mindset, which leads them to have higher expectations of themselves as learners and creators and thus have better learning outcomes. This attitude helps students in exploring, in seeking to improve their skills and acquiring knowledge and in viewing mistakes and failures as a part of the learning process (Masters, 2014). Transitioning from the traditional method of hands-on and project-based learning activities, where the teacher provides materials, tools and central topic ideas and/or problem, to learning based on the Constructionism theory, where the learners have the space to identify and/or even propose a problem that is meaningful to them, while learning from others, is a major leap for learning (Schad & Monty Jones, 2020).

Finally, learning that is guided by constructionism has its focal point on personal, concrete forms of knowledge, where students are leading their own learning (Papert, 1991). This means that learners enter a new state of constructing knowledge and the world around them and constantly reconstruct through personal experience, directing the learning structures that need to take place, in order to accomplish the goals they set and present the final outcome (Ackermann, 2001). Therefore,

learning becomes more demanding and at the same time more fulfilling when that project is finalised, and the outcome is completed. Students have higher valence of negative emotions when taking part in such open-ended activities that require a lot of decision-making by them (Vongkulluksn et al., 2018). However, when students achieve their said goals, they are filled with positive feelings of completion, self-confidence, and an increase in self-efficacy they have gained through learning activities based on Constructionism theory (Bandura, 2001).

### ***Self-reflection***

The digital self-assessment tool was designed with an aim to be tested and further used in makerspace contexts for secondary education learners. It is a known fact, that maker education activities take place in makerspace contexts which encourage interdisciplinary learning, follow an ill-defined structure, and require higher-order cognitive processes from students as well as the application of several skills (Marsh, Arnseth & Kumpulainen, 2018). At the same time when students are involved in learning activities based on Constructionism theory, they also need to be aware of regulating their emotions and motivation to accomplish the initial goal. This complex method of learning requires high cognitive demands from actively participating students, while on the contrary, students give less focus on cognitive monitoring and self-regulation (Usher & Schunk, 2017). Hence, it is a necessity for learners to develop self-regulation strategies when participating in maker activities. Consequently, the ASSESSMAKE21 digital solution has been generally designed in accordance with self-regulation theories and more specifically, to self-reflection cognitive processes.

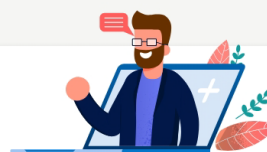
According to Zimmerman (2000) reflection is part of a three-phase cyclical model of self-regulation taking place in learning. These three phases are: forethought phase, performance phase, and reflection phase. To create a digital solution that will help students raise their awareness of 21<sup>st</sup> century skills in makerspace contexts, attention was given to the last two phases of self-regulation, which are the 'performance' and 'reflection' phases. The two phases reflect on the different educational needs of the practitioners and teachers from the participant countries who follow different sets of routines in their classes that require the differentiation of the tool. Thus, the tool has been designed on three use approaches. These are 1) recognising a 21<sup>st</sup> century skill and reflecting during the lesson, 2) recognising a 21<sup>st</sup> century skill during the lesson and reflecting at the end, and 3) reflecting only at the end of the lesson. More specifically, the first approach focuses on the performance phase and the last two approaches emphasise on the reflection phase.

### Choose approach

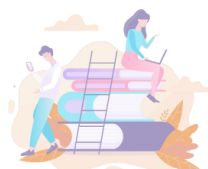
< Back

#### Approaches

You know your students better than us! Choose which approach of this tool you would like to adopt for your classroom.

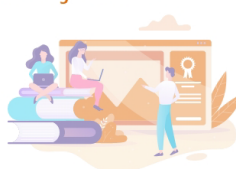


#### Parallel Approach



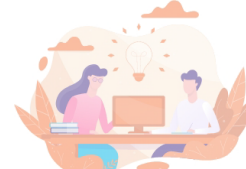
Students **input** what skills they think they are using and **complete activities during the maker session**

#### Parallel tapping / challenges at the end



Students **input** what skills they think they are using **during the maker session** and **complete activities at the end of the classroom**

#### At the end Approach



Students **at the end of the classroom rate** on a scale which skills they think they were using during their maker sessions. **Then take a series of activities** based on their input

Cancel

Next

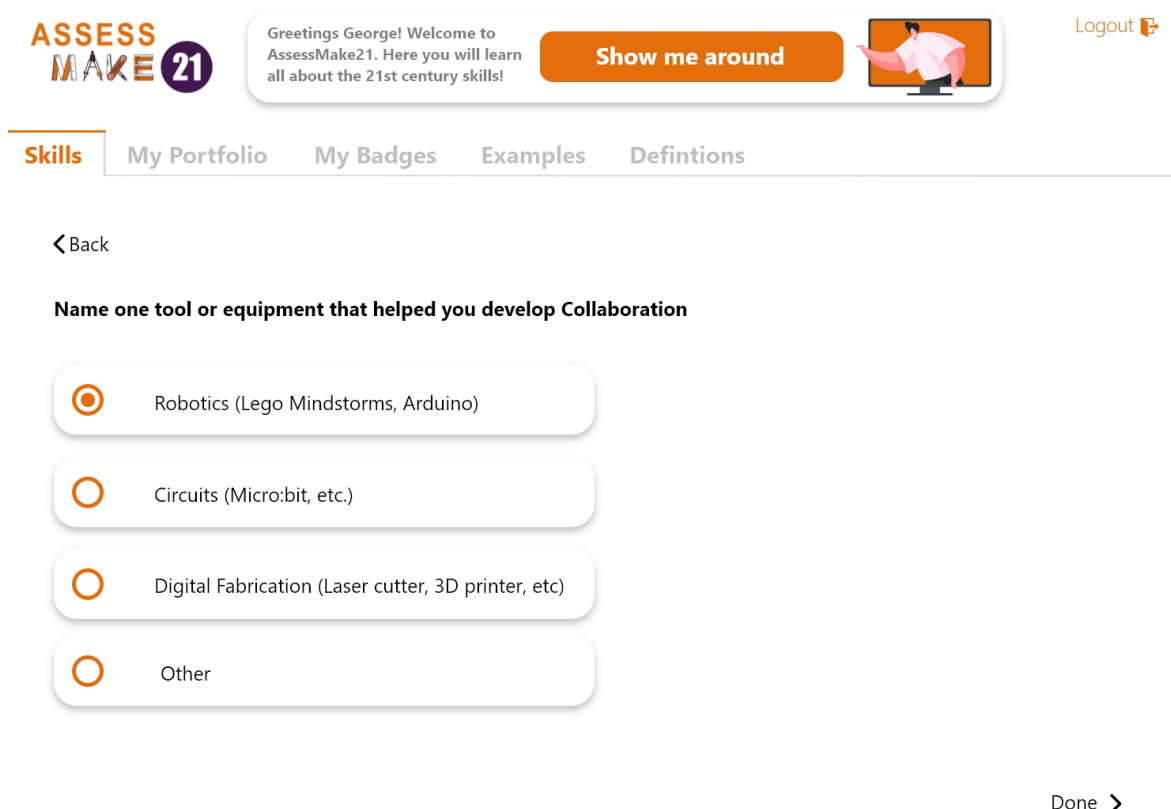
Reflection allows students to analyse their actions in class, at both a macro and micro level. At a macro level, students can stop and reflect, while the lesson is in progress, identify strong or weak points they might be experiencing, recognise their emotions at the time, and pay the appropriate attention to those, as well as make the necessary adjustments as they create and tinker in the makerspace context. On the other hand, at a micro level, students can evaluate their responses and learning outcomes at certain events when the learning process is over (Zimmerman, 1989). During the first approach of the tool, which aligns with Zimmerman's 'performance' phase, individuals engage in monitoring their thoughts, their emotions, their actions, and behaviours in the given context and make adaptations based on the strategies they apply. It is necessary for students to monitor a continuously transforming task using strategies, while they are more involved as the learning process continues (Usher & Schunk, 2017).

A good example of monitoring one's actions is provided in the figure below. The challenge prompts students to think of a tool or equipment that helped them develop a specific skill. This



action happens after the students have identified that they are developing a 21<sup>st</sup> century skill, choosing to tap on a skill, and reflecting on their actions, by completing a challenge.

The last two approaches of the digital solution are based on the reflection phase, where students are involved in self-regulatory processes through assessing and reacting to their own behaviours after the learning has taken place (i.e. at the end of the making session). During this phase, students



examine and analyse, through higher order thinking processes, the results of their efforts and the practices that guided to them (Usher & Schunk, 2017).

In regard to the digital solution, students are prompted by the teacher to devote some time at the end of the lesson to reflect on their actions and behaviours related to the development of 21<sup>st</sup> century skills, when they were taking part in the maker activities. The self-reflection activity happens either way, depending on the approach that has been selected by the teacher (recognise a skill and reflect at the end, or reflect at the end only).

For example, given that students follow the structure of the second approach, it would mean that they would participate in the maker activities and tap a 21<sup>st</sup> century skill on the digital self-assessment tool whenever they recognise, they are developing it. When the session is over, students click on the button '*The session is over*' and the tool displays challenges that prompt them to reflect on the skills they have tapped during the maker session. Several challenges should appear so that students devote adequate time to reflect on the development of 21<sup>st</sup> century skills in the makerspace

context. The reflection phase would allow students to look at events and certain circumstances during the lesson from a different view, when the learning is over. However, important contributions can be taken into consideration for the next efforts of the students in the makerspace. The gains of self-reflection at the end of the lesson can be multiple, from reviewing the strategies that were used in class, contemplating on their expression of emotions in class, to reflecting on the use of a specific tool in the makerspace context and recognising the progress they have made (Pintrich, 2000).

### ***Gamification***

Gamified learning derived from Constructivist learning, which is established on the learners' need to learn through reflection on doing, which happens through experience. In brief, gamification is described "*as the process of applying game elements to non-game contexts*" (Zainuddin, et al., 2020, p.1) in an attempt to employ well-known mechanisms from games (Hamari et al., 2016). Implementing gamification elements to an application for educational purposes may vary from immersing the user in a narrative rich role-play and adding gamefulness to the most common feature of adding points, badges and leaderboards (Hamari, Hassan & Dias, 2018).

The design of ASSESSMAKE21 digital self-assessment tool was created to be as little intrusive as possible during the learning procedure, in order to avoid stressing students with further distractions, given that making activities require high-order thinking from them (Marsh, Arnseth & Kumpulainen, 2018). Subsequently, self-reflection tasks should not be time-consuming and act as barriers to the creating process in makerspace contexts. Another factor we had taken into account, was the fact that the majority of learners are not used to assessment or reflection procedures during the making activities; hence the risk of not using the app in a productive and valuable way during the making session. These noticeable challenges led us in contemplating possible ways to overcome them, to increase the usefulness of the tool, as well as to attract students' interest by recognising the advantages of this tool during the making activities, in order to achieve the initial goal (reflecting on the 21st century skills developed in class).

The above-mentioned reasons led us to implement gamification elements and design a gamified environment that will have an impact on engagement and learning for students. Alcorn and Turner (2015) in their book "42 Rules for Engaging members through gamification" list user engagement as the top challenge for organisations to tackle. It is noteworthy to say that rewarding and engaging experiences for users during their interaction with the app, ought to have a positive effect on the motivation and user engagement level, so that students will be actively engaged in the learning process. By implementing gamification elements into this app, we aim to enhance the learning experience and support students who are not keen on or used to the reflection process, which in fact requires metacognitive and higher-order thinking (Usher & Schunk, 2017). Hence, gamification

elements in ASSESSMAKE21, will generate more gameful and enjoyable learning experiences for students (Deterding, et al., 2011).

There is a significant issue raised by Godhe, Lilja and Selwyn (2019) referring to the physical and mental demands of maker learning that heavily rely on two factors. The first factor involves the initial design of the maker activity (lesson plan) by the teacher or facilitator of a makerspace and secondly, the issue of motivation that derives from students who are mentally challenged in a long iterative process; to identify a problem, list possible solutions and finally select the best possible solution, design, test, and redesign the model to eventually have some value to them, their peers, and their community. This perpetual cycle involving student's motivation and the constant mental demand of maker learning on the student, has an adverse effect on students' engagement and motivation levels. Hence, adding gamification elements to such a mentally demanding learning situation, as such a maker activity, has been found to have a positive effect on stimulating learners' motivation, engagement, and social influence (Zainuddin, et al., 2020; Hamari et al., 2016).

Considering the above-mentioned points.

- a. Most of the learners in making contexts are not used to applying reflection or using any digital tools to achieve that.
- b. Maker learning is a mentally demanding activity that requires higher order thinking from students and high levels of motivation throughout the maker activity.
- c. Motivation, engagement, and social influence can be increased using gamified environments.

In this project, we have adopted several gamification elements (activities, levels, modes, rewards, and content) in the design of ASSESSMAKE21 digital self-assessment tool. In the following section, we describe the different elements and present snapshots from the tool to help explain their use and purpose in the tool.

### ***Levels***

The first gamification element that was adopted in the design of ASSESSMAKE21 tool is the categorisation of challenges in levels. There are four levels of achievement in the tool with an additional level, named "Infinite level", to continuously run with the challenges that have been displayed in the previous levels. The design of levels in this app was supported by the feedback gathered during the second round of interviews with practitioners and teachers in makerspaces from the partner countries. The results from the coding analysis showed that the challenges were well-articulated and served the purpose for self-reflection during the making activities. On the other hand, interviewees referred to the length of each level, stating that the number of challenges, especially in the first two levels of the app, should be fewer in number, so that students will be granted a badge faster, having an immediate effect on their motivation levels while using the app.

Based on these reasons, as well as others, like the length of a project or the amount of time a teacher allocates for the students' self-reflection process, we have come up with three different duration modes to support different teacher needs. Hence, three modes of duration (short, medium, long) are introduced, differentiated by the number of challenges and pictures taken by the students. It is important to mention at this point, that the teacher has the option to switch from one mode to the other, when they see fit, to support their students better. Specifically, the duration modes are:

1. The short mode includes 4 challenges and 1 picture taken.
2. The medium mode includes 6 challenges and 2 pictures taken.
3. The long mode includes 8 challenges and 4 pictures taken.

#### Duration modes

- The short mode includes 4 challenges and 1 picture taken.
- The medium mode includes 6 challenges and 2 pictures taken.
- The long mode includes 8 challenges and 4 pictures taken.

In addition, the challenges of each level are separated in four categories, based on the different types of activities in the app. These are:

- Basic challenge
- Two-step challenges (2 challenges display, one after the other, which are interconnected)
- Picture taking challenge
- Open-ended challenge (express yourself)

The tables below show the differentiation between the three modes as well as the categorisation of challenges based on the type of activity in each level.

#### Short mode (includes 4 challenges and 1 picture taken)

| <b>Type of activity</b>                    | <b>Level 1</b>               | <b>Level 2</b>               | <b>Level 3</b>              | <b>Level 4</b>              |
|--|------------------------------|------------------------------|-----------------------------|-----------------------------|
| Basic challenge                            | Challenge 5                  | Challenge 4                  | Challenge 1                 | Challenge 1                 |
| Two-step challenge                         | Challenge 2 +<br>Challenge 3 | Challenge 2 +<br>Challenge 3 | Challenge 6+<br>Challenge 7 | Challenge 3+<br>Challenge 7 |
| Picture taking                             | Challenge 9                  | Challenge 9                  | Challenge 11                | Challenge 9                 |
| Open-ended challenge<br>(express yourself) | Challenge 8                  | Challenge 7                  | Challenge 8                 | Challenge 10                |

#### Medium mode (includes 6 challenges and 2 pictures taken)

| Type of activity                           | Level 1                      | Level 2                      | Level 3                     | Level 4                     |
|--|------------------------------|------------------------------|-----------------------------|-----------------------------|
| Basic challenge                            | Challenge 4                  | Challenge 1                  | Challenge 1                 | Challenge 1                 |
|  | Challenge 7                  | Challenge 4                  | Challenge 4                 | Challenge 2                 |
| Two-step challenge                         | Challenge 2 +<br>Challenge 3 | Challenge 2 +<br>Challenge 3 | Challenge 6+<br>Challenge 7 | Challenge 3+<br>Challenge 7 |
| Picture taking                             | Challenge 9<br>(x2)          | Challenge 9<br>(x2)          | Challenge 11<br>(x2)        | Challenge 9<br>(x2)         |
| Open-ended challenge<br>(express yourself) | Challenge 5                  | Challenge 6                  | Challenge 5                 | Challenge 6                 |
|  | Challenge 8                  | Challenge 7                  | Challenge 8                 | Challenge 10                |

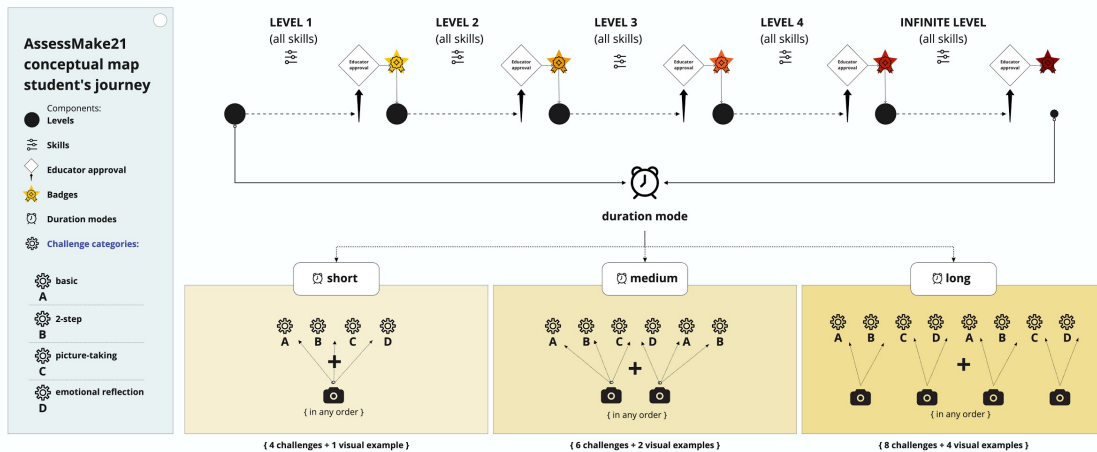
Long mode (includes 8 challenges and 4 pictures taken)

| Type of activity                           | Level 1                      | Level 2                      | Level 3                     | Level 4                       |
|--|------------------------------|------------------------------|-----------------------------|-------------------------------|
| Basic challenge                            | Challenge 1                  | Challenge 1                  | Challenge 1                 | Challenge 1                   |
|  | Challenge 4                  | Challenge 4                  | Challenge 4                 | Challenge 2                   |
|  | Challenge 7                  |                              |                             | Challenge 4                   |
| Two-step challenge                         | Challenge 2 +<br>Challenge 3 | Challenge 2 +<br>Challenge 3 | Challenge 2+<br>Challenge 3 | Challenge 3+<br>Challenge 7   |
|  |                              | Challenge 2+<br>Challenge 8  | Challenge 6+<br>Challenge 7 | Challenge 11+<br>Challenge 12 |
| Picture taking                             | Challenge 9<br>(x4)          | Challenge 9<br>(x4)          | Challenge 11<br>(x4)        | Challenge 9<br>(x4)           |
| Open-ended challenge<br>(express yourself) | Challenge 5                  | Challenge 6                  | Challenge 5                 | Challenge 5                   |
|  | Challenge 6                  | Challenge 7                  | Challenge 8                 | Challenge 6                   |
|  | Challenge 8                  |                              |                             | Challenge 8                   |

|  |  |  |  |              |
|--|--|--|--|--------------|
|  |  |  |  | Challenge 10 |
|--|--|--|--|--------------|

***Procedures***

Students will have the opportunity to interact with the tool in their classroom to introduce themselves to the five 21<sup>st</sup> century skills (i.e. onboarding session). They will then be given their first project, during which they will use the digital self-assessment tool to reflect on the development of these skills for the first time. That is, students will start working on their making activities and tap on a skill as soon as they identify they are developing it. Depending on the duration mode the teacher has selected, students will reflect by answering several challenges and taking several pictures.



## ASSESSMAKE21 Educator's Dashboard

- Home
- + Create a new classroom
- Class 1
- Class 2
- Class 3
- Class 4
- Class 5

Logout

### Choose duration

< Back

#### Duration

Choose how many activities students should complete to progress to the next level, based on the number and duration of your making activities in the classroom.

*\*By all means, a student can further develop and reflect on the tool much faster than his/her peers.*

#### Short Duration

Max. 2x80' lessons



For each level: 5 Activities

4 Challenges  
+ 1 Visual Example

#### Medium Duration

Max. 3x80' lessons



For each level: 8 Activities

6 Challenges  
+ 2 Visual Examples

#### Long Duration

4x80' lessons +



For each level: 12 Activities

8 Challenges  
+ 4 Visual Examples

Cancel

Next

- **Short mode:** In the first case, the teacher has selected the short duration mode, which requests from students to reflect on four challenges and take only one picture, in a total duration of maximum two eighty-minute-making sessions. Students have the possibility to take a picture of their artefact, when they think it makes a good visual example of the development of a skill and reflect on it. As soon as the four challenges and the one picture are taken, then the student will apply for the first level badge.
- **Medium mode:** In the second case, the teacher has selected the medium duration mode, which requests from students to reflect on six challenges and take two pictures, in a total

duration of maximum three eighty-minute-making sessions. Students work on their making activities and tap on a skill in the digital tool once they identify the development of a 21st century skill. After each tap, a challenge will appear, asking them to reflect on the development of that skill. In the meantime, students have the opportunity to take up to two pictures, during the first level, as good visual examples of that skill. In case the student does not choose to take a picture by him/herself, using the respective button in the Home page, then a challenge will randomly appear later on prompting the student to upload or take a picture of his/her artefact. The student has the option to skip once and get a different challenge instead. This triggers the student to find a good example of that skill and take a picture of it, so that he/she can upload it next. As soon as the six challenges and the two pictures are taken, then the student will apply for the first level badge.

- **Long mode:** In the third case, the teacher has selected the long duration mode, which requests from students to reflect on eight challenges and take four pictures, in a total duration of maximum four eighty-minute-making sessions. They are also presented with picture-taking challenges to serve as good visual examples of the development of a skill, yet they can skip twice and reflect on a different type of activity, if they do not feel like doing so instead. In this case the students can take pictures by using the respective button in the Home page when they recognise that their artefact is a good visual example of a skill. As soon as the eight challenges and four pictures are completed, students can apply for the first badge of level one.

The procedure of these modes extends to the following levels (2, 3, 4), where students are presented with the same number of challenges to reflect on and the same number of pictures to take. Instead, the Infinite level is the only level, with no specific duration mode, since the students reflect repetitively, through all challenges.

It is noteworthy to say that regardless of the type of activity each challenge fits in, all challenges in the same level present the same degree of difficulty. This was decided, by considering the significance of effectiveness of achievements in motivation and performance. Students who are novel users of a digital self-assessment tool are bound to face additional difficulties in the first level, even though it has fewer challenges, due to learnability processes (i.e. becoming familiar with the tool and the 21<sup>st</sup> century skills). As the students develop their 21<sup>st</sup> century skills during the making activities, they will also develop their self-reflection skills. Having this in mind, challenges in each further level are requesting deeper and higher order thinking progressively. As the students spend more time with the tool, they become more familiarised with the development of the skills, the reflection progress, and the tool itself. Therefore, students utilise achievements with higher difficulty in each further level and in lower quantity as they progress through levels, based on the duration mode selected by the teacher (Groening & Binnewies, 2019).




























## Badges / rewards

Another gamification element adopted in the making of this digital self-assessment tool are badges. Badges can keep users engaged in the tool (Barata et. al., 2017). Students are encouraged to interact with the tool, tap a skill, and reflect on the challenge displayed. As soon as they complete Level 1 of a skill, their progress is rewarded with a digital badge per skill. The badges are distinguished in four colours (bronze, silver, gold and platinum) representing the four levels of achievement. The different colours of the badges have a symbolic representation to further engage students in gaining higher-value badges, as they progress from Level 1 (bronze) to Level 4 (platinum).

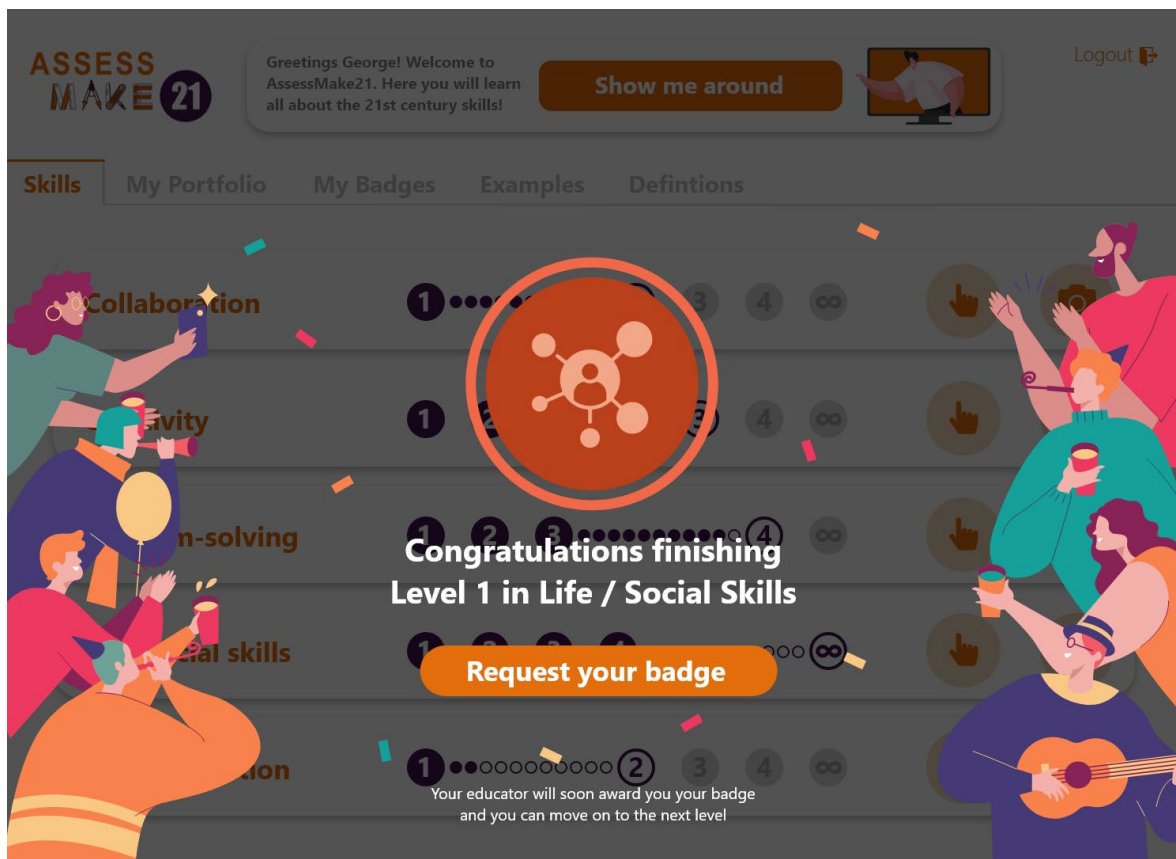
In addition, each skill has differentiated badges. This entails that when students gain a badge for Level 1 - Collaboration - they will recognise it as a different accomplishment, of gaining Level 1 - Creativity - and through these multiple different achievements, their performance will be enhanced. The sum of the achievements across several skills in the tool will improve the students' motivation to continue reflecting on the development of these skills (Groening & Binnewies, 2019).

The screenshot shows the AssessMake21 user interface. At the top left is the logo 'ASSESS MAKE 21'. A welcome message reads: 'Greetings George! Welcome to AssessMake21. Here you will learn all about the 21st century skills!'. A 'Show me around' button and a 'Logout' link are also visible. Below the navigation bar, the 'My Badges' section is active. On the left, there are buttons for 'Collaboration', 'Creativity', 'Problem-solving', 'Life/Social Skills', and 'Communication'. On the right, there are four badges for 'Creativity' at different levels: Level 1 (red), Level 2 (blue), Level 3 (yellow), and Level 4 (dark blue). Each badge features a lightbulb icon within a circular or laurel wreath border.

| Assessmake21 Badges   | Level 1 Bronze   | Level 2 Silver   | Level 3 Gold  | Level 4 Platinum   |
|---|--|--|---|--|
| <b>Collaboration</b>         |   |   |   |   |
| <b>Creativity</b>            |   |   |   |   |
| <b>Problem Solving</b>       |   |   |   |   |
| <b>Life / Social Skills</b>  |   |   |   |   |
| <b>Communication</b>         |  |  |  |  |

Moreover, the variety of badges can also support teachers' quick review of an individual or entire class achievements. Finally, the visualisation for each skill is enhancing the focal point of spreading awareness for 21<sup>st</sup> century skills, making it easier and accessible for students to identify one skill from the other. Despite the fact that badges play a significant role in the flow of the app, previous research has shown that the sole existence of gamifying elements does not guarantee success for increasing intrinsic motivation and enhancing the engagement or in depth learning of the content (Ding et al., 2017). Having said that, the involvement of the teacher in the gamified learning process, and the training that takes place prior to its use (when the teacher introduces the app to the students), are crucial points that contribute to the accomplishment of the goals of this project.

To sum up, badges have an essential role in the continuous engagement of students with the app. They serve as an element of reward that is granted to them when the reflection process for a level of a specific skill is completed, confirming that they have successfully finalised an important piece of the puzzle and become more efficient in developing 21<sup>st</sup> century skills. When the teacher reviews the student's progress in a level, he/she has the option to send a remark, comment, or provide feedback on their work. Eventually, the teacher grants students with a badge, and lets students know that their reflection on the development of 21<sup>st</sup> century skills was successful in that level, thus, increasing their level of motivation (Barata, et.al., 2013).



### ***Content unlocking***

The third game design element implemented in this digital tool is content (challenges) unlocking. That is, when a student identifies the development of a skill, he/she taps on that skill, extending the progress bar of the first level of a skill. The remaining levels of that skill display as locked, creating a sense of intrigue and curiosity for the student and gradually unlock as they pass levels. This entails engaging the student in an interactive experience, where the unlocking of content (challenges) depends on the progress made, while at the same time learning and exploration unravels to the next levels (Alcorn & Turner, 2015). In the meantime, students who are heavily involved in the making experience are considered to be in ‘the flow’, they achieve peak performance when they complete the last challenge of a level and apply for a badge (Csikszentmihalyi, et al., 2017). These two game design elements; the progress bar and the content unlocking, in line with the flow theory, create a sense of “easy fun” for the student, who is actively engaged in the process of learning, ensuring that the challenges of each level are appropriate to the skill level of the student (Zainuddin, et al., 2020).



The screenshot displays a user interface for the ASSESSMAKE21 platform. On the left, there is a vertical list of five skill categories, each in a rounded rectangular button with a hand cursor icon and a camera icon: **Collaboration**, **Creativity**, **Problem-solving**, **Life/Social skills**, and **Communication**. To the right, an illustration of a man in a yellow shirt is shown interacting with a tablet. A speech bubble next to him contains the text: "Input which skills you have used today and take pictures of your progress. Then take challenges based on your input!". Below this, a curved arrow points to a button labeled **Complete Challenges**.

Thus, with the successful completion of each level and attainment of a badge, students unlock the next level, with the content available to them. This process of unlocking content and gradual progression increases the motivation levels of students and hence, performance levels are also raised, creating a chain reaction to the upcoming reflection processes and consequently, the development of 21<sup>st</sup> century skills (Groening & Binnewies, 2019). This is also aligned with the high difficulty and low quantity theory which reinforces the enjoyable and engaging experience of the student (Zainuddin, et al., 2020).

All in all, the gamification elements used in ASSESSMAKE21 received good reviews regarding the design of the interface and the use approaches that enhance the reflection process. In addition, the digital tool was designed having the user as the central focus, since the most crucial person in the gamified environment is the user and in this case the students. Lastly, the digital tool is compatible with various devices, since its strongest advantage is that it presents a rich graphical user interface, that features simple and coherent functions that are easily understood by the young users (Alcorn & Turner, 2015). Taking into account the recent findings about gamification elements, we expect that the gamified environment designed for the ASSESSMAKE21 digital self-assessment tool will have positive reactions among the students and act as an enabler of user motivation and engagement which will support students in their journey of rewarding and intriguing experiences (Zainuddin, et al., 2020).



|                    |                        |  |  |
|--------------------|------------------------|--|--|
| Collaboration      | 1 ●●●●●●○○○ (2) 3 4 ∞  |  |  |
| Creativity         | 1 2 ●○○○○○○○○○ (3) 4 ∞ |  |  |
| Problem-solving    | 1 2 3 ●●●●●●●○○ (4) ∞  |  |  |
| Life/Social skills | 1 2 3 4 ○○○○○○○○○○ ∞   |  |  |
| Communication      | 1 ●○○○○○○○○○ (2) 3 4 ∞ |  |  |

### *Bloom's Taxonomy*

ASSESSMAKE21 digital self-assessment tool has enhanced the complexity of challenges progressively throughout the levels, as the classification based on Bloom's original taxonomy shows. This is evident, since students' metacognitive thought increases, as they interact both with the tool and the skills, having an impact on the identification of the skills that affects students' sense of ownership and development of skill literacy. The original taxonomy of educational objectives was created by Bloom, et. al. in 1956, as a framework for teachers to classify statements of what their students were expected or intended to learn because of instruction (Krathwohl, 2002). The revision of the original taxonomy was an essential step to add relevance for the students and teachers in the 21<sup>st</sup> century. The structure of the revised Bloom's taxonomy clearly represents "the alignment between standards and educational goals, objectives, products and activities" along with a new terminology that is associated with the 21<sup>st</sup> century needs (Forehand, 2005, p.5). As a result, ASSESSMAKE21 digital self-assessment tool has implemented the revised Bloom's taxonomy (2001) as the basis to categorise the challenges of each level in the tool. The challenges that have been designed based on the revised Bloom's taxonomy require students to achieve the easier attaining goals first, providing a sense of achievement. As the levels progress, more complicated challenges, based on the classification that occurred, appear, requiring from the students higher-order thinking, following the order of the revised taxonomy "from simple to

complex and concrete to abstract” (Krathwohl, 2002, p.1). This classification offers a sense of gradual incline in developing the 21st century skill, each time the student is reflecting (Anderson, Krathwohl, et al., 2001). The revised taxonomy is structured in a hierarchical order that includes six categories of the Cognitive Process dimension which differ in their complexity (Krathwohl, 2002).

Nonetheless, it is noteworthy to mention that the teacher has an essential role in the revised taxonomy, switching the strict hierarchical order to a more flexible order of categories overlapping one another (Anderson, Krathwohl, et al., 2001). As displayed in the table below, the challenges are classified based on Bloom’s revised taxonomy, starting from Level 1, in which challenges follow “Remember” and “Understand” categories, in addition to the “Evaluate” category. It should be noted that the “Evaluate” category is found in all levels, since Evaluation of one-self is crucial to be accommodated from the beginning in all levels of this self-assessment digital tool. However, “Apply” category was not included in the design of the challenges in any level. As the levels progress, one can see that Level 3 and 4 have included most categories from Bloom’s revised taxonomy. This is due to the fact that students’ metacognitive thinking is increased as they progress in levels, thus the challenges become more complex and require higher-order thinking as they familiarise themselves with the tool and the awareness of the development of 21<sup>st</sup> century skills in making contexts (Krathwohl, 2002). It is also evident that categories do not follow the strict hierarchical order of the original taxonomy (Anderson, Krathwohl, et al., 2001). On the contrary, Level 1 and 2 challenges have the fifth category “Evaluate” incorporated in the introductory levels of the tool.

Classification of challenges based on Bloom’s revised taxonomy

|         | Remember | Understand | Apply | Analyze | Evaluate | Create |
|---------|----------|------------|-------|---------|----------|--------|
| Level 1 | x        | x          |       |         | x        |        |
| Level 2 | x        | x          |       |         | x        |        |
| Level 3 | x        | x          |       | x       | x        |        |
| Level 4 | x        | x          |       | x       | x        | x      |

The Bloom’s taxonomy was followed to classify the standards and indicators of achievement for each level allow the teacher to structure the students’ learning path and acquire a common understanding of the objectives that are classified in the categories, hence enhancing communication among teachers and students (Anderson, Krathwohl, et al., 2001). In addition, the wording of the challenges is based on Bloom’s revised taxonomy, offering the teachers and the

students the common ground of talking about their development, using common language that is used in scientific frameworks, such as the revised Bloom's taxonomy (Krathwohl, 2002). This way students and teachers, as well as researchers can communicate effectively with one another, limiting the chances of miscommunication.

Consequently, with the support from the revised taxonomy, students across the four partner countries will be able to develop and enrich their vocabulary, as well as acknowledge the development of 21<sup>st</sup> century skills, following the aspect of broad educational goals that maker activities have. Therefore, with the implementation of the revised taxonomy, teachers can determine these broad educational goals, which follow the national curriculum standards (Krathwohl, 2002). As a result, teachers and practitioners can have a meaningful structure in terms of objectives related to the development of 21<sup>st</sup> century skills, since now, there is a gap in assessment methods of these skills in makerspace contexts. Through the introduction of the revised taxonomy, teachers can design their maker activities in a sense where students can develop 21<sup>st</sup> century skills, acknowledge and reflect on those, by using the digital self-assessment tool. Finally, the revised Bloom's taxonomy that is used as a structure for the design of the self-reflection challenges, can be used as a panorama of the range of educational possibilities, in contrast to any curriculum or particular educational course that limits the learning possibilities.

Finally, the six categories of the revised Bloom's taxonomy can be used for makerspace contexts, since they have been designed to "*cut across subject matter lines*" (Krathwohl, 2002, p.214). This allows practitioners and teachers to adapt the educational objectives to the multifaceted needs of making activities, filling the void that existed.

### ***Maker education***

Recently, there has been an expression of interest for the maker movement from educational institutions to integrate "maker-centred learning" (Clapp, et al., 2016). This term has been used to create learning frameworks for encouraging learning through making, that is based on the constructivist and constructionist theoretical frameworks. Apparently though, even after the extensive interest for maker learning, an assessment method has not yet been developed, since it is agreed that such method should consider the interdisciplinary nature of maker-centred learning, as well as the multimodal learning of the maker movement (Schad & Monty Jones, 2020).

Blikstein et al. (2017) argues that the assessment methods for maker-centred learning should take into account the multimodal essence of activities that take place in a makerspace context. Such activities may include fabrication technologies and their difference from computer-based skills. The broad range of activities that take place in a makerspace require the differentiation in terms of assessment. In fact, now that more and more schools integrate maker learning in their facilities, it is becoming a necessity to introduce assessment for maker-centred learning. ASSESSMAKE21

digital self-assessment tool aims to work towards this purpose of supporting teachers and students in the first step of being aware of 21<sup>st</sup> century skills and enhancing their development in makerspace contexts through the self-reflection process that occurs during class.

Through this endeavour of designing this digital self-assessment tool, scheduled to be used in makerspace contexts, we aim to enhance the learning journey of students in makerspaces and support them with the appropriate challenges and features.

An essential feature of this digital tool is the “Uploading a picture/taking a photo” of your project that resembles a good visual example of a specific 21<sup>st</sup> century skill, which then requests students to reflect upon that example. Students have the freedom of selecting when to take a picture of their artefact or upload a picture they have taken earlier, for a specific skill. This allows them to constantly reflect on their project and be aware of possibly good moments that represent “worth-taking” photos for a skill. This can be either a picture of their artefact that has or may not have been finalised and/or pictures of their design process, moments that display an element of a skill or even pictures of their brainstorming sessions that elaborate on a skill. Eventually, this feature enhances students’ awareness of the development of 21<sup>st</sup> century skills, since they are in charge of selecting when to take the picture and what is a good example of a skill that will then be described in brief through their reflection. Students will have the opportunity to express themselves as designers, engineers or constructors that cater to many forms of working, expressing and building (Blikstein, 2013).

The screenshot displays the AssessMake21 web application interface. At the top, there is a navigation bar with the logo 'ASSESS MAKE 21' on the left, a welcome message 'Greetings George! Welcome to AssessMake21. Here you will learn all about the 21st century skills!' in the center, a 'Show me around' button, and a 'Logout' link on the right. Below the navigation bar is a menu with options: 'Skills', 'My Portfolio', 'My Badges', 'Examples', and 'Defintions'. The 'Skills' option is currently selected. Underneath the menu, there is a breadcrumb trail: '< Back' followed by 'Creativity example'. The main content area features two large buttons: 'Take a picture of your example' (with a camera icon) and 'Upload a picture of your example' (with an upload icon), separated by '—OR—'. To the right of these buttons is an illustration of hands holding a tablet displaying a blue Uno R3 microcontroller board. Below the illustration, text reads: 'Take a picture of your project as an example of developing your 21st century skill and reflect on it'.



Dewey mentions in his book “The child and the curriculum” in 1959 (Godhe, Lilja & Selwyn, 2019) that interaction between the students and the curriculum in the educational practice is one of the greatest issues a teacher should overcome. He continues to say that the child’s own experience and formal knowledge should be seen by the teacher as two engaging broad factors instead of points of departure. Therefore, experiences that occur in the maker-centred learning should consider first and foremost the social and material interactions and how these can be related to the national curriculum objectives. Taking this into account, the challenges that were designed across all levels in this digital tool carry this mode of thinking, of engaging the two factors of the child’s own experiences that occur during the making activities and the formal knowledge.

ASSESS MAKE 21

Greetings George! Welcome to AssessMake21. Here you will learn all about the 21st century skills!

Show me around

Logout

Skills My Portfolio My Badges Examples Defintions

< Back

How does "developed shared understanding" make you feel?

Happy  Honest  Compassionate

Ambitious  Satisfied  Confident

Stressed  Empathetic  Anxious

Week  Overwhelmed  Focused

Bored  Angry

Done >

It is apparent that in order to achieve this interaction of the experiences that occur in class and the learning objectives of each lesson, the tools, materials and equipment used in the maker activities ought to be included in the self-reflection process of this digital tool. Tools, machines and materials have a dual role in the making movement, first to support the learning process for students and secondly and most importantly, to serve as a tool for expression when constructing an artefact (Martin, 2015). Bevan (2017) also argues the significance of experiential learning that occurs in makerspace contexts, whereas students take part in hands-on activities that require higher-order thinking, tinkering, exploration and building which enables the ‘hand’ and the ‘head’ to work simultaneously. This action stimulates the natural motivation of students that derives from “*a sense of playfulness or the unexpected*” (p.76). Based on this, we have designed challenges that include

reflection regarding the use of making tools, which give students access to a deeper reflection to sophisticated tools for building and for thinking (Blikstein, 2008). In this sense, we have included categories of tools, such as microcontrollers/microprocessors, robotics and coding, crafting, digital and non-fabrication tools, photography tools and soldering, that empower students to engage in diverse forms of thinking, including computational thinking (Martin, 2015). In fact, Blikstein (2013) lists cutting edge hardware and software that is related to making activities, which is extensive and broad. It is obvious that makerspace contexts can be built with or without some of these tools, materials and equipment, which is up to the teacher's goals or even more importantly access one has to some of these tools to include in their lessons (Blikstein, 2013). This was also a requirement for this project, to make the categories of tools modifiable by the teacher, so that one can add or remove tools, based on their needs and accessibility to those.

Hence, we have integrated a feature for the teacher in the educator's dashboard to select, add and remove tools, materials and equipment which is relevant to each class they are teaching. With this addition, our aim is to support the teachers' journey when using the tool and allow them to modify important elements, which are then, going to be integrated in the general challenges for the students.

**ASSESSMAKE21**  
Educator's Dashboard

Home

+ Create a new classroom

Class 1

Class 2

Class 3

Class 4

Class 5

Logout

### Choose tools

< Back

#### Tools & Technologies

Customize the experience of your students based on the technologies you are planning to use. These will be fed to your student's challenges.

Add a new technology Add +

| Technology                                     | Rename | Delete | Checkbox                            |
|--|--------|--------|-------------------------------------|
| <b>Fabrication Technologies</b>                |        |        |                                     |
| 3D printer                                     | Rename | Delete | <input checked="" type="checkbox"/> |
| Laser Cutter                                   | Rename | Delete | <input type="checkbox"/>            |
| 3D pen   | Rename | Delete | <input checked="" type="checkbox"/> |
| CnC Router                                     | Rename | Delete | <input checked="" type="checkbox"/> |
| <b>Micro- processors/controllers/computers</b> |        |        |                                     |
| Arduino  | Rename | Delete | <input type="checkbox"/>            |
| Raspberry Pi                                   | Rename | Delete | <input checked="" type="checkbox"/> |
| Micro-bit                                      |        |        |                                     |
| <b>Other</b>                                   |        |        |                                     |
| Arts & Crafts                                  | Rename | Delete | <input type="checkbox"/>            |
| Computer                                       | Rename | Delete | <input checked="" type="checkbox"/> |

Cancel Next

Next, another element that is considered an important addition to this digital tool is the “My Portfolio” category. Through this category, students can find at any time, the artefacts they have uploaded during their self-reflection process listed by skill and sorted by levels. In this section, students can review their work and reflect on the development of 21<sup>st</sup> century skills, from Level 1 to the Infinite Level. This allows them to see any past mistakes, reflect on them, present their artefacts to their classmates, family and friends, and see their improvements and gain motivation. In addition, through their portfolio, students can quickly access their projects and reflect on the broad range of multidisciplinary knowledge and skills that are developed during the making activities (Blikstein, 2013). Finally, students will have created a digital portfolio of their most meaningful curriculum constructions, that have been created by them and have become valuable to their school community (Freire, 1974).

### *21<sup>st</sup> century skills*

The last section of the conceptual pedagogical framework for ASSESSMAKE21 is completed with a literature review of the most well-known frameworks for 21<sup>st</sup> century skills. Through this project, we aim to raise awareness of the development of 21<sup>st</sup> century skills in makerspace contexts, with the use of this digital self-assessment tool. It has been established that maker-centred learning

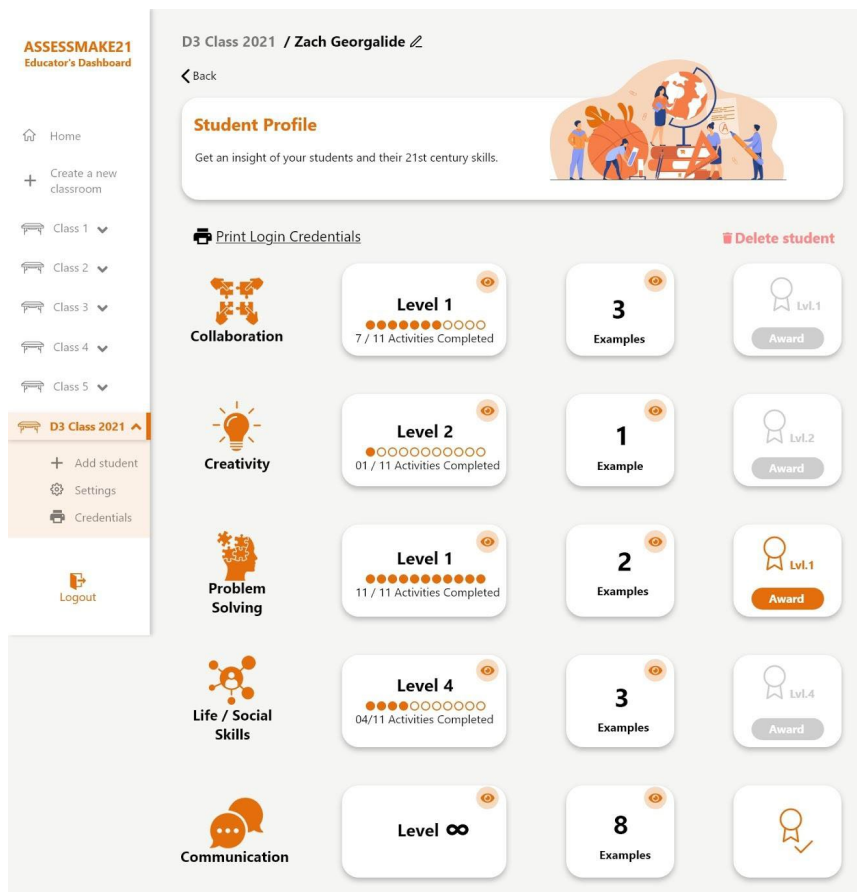
promotes multifaceted skills and helps students develop these, through complex design and making practices (Sheridan, et al., 2014).

A thorough literature review of the most well-known frameworks for 21<sup>st</sup> century skills has arrayed a list of five 21<sup>st</sup> century skills, which have been selected and included in the digital tool. These are the following: Collaboration, Creativity, Problem solving, Life/Social skills and Communication. These 5 skills have been found to be developed more in makerspace contexts based on three data collection methods; a) interviews with the practitioners of the four partner countries, b) design thinking workshops where researchers and practitioners from makerspaces of the four partner countries attended and c) literature review of frameworks for 21<sup>st</sup> century skills. Based on these results, we have designed challenges for each level that focus and aim to the reflection of these skills. It is apparent that these challenges appear similarly and with the same order, to all five skills, as the student reflects. For instance, when a student identifies that he is developing 'Creativity', he taps on the 'Creativity button' to have a challenge appear. Next, when the student identifies a different skill, for example, 'Problem solving', the same procedure will repeat, with the same challenge, but with only one difference, the challenge will refer to the skill that has been recognised and tapped by the student. Therefore, students have a better understanding of the self-reflection process, since they get to reflect on the same challenge in different occasions and different contexts each time.

It was apparent to us that due to the complex and demanding learning process of making activities, as well as the crucial development of 21<sup>st</sup> century skills, students should have the opportunity to be as flexible as they like. This would enable them to feel deeply immersed in the making process, develop the 21<sup>st</sup> century skills and reflect at their own time, depending on the approach the teacher has selected. As a result, students can tap on a specific skill they have identified, followed by a challenge that requires their reflection on the development of that specific 21<sup>st</sup> century skill. Thus, students acquire responsibility over their learning path, to plan, build and reflect on the development of 21<sup>st</sup> century skills during the making activities. Therefore, through this creative approach, students' autonomy and understanding is supported (Kahn, 2010).

The autonomy provided to students is displayed through the function that each skill in the tool is independent from one another and can be progressed at different times, regardless levels. Simply, this acknowledges the fact that students can develop and reflect at a skill at different times and progress independently. For instance, learners may identify that they are developing Collaboration and Problem-Solving more than the remaining skills of the app. When an educator logs in the educator dashboard and looks at the graphs displaying either the overall picture of the class or an individual's reflections, the teacher can gather important information based on that. The benefits of this action can be translated in two ways, either as how the classroom is reflecting on the making activities the teacher has prepared, thus being too focused on some skills and less on others or the

lack, confusion or misinformation of students to recognise the development of the other skills that happen to be in the tool. This can provide essential information to the educator as to how the class is progressing in terms of development of skills, as well as awareness of skills. Thus, the educator is able to self-reflect using these graphs and make the necessary changes that may require a swift focus of the making activities to develop other skills or to further explain the 21<sup>st</sup> century skills to students that have difficulty recognising.



However, research has shown that challenges arise when the development of 21<sup>st</sup> century skills are integrated in teaching and learning. The first challenge exemplifies the fact that the 21<sup>st</sup> century skills are not explicit to either teachers or students (Kipp, Kapros & O’Keeffe, 2018). This is arguably a great issue when dealing with young students who have no familiarity with the topic. Therefore, the issue extends not only to teaching these skills in makerspace contexts, but also to prompting students to self-reflect on this subset of skills. Subsequently, a section of concise, clear, and coherent information about each skill is provided in this digital self-assessment tool. The “Definitions” category is accessible in the app at all times, as a constant vocabulary support for students to inform themselves about this subset of skills, to clarify meanings of elements that are

not clear enough through the use of learning outcomes and also to remind themselves about skills or elements they have not yet developed in the duration of the making activities. Learners have access to definitions for each skill, elements of each skill and which learning outcomes derive from each element. The elements and learning outcomes that have been selected operate as indicators for the students, so as to have a structural support on which elements summarise each skill and what indicators are there to be found and accomplished by students during their self-reflection process. At this point, it is essential to mention that the introduction of the subset of skills that have been selected for this digital tool, happens prior to the introduction of the tool at an earlier stage.

**ASSESS MAKE 21**

Greetings George! Welcome to AssessMake21. Here you will learn all about the 21st century skills!

Show me around

Logout

Skills My Portfolio My Badges Examples **Defintions**

**Collaboration**

**Creativity**

**Problem-solving**

**Life/Social Skills**

**Communication**

**What is Collaboration?**

Collaborative learning is an active form of learning between two or more individuals that work together in a physical or virtual environment. Group members continuously attempt to build and maintain a shared understanding of the problem they are working to solve.

Collaborative learning is developed through these dimensions.

- Develop shared understanding
  - Identify, evaluate and achieve joint goals
  - Establish practices associated with different roles in a group (e.g. leader, team member)
  - Gather together relevant resources and information
- Contribute collectively
- Regulate the work of the group
- Develop good relationships with others and a sense of well-being in a group

Secondly, 21<sup>st</sup> century skills are developed in multimodal aspects of learning, further complicating the issue of making these skills explicit to students as well as reduce the risk of misinformation among them and especially, when they are individually self-reflecting (Kipp, Kapros & O’Keeffe, 2018). Thus, we have come to the conclusion of creating the “Examples” category, a section in the digital self-assessment tool, where students are able to navigate in the app and look at good visual examples for each skill, along with a short reflection. This allows students to review reflections of

real artefacts that were created in making activities and use them as good examples on how to implement elements and learning outcomes of each skill in their own reflection.



Greetings George! Welcome to AssessMake21. Here you will learn all about the 21st century skills!

Show me around



Logout

- Skills
- My Portfolio
- My Badges
- Examples**
- Defintions

Collaboration

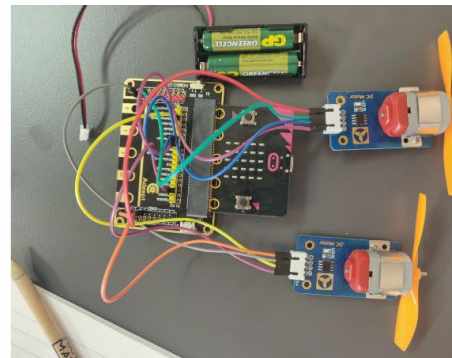
Creativity

Problem-solving

Life/Social Skills

Communication

I am very happy with the result my group and I created. We all contributed to make the two fans spin, we searched information together, we experimented with many ways and we programmed the Micro:bit together.



Definition



< 1 2 >

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## INNOVATIVE DIGITAL SOLUTIONS TO ASSESS 21<sup>ST</sup> CENTURY SKILLS IN MAKERSPACES

### Appendix A - Innovative elements of ASSESSMAKE21 (vis-à-vis SkillTrack!)

*Note: major change/innovation are marked with green highlight*

| Feature  | Validated elements that remained from SkillTrack tool   | Innovative elements of ASSESSMAKE21  |
|--|---|--|
| <b>Instructional Design</b>                            |   |  |
| Self Assessment  | Self-assessment was chosen as the best way to increase awareness of students and enhance the development of 21st century skills in makerspace contexts.   |  |
| Self Assessment  | Students self-assess their achievement in each skill, by selecting a level they think they have reached from “Novice” to “Mastery” (Marzano style rating scale)   |  |
| Formative Assessment                                   | Formative assessment is considered important during maker learning, since the continuous process that occurs in a makerspace setting is valuable for learning and the development of 21st century skills. |  |
| Classification of challenges based on Bloom’s Taxonomy |   | Challenges were classified based on the six levels of Bloom’s Revised Taxonomy, so that students progress through reflection at each next level. |
| <b>Skills</b>  |   |  |
| Number of skills                                       | Keep the number of 21st century skills to five. More would be difficult to handle by students and less than five would be too little.   |  |

|  |   |   |
|--|---|---|
| 21st century skills  |   | Research was done and a new set of appropriate skills defined: A thorough literature review on the most recent and famous frameworks on 21st century skills and review of evidence-based research was done in addition to two rounds of interviews with practitioners and teachers working in makerspace contexts, as well as a design thinking workshop with researchers and experts in maker education. The triangulation allowed us to conclude to the five 21st century skills that are most developed by students in makerspace contexts. These were rephrased and made more explicit for students and teachers to better understand. A definition for each skill was essential, as well as dimensions that each skill is categorised into. Finally, it was important for the purposes of the self-assessment to develop learning outcomes for each dimension in order to facilitate the self-assessment process for students. |
| <b>Tagging</b>   |   |   |
| Tagging the use of skills in makerspace projects/environment | The tagging option is important for recognizing the skill during the maker session. |   |
| Tagging  |   | Tagging was converted to tapping and is visualized as a graphical element on the Home screen, next to each skill  |
| Frequency of tagging   |   | <p>The number of taps between challenges has been reduced to one, so that students can tap and have a challenge to complete after this, based on the notion of action and reaction.</p> <p>In the original Skilltrack app the default configuration was for 1 tagging task between each challenge at level 1 and to slowly increase to 2 and then 3 tags between challenges at later levels. This was intended to allow students to progress quickly in the earlier stages and to achieve the associated rewards.</p>   |
| <b>User Experience</b>                                       |   |   |
| Engaging and user-friendly design                            |   | More graphically based interface for students to interact with to make it more visually engaging and insertion of more images for clear and coherent understanding by students.   |

|   |  |   |
|---|--|---|
| Native language support                 |  | ASSESSMAKE21 will be available in three languages (English, Swedish, and Greek) so that students are comfortable in answering and reflecting using the tool in their mother tongue  |
| Onboarding                              |  | Onboarding phase was removed. Instead ASSESSMAKE21 offers a section for the 21st century skills with a definition for each skill, the dimensions of each skill and the learning outcomes of each dimension. This section is called “Definitions”.   |
| Support for multiple modes of operation |  | There are three <b>Approaches</b> an educator can choose from to use in the class or makerspace. They have been designed to help educators personalize their teaching style while using the self-assessment digital tool. These approaches vary from having to tap skills, self-reflect by answering challenges during the making session, or having to tap skills they are developing during the maker session and answer in the end, or rate the use of the skills at the end of the making session and reflect by answering challenges based on the rating. This offers educators flexibility and adaptability when designing their lessons when using the ASSESSMAKE21 digital tool. This is highlighted as major change/innovation |
| More flexible experience duration       |  | Duration modes: There are three different duration modes (short, medium and long) from which educators are allowed to choose from for their learning context to fit their educational needs. For example, this allows the app to better support both long running experiences in formal educational contexts such as schools as well as short running experiences in more informal contexts. In the original Skilltrack app this was not an explicit feature that an educator could select for themselves but something that could be customised by the developers to adapt the application to different contexts of use. This is highlighted as major change/innovation.   |
| <b>Gamification</b>                     |  |   |
|   |  |   |

|                            |  |   |
|----------------------------|--|---|
| Badges                     | Reward students with badges after completing a level of achievement in a skill.  | Badges are coloured bronze, silver, gold, platinum for different levels.  |
| Badge Collection           | ASSESSMAKE21 offers a section for students to review the badges they have already earned. These are sorted by skill and they can easily see in which level they are progressing more and what skills need more development. This section is called “ <i>My badges</i> ”. |   |
| Levels (Content Unlocking) |  | <p>Students unlock levels as they achieve each level of a certain skill.</p> <p>Levels are independent from one another. Students can progress freely, at their own pace in the skills, without any constraints from the levels.</p> <p>In the original Skilltrack app a student could only progress to the next level once they had completed all 5 skills. This was originally intended to ensure that students did not receive challenges with different levels of cognitive complexity</p>  |
| Levels (Infinite level)    |  | <p>Gamification element: Levels – There are four levels with an additional level, called Infinite level, in which activities run continuously when students reach all previous levels and keep reflecting on the development of 21st century skills. The original Skilltrack approach was to have as many levels as the instructional design could develop but only 4 were initially created for the purposes of the evaluation of the app. This is highlighted as major change/innovation.</p> |
| Level indicators           |  | <p>Student can always see a visual of what level they are currently on and how many levels are left to complete for each skills.</p> <p>The original Skilltrack app colour coded the UI to visually identify the level that a student was on but did not provide a clear overview of progress through levels. This is highlighted as we would note as major change/innovation.</p>  |
| Progress through levels    | Progress through each level is visualised to a) reward students for their activity and b) motivate them to complete the level  |   |

| <b>Challenges</b>  |  |   |
|--|--|---|
|  | Inclusion of some of the tasks from each level from the SkillTrack tool and used in the ASSESSMAKE21 tool.   |   |
| Technology related challenges  |  | Inclusion of technical skills that a student can relate more during the self-assessment in maker learning settings.   |
|  |  | Real-world application questions that relate to the importance of authentic context in class settings were added. Examples of these questions include but are not limited to "I am making compromises when collaborating with others, to achieve our joint goal", "I resolve conflict effectively to avoid spreading bad seeds in the group." "I investigate the problem given in alternative ways, so that I can generate different solutions." These questions help students reflect in statements that may or may not happen while developing 21st century skills. |
| Use of open-ended questions  |  |   |
| Anchored rating scales   | A Marzano scale was added in self-assessment challenges, to clarify to students what they are expected to know and apply when they are assessing a 21st century skill. |   |
|  |  | "Other option" was added in some of the close-end questions in order to allow students to edit and write their own answers, if they relate to none of the above options.  |
| <b>Exemplars / Skills ePortfolio</b>   |  |   |
| Save real world examples of how and when skills are used   | The SkillTrack tool requests from students to take or upload pictures of their work that resemble good examples of 21st century skills.                                |   |
| Prompt reflection on how/when a skill was used and why it might or might not be a good example of using that skill | Students elaborate on the development of the skills, by reflecting through several progressive questions during the different levels.                                  |   |

|  |   |  |
|--|---|--|
| Ability to capture real world examples of skills at any time, independently of progress through levels |   | Students can take photos or upload pictures of their work as good examples of the development of 21st century skills and reflect on an example, at any time of their interaction with the tool. This can be done during they are working on a project and/or after they have finalised a project. This allows them to reflect also on the progress of an artifact, not only in the end. Students can take pictures by selecting the visual element, next to each skill or taking a picture when the challenge appears in the order of the rest of the challenges. We highlight that the innovation is the ability to upload and reflect on an example at any time. This is a major change/innovation |
| Examples   |   | ASSESSMAKE21 offers a section of ready examples that showcase real situations of students developing 21st century skills with a short reflection for each picture. These examples stand as good visual examples for students to understand each skill better. This section is called “Examples”. In the original Skilltrack app these were part of the onboarding phase. This is highlighted as a change/innovation.   |
| Skills Library / My Portfolio  | ASSESSMAKE21 offers a section for students to access the pictures they have taken or uploaded from their device. These pictures are visual examples of the 21st century skills they have developed during each level for each skill. They are sorted by each skill and each level to be found easily. This is a good way to recognize their development in 21st century skills and acts as their digital portfolio. This section is called “My portfolio” |  |
| <b>Educators Dashboard</b>   |   |  |
| Teacher approval of progress badges  | The teacher rewards students with a badge they have applied for.  |  |
|  | Alert function is important   |  |
| Student Inactivity Notification  | Inactivity function is important.   |  |
| Class Overview   | It was designed to have a clear class overview with coherent and clear statistical results from a class’ perspective and from an individual’s perspective.  |  |



|  |  |   |
|--|--|---|
| Individual student view                                      | Educators can easily review the accomplishment for each individual, by having quick access to the level of achievement for each skill, the badges they have received and whether they requested a new badge or not. Therefore, checking each student is easy to do, by clicking on the student's name to access their profile. |   |
| Class management   | Educators can create a new class, add, or remove students easily by using the functions in the Home page of the Educator's dashboard.  |   |
| Customise student experience to specific maker space context |  | Educators can modify the list of tools, materials and machines they have available in their class or makerspace. The tools that are selected by the educator, will be shown in the form of a challenge later on to the students. This offers them a personalization of challenges based on their classroom's needs. |
| Group based management                                       |  | Educators can reorder students in the overall classroom view, they can colour code them and add them in groups.   |
| Notes on students  |  | Educators can write notes, by using a specific function button.   |

*Note: major change/innovation are marked with green highlight*

INNOVATIVE DIGITAL SOLUTIONS TO ASSESS 21<sup>ST</sup> CENTURY SKILLS IN  
MAKERSPACES

---

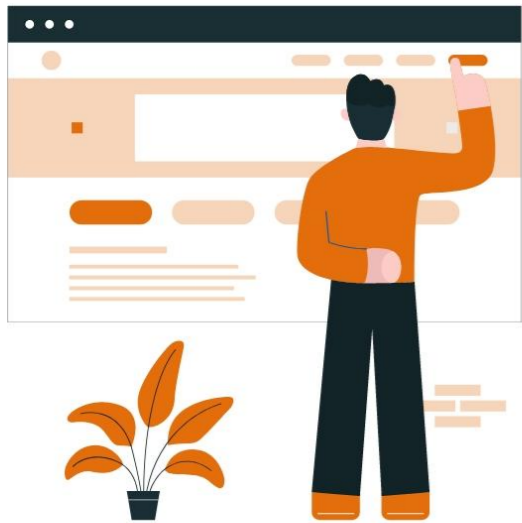
**Appendix B – Educators Tool Wireframe Annotations**

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## AssessMake21: Educators Tool Wireframe Annotations for the elements and interactions

This document annotates the most important interactive elements of the interface.



# ASSESS

## MAKE 21

Educator's Dashboard

**Email**

**Password**

**Log In**

Don't have an account? **Sign up**

## 1. Login Page

| Element Label | Element Name | Type       | Description   |
|---------------|--------------|------------|---|
| A             | Email        | Text Input | Educators will input their email as first credential to log in                          |
| B             | Password     | Text Input | Educators will input their password. The password can be revealed with the "hidden eye" |
| C             | Log in       | Button     | Pressing the button logs the user in the educator's dashboard                           |
| D             | Sign up      | Text Link  | Link for educators to create a account  |



# ASSESS

## MAKE 21

Educator's Dashboard

**Username**

Jhon Dhoe

A

**Email**

jhondhoe@edu.ac.org

B

**Password**

••••••••

C

Sign Up

D

[Take me back to Log in](#)

E

## 2. Register

| Element Label | Element Name | Type       | Description   |
|---------------|--------------|------------|---|
| A             | Username     | Text Input | Educators can input their names                               |
| B             | Email        | Text Input | Educators can input their email to register                   |
| C             | Password     | Text Input | Educators can input the password to be used                   |
| D             | Sign Up      | Button     | Button signs Up the educators and takes them for verification |
| E             | Take me back | Text Link  | Link takes them back to login page                            |



# ASSESS



21

Educator's Dashboard

## Registration email sent

An account registration request has been sent to your email. Please check your email for activation details

[I did not received an email](#) <sup>A</sup>

[Take me back to Login](#) <sup>B</sup>

## 3. Register Verification

| Element Label | Element Name              | Type      | Description                  |
|---------------|---------------------------|-----------|------------------------------|
| A             | Did not received an email | Text Link | Re-sends email verification  |
| B             | Take me back              | Button    | Takes educator back to login |

Welcome back, Andrew!

Manage your classrooms and get an insight of the development for the 21st century skills of you students.



**Class 1**  
12 students



**Class 2**  
21 students



**Class 3**  
32 students



**Class 4**  
25 students



**Class 5**  
18 students



Create a new Class!

## 4. Home

| Element Label | Element Name           | Type       | Description                        |
|---------------|------------------------|------------|------------------------------------|
| A             | Create a new classroom | Menu Item  | Shows the profile of the classroom |
| B             | Class 1                | Menu Item  | Creates a new classroom            |
| C             | Class 1                | Label Card | Shows the profile of the classroom |
| D             | Create a new Class     | Label Card | Creates a new classroom            |
| E             | Log Out                | Icon Link  | Logs out the educator              |

Welcome back, Andrew!

Manage your classroom development for

Come back soon



Are you sure you want to Log Out?

A

Log Out

B

Cancel

## 5. Log Out Verification

| Element Label | Element Name | Type             | Description                  |
|---------------|--------------|------------------|------------------------------|
| A             | Log Out      | Button           | Logs out the educator        |
| B             | Cancel       | Secondary Button | Keeps the educator logged in |



Create a new classroom

< Back G

Add students

Register your students here by either pasting a list with their names or uploading a csv document. Let us do the rest!



|                     | A | B |
|---------------------|---|---|
| Augustine Black     |   | X |
| Colleen Sunderland  |   | X |
| Danielle Gerogalide |   | X |
| Dorothy Keen        |   | X |
| Thomas Bansky       |   | X |
| Vincent Edisson     |   | X |
| Zach Georgalide     |   | X |
| Eloise Thompson     |   | X |
| Emily Freya         |   | X |
| Erin Coral          |   | X |
| Melissa Cambridge   |   | X |
| Matt Steward        |   | X |
| Maggie Rogers       |   | X |
| Louis Barkley       |   | X |

OR

Drag a csv. file here

or

**Select File** C

D ⓘ How to format a CSV properly

Cancel

Next

## 6. Create Classroom : Register Students

| Element Label | Element Name  | Type               | Description   |
|---------------|---------------|--------------------|---|
| A             | Student Names | Text               | Educators can Manually or copy paste names of students              |
| B             | x             | Icon Link          | Educators can delete a student                                      |
| C             | i             | Icon Link          | Information point for guidance for .csv                             |
| D             | Select file   | Button / Drag area | Drag area to drag and drop a csv / or browse button to select a csv |
| E             | Cancel        | Button             | Cancels any progress and brings educator back to home               |
| F             | Next          | Button             | Progress educator to the next step                                  |
| G             | Back          | Text Link          | Takes Educator back to home   |

### Create a new classroom

< Back

#### Add students

Register your students here by either pasting a list with their names or uploading a csv document. Let us do the rest!



Jon Doe |



Add your students here or  
Paste them all together.



#### How to format a CSV properly

- Separate data fields with a delimiter, usually a comma.
- Keep each record on a separate line.
- Do not follow the last record in a file with a carriage return.
- Remember that the enclosing character (typically double quotes) must be used when required, such as when the delimiter appears in a field.

Cancel

Next

## 7. Create Classroom:Information point for guidance for .csv

| Element Label | Element Name | Type      | Description           |
|---------------|--------------|-----------|-----------------------|
| A             | x            | Icon Link | Close the information |

Create a new classroom

< Back

Add students


Register your students here by either pasting a list with their names or uploading a csv document. Let us do the rest!



- Augustine Black ✕
- Colleen Sunderland ✕
- Danielle Gerogalide ✕
- Dorthy Keen ✕
- Thomas Bansky ✕
- Vincent Edisson ✕
- Zach Georgalide ✕
- Eloise Thompson ✕
- Emily Freya ✕
- Erin Coral ✕
- Melissa Cambridge ✕
- Matt Steward ✕
- Maggie Rogers ✕
- Louis Barkley ✕

A

OR



Drag a csv. file here

or

**Select File**

i How to format a CSV properly



Class\_example.csv  
49.5 KB

✕

B

**Cancel** **Next**

## 8. Create Classroom:CSV Upload

| Element Label | Element Name | Type           | Description   |
|---------------|--------------|----------------|---|
| A             | Names        | Text           | Uploading a csv generates a list with names presented on the left                           |
| B             | Document     | Visual Element | Verification of successful upload of csv. / Can be deleted to re-upload a new one if needed |

### Create a new classroom

< Back

#### Add students

Register your students here by either pasting a list with their names or uploading a csv document. Let us do the rest!



Jon Doe |



Add your students here or  
Paste them all together.

OR

Drag a csv. file here  
or  
**Select File**

i How to format a CSV properly

**X** The upload was unsuccessful. Please make sure that the formatting of the document is correct. **X**

**Cancel** **Next**

## 9. Create Classroom:CSV Upload Fail

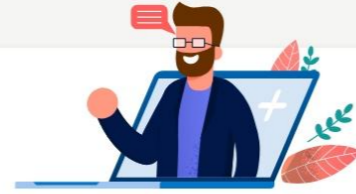
| Element Label | Element Name  | Type           | Description   |
|---------------|---------------|----------------|---|
| A             | Upload Failed | Visual Element | If the csv. document is not formatted correctly then the upload fails |
| B             | Next          | Button         | Next button is not active until the list is generated succesfully     |

### Choose approach

< Back

#### Approaches

You know your students better than us! Choose which approach of this tool you would like to adopt for your classroom.



#### Parallel Approach <sup>A</sup>



Students **input** what skills they think they are using and **complete activities during the maker session**

#### Parallel tapping / challenges at the end



Students **input** what skills they think they are using **during the maker session** and **complete activities at the end of the classroom**

#### At the end Approach



Students **at the end of the classroom rate** on a scale which skills they think they were using during their maker sessions. **Then take a series of activities** based on their input

Cancel

Next

## 10. Create Classroom: Approaches

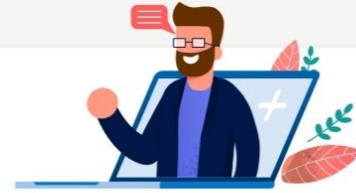
| Element Label | Element Name  | Type | Description   |
|---------------|---------------|------|---|
| A             | Approach Card | Card | Choose between 3 approaches by clicking on the cards or toggle button |

## Choose approach

< Back

### Approaches

You know your students better than us! Choose which approach of this tool you would like to adopt for your classroom.



#### Parallel Approach



Students **input** what skills they think they are using and **complete activities during the maker session**

#### Parallel tapping / challenges at the end



Students **input** what skills they think they are using **during the maker session** and **complete activities at the end of the classroom**

#### At the end Approach



Students **at the end of the classroom rate** on a scale which skills they think they were using during their maker sessions. **Then take a series of activities** based on their input

Cancel

Next

# 10. Create Classroom: Approaches

Each Approach card is highlighted accordingly. Clicking on another card switches the approach

### Choose duration

< Back

#### Duration

Choose how many activities students should complete to progress to the next level, based on the number and duration of your making activities in the classroom.



*\*By all means, a student can further develop and reflect on the tool much faster than his/her peers.*

**Short Duration**  **A**  
Max. 2x80' lessons

**For each level: 5 Activities**

4 Challenges  
+ 1 Visual Example

**Medium Duration**   
Max. 3x80' lessons

**For each level: 8 Activities**

6 Challenges  
+ 2 Visual Examples

**Long Duration**   
4x80' lessons +

**For each level: 12 Activities**

8 Challenges  
+ 4 Visual Examples

Cancel

Next

## 11. Create Classroom: Duration

| Element Label | Element Name  | Type | Description  |
|---------------|---------------|------|--|
| A             | Duration Card | Card | Choose between 3 durations by clicking on the cards or toggle button |

### Choose duration

< Back



#### Duration

Choose how many activities students should complete to progress to the next level, based on the number and duration of your making activities in the classroom.

*\*By all means, a student can further develop and reflect on the tool much faster than his/her peers.*

**Short Duration**

Max. 2x80' lessons

**For each level: 5 Activities**

4 Challenges  
+ 1 Visual Example

**Medium Duration**

Max. 3x80' lessons

**For each level: 8 Activities**

6 Challenges  
+ 2 Visual Examples

**Long Duration**

4x80' lessons +

**For each level: 12 Activities**

8 Challenges  
+ 4 Visual Examples

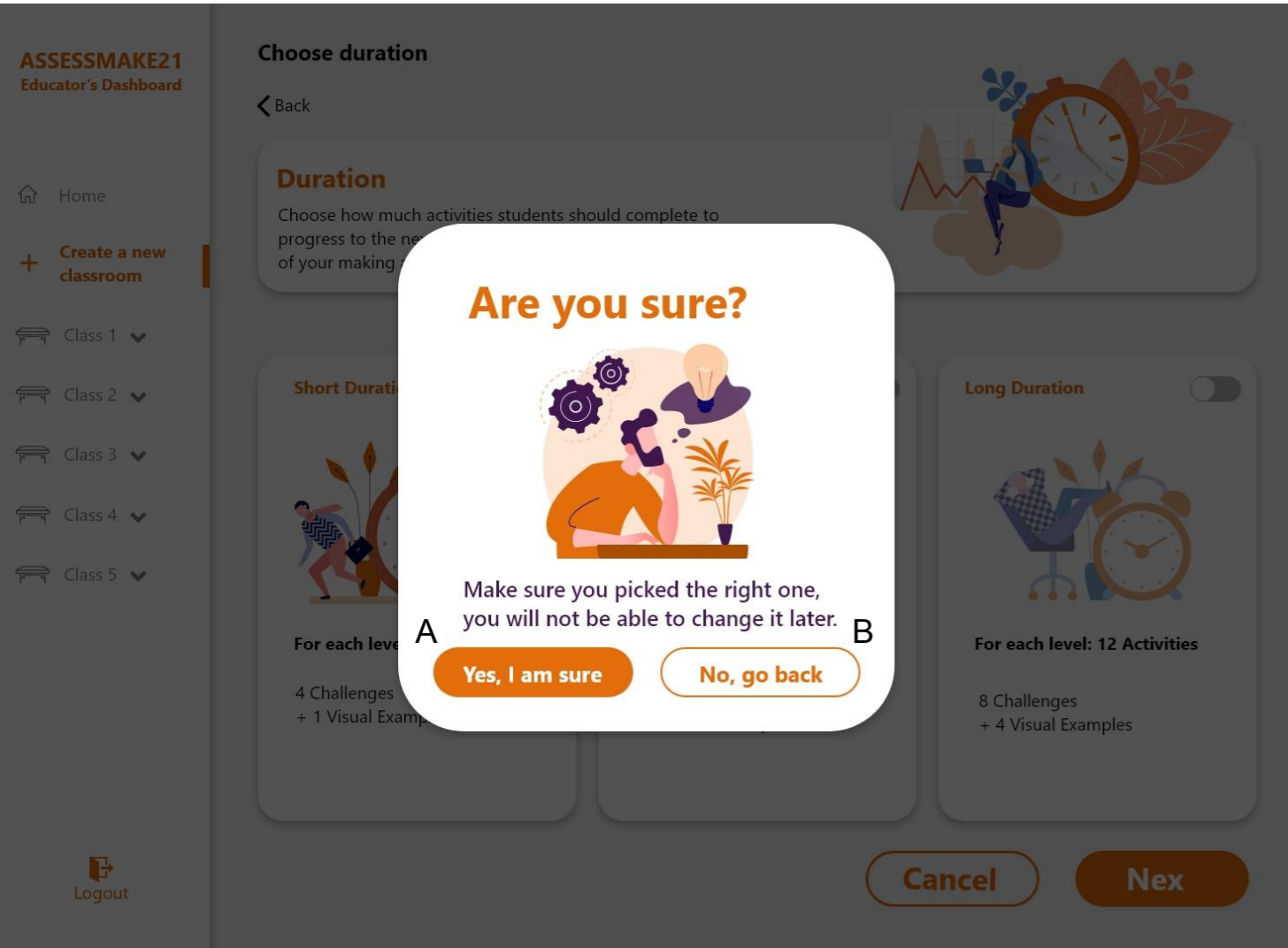
Cancel

Next

# 11. Create Classroom: Duration

Each Approach card is highlighted accordingly. Clicking on another card switches the approach





## 12. Create Classroom: Duration Verification

| Element Label | Element Name   | Type   | Description   |
|---------------|----------------|--------|---|
| A             | Yes, I am sure | Button | Warning that the option will not be able to be changed later on |
| B             | No, Go Back    | Button | Hide warning / Take educator back to the duration Cards         |

**ASSESSMAKE21**  
Educator's Dashboard

Choose tools

Tools & Technologies

Customize the experience of your students based on the technologies you are planning to use. These will be fed to your student's challenges.

Add a new technology Add +

Please select at least 5 tools that you are planning to use in your classroom

A Okay

3D printer Rename Delete

Laser Cutter Rename Delete

3D pen Rename Delete

CnC Router Rename Delete

Micro- processors/controllers/computers

Arduino Rename Delete

Raspberry Pi Rename Delete

Micro-bit

Other

Arts & Crafts Rename Delete

Computer Rename Delete

Cancel Next

Logout

## 13. Create Classroom: No Tools selected warning

| Element Label | Element Name | Type   | Description                                   |
|---------------|--------------|--------|---|
| A             | Okay         | Button | Take educator back to select at least 5 tools |

### Choose tools

< Back

#### Tools & Technologies

Customize the experience of your students based on the technologies you are planning to use. These will be fed to your student's challenges.



A   B

|  | C                      | D                      | E                                   |
|--|------------------------|------------------------|-------------------------------------|
| <b>Fabrication Technologies</b>                |                        |                        |                                     |
| 3D printer                                     | <a href="#">Rename</a> | <a href="#">Delete</a> | <input checked="" type="checkbox"/> |
| Laser Cutter                                   | <a href="#">Rename</a> | <a href="#">Delete</a> | <input type="checkbox"/>            |
| 3D pen   | <a href="#">Rename</a> | <a href="#">Delete</a> | <input checked="" type="checkbox"/> |
| CnC Router                                     | <a href="#">Rename</a> | <a href="#">Delete</a> | <input checked="" type="checkbox"/> |
| <b>Micro- processors/controllers/computers</b> |                        |                        |                                     |
| Arduino  | <a href="#">Rename</a> | <a href="#">Delete</a> | <input type="checkbox"/>            |
| Raspberry Pi                                   | <a href="#">Rename</a> | <a href="#">Delete</a> | <input checked="" type="checkbox"/> |
| Micro-bit                                      |                        |                        |                                     |
| <b>Other</b>                                   |                        |                        |                                     |
| Arts & Crafts                                  | <a href="#">Rename</a> | <a href="#">Delete</a> | <input type="checkbox"/>            |
| Computer                                       | <a href="#">Rename</a> | <a href="#">Delete</a> | <input checked="" type="checkbox"/> |

Cancel

Next

## 14. Create Classroom: Tools & Technologies

| Element Label | Element Name   | Type       | Description  |
|---------------|----------------|------------|--|
| A             | Add technology | Text Input | Educators can input any tools or technologies planned to be used |
| B             | Add            | Button     | Pressing the button adds the technology to the list              |
| C             | Rename         | Text Link  | Educators can rename a technology                                |
| D             | Delete         | Text Link  | Educators Can Delete a technology                                |
| E             | Tick Box       | Tick Box   | Educators can select/deselect a technology                       |

## Final Details

< Back

### Almost there!

Name your classroom and make sure that all the classroom options are correct.



### Technologies

#### Fabrication

3D printer  
3D pen  
CnC Router

#### Micro- processors/controllers/computers

Raspberry Pi  
Micro-bit

#### Other

Computer

A  
Change

### Short Duration

Max. 2x80' lessons

#### For each level: 5 Activities

4 Challenges  
+ 1 Visual Example

B  
Change

### Parallel Approach

Students **input** what skills they think they are using and **complete activities** during the maker session

C  
Change

### Classroom Name

Name your classroom here

D

Cancel

Next

# 15. Create Classroom: Final Details

| Element Label | Element Name         | Type       | Description  |
|---------------|----------------------|------------|--|
| A             | Technologies: Change | Text Link  | Students here will input their 6-digit code as their credentials every time they need to login |
| B             | Duration: Change     | Text Link  | Pressing the button logs the user in   |
| C             | Approach: Change     | Text Link  | Educators can change the approach (takes them back to the approach cards and then back here)   |
| D             | Classroom Name       | Text Input | Educators can name their classroom   |

### Login Credentials

< Back

#### Login Credentials

We have generated a unique login code for each student. This is the only login credential that students will need. You can print them whenever you need.



|                     | A           | B |                 |               |
|---------------------|-------------|---|-----------------|---------------|
| Augustine Black     | A-D-2-5-W-6 | X | Georgia Lada    | A-D-2-5-W-6 X |
| Colleen Sunderland  | 5-S-R-5-3-G | X | Alicia Perry    | 5-S-R-5-3-G X |
| Danielle Gerogalide | K-1-2-5-M-L | X | Kevin Kord      | K-1-2-5-M-L X |
| Dorothy Keen        | Q-E-R-1-9-T | X | Gabriela Kort   | Q-E-R-1-9-T X |
| Thomas Bansky       | F-V-C-6-W-6 | X | George Blue     | F-V-C-6-W-6 X |
| Vincent Edisson     | A-Z-4-8-B-T | X | Kelvin White    | A-Z-4-8-B-T X |
| Zach Georgalide     | B-D-2-F-T-6 | X | Zach Georgalide | B-D-2-F-T-6 X |
| Eloise Thompson     | N-1-H-5-F-6 | X | Josephine Slova | N-1-H-5-F-6 X |
| Emily Freya         | M-0-J-3-W-6 | X | Michael Bor     | M-0-J-3-W-6 X |
| Erin Coral          | S-H-2-5-F-6 | X | Lazarus Brok    | S-H-2-5-F-6 X |
| Melissa Cambridge   | D-2-2-I-5-6 | X | Katerina Kame   | D-2-2-I-5-6 X |

**C** [Print Login Credentials](#)

Cancel

Done

## 16. Create Classroom: Login Codes

| Element Label | Element Name            | Type           | Description  |
|---------------|-------------------------|----------------|--|
| A             | A-D-2-5-W-6             | Text           | The login code for each student                                    |
| B             | X                       | Icon           | Educators can delete a student                                     |
| C             | Print Login Credentials | Text/icon Link | Educators can save as pdf or print the credentials of the students |

Home

Create a new classroom

Class 1

Class 2

Class 3

Class 4

Class 5

**D3 Class 2021**

Add student

**Setting**

Credentials

Logout

D3 Class 2021

Back

**Settings**

Here you can edit the settings of your classroom!



Print Login Credentials **A** Settings

**Students**

**B C**

|                     |                        |                        |                 |                        |                        |
|---------------------|------------------------|------------------------|-----------------|------------------------|------------------------|
| Augustine Black     | <a href="#">Rename</a> | <a href="#">Delete</a> | Georgia Lada    | <a href="#">Rename</a> | <a href="#">Delete</a> |
| Colleen Sunderland  | <a href="#">Rename</a> | <a href="#">Delete</a> | Alicia Perry    | <a href="#">Rename</a> | <a href="#">Delete</a> |
| Danielle Gerogalide | <a href="#">Rename</a> | <a href="#">Delete</a> | Kevin Kord      | <a href="#">Rename</a> | <a href="#">Delete</a> |
| Dorothy Keen        | <a href="#">Rename</a> | <a href="#">Delete</a> | Gabriela Kort   | <a href="#">Rename</a> | <a href="#">Delete</a> |
| Thomas Bansky       | <a href="#">Rename</a> | <a href="#">Delete</a> | George Blue     | <a href="#">Rename</a> | <a href="#">Delete</a> |
| Vincent Edison      | <a href="#">Rename</a> | <a href="#">Delete</a> | Kelvin White    | <a href="#">Rename</a> | <a href="#">Delete</a> |
| Zach Georgalide     | <a href="#">Rename</a> | <a href="#">Delete</a> | Zach Georgalide | <a href="#">Rename</a> | <a href="#">Delete</a> |
| Eloise Thompson     | <a href="#">Rename</a> | <a href="#">Delete</a> | Josephine Slova | <a href="#">Rename</a> | <a href="#">Delete</a> |
| Emily Freya         | <a href="#">Rename</a> | <a href="#">Delete</a> | Michael Bor     | <a href="#">Rename</a> | <a href="#">Delete</a> |
| Erin Coral          | <a href="#">Rename</a> | <a href="#">Delete</a> | Lazarus Brok    | <a href="#">Rename</a> | <a href="#">Delete</a> |
| Melissa Cambridge   | <a href="#">Rename</a> | <a href="#">Delete</a> | Katerina Kame   | <a href="#">Rename</a> | <a href="#">Delete</a> |

**Technologies / Tools**

**D**

# 17. Settings for a classroom

| Element Label | Element Name            | Type          | Description  |
|---------------|-------------------------|---------------|--|
| A             | Print Login Credentials | Text Link     | Take educator to the credentials Page                            |
| B             | Rename                  | Text Link     | Rename a student   |
| C             | Delete                  | Text Link     | Delete a student   |
| D             | Technologies / Tools    | Card          | Change the technologies card                                     |
| E             | Languages               | Cards         | Change the language Cards / Toggle Buttons (of the student tool) |
| F             | Classroom Names         | Text Input    | Educators can rename their classroom                             |
| G             | Approaches              | Cards         | Educators can switch approach of the student tool                |
| H             | Auto-reward             | Toggle Button | Option to auto-reward the badges of the students                 |

D3 Class 2021

A Login Credentials B Settings

Back

### Classroom Overview

See an overview of your classroom progress for developing their 21st century skills! You can also check each student for more details.



+ Add a new student C

D Search students

**Zach Georgalide**  
A-2-5-W-6  
Requested a badge Student Inactive  
- Computational Thinking  
- Arduino

**Eloise Thompson**  
M-0-J-3-W-6  
Requested a badge Student Inactive  
- Drawing  
- Arts & Crafts

**Emily Freya**  
Q-E-R-1-9-T  
Requested a badge Student Inactive  
- CnC Router  
- Shy

**Augustine Black**  
5-S-R-5-3-G  
Requested a badge Student Inactive  
- 3D printer  
- 3D pen

**Coleen Sunderland**  
S-H-2-5-F-6  
Requested a badge Student Inactive  
- Arduino  
- 3D Printer

**Dorothy Keen**  
F-V-C-6-W-6  
Requested a badge Student Inactive  
- Team Leader  
- Listener

## 18. Class Overview

| Element Label | Element Name      | Type           | Description  |
|---------------|-------------------|----------------|--|
| A             | Login Credentials | Text Input     | Students here will input their 6-digit code as their credentials every time they need to login |
| B             | Settings          | Button         | Pressing the button logs the user in   |
| C             | Add a new student | Text Link      | Takes educator to the "add a student page"   |
| D             | Search Students   | Search Bar     | Search students here (searching a student hides the rest and show only the results)            |
| E             | Student Card      | Card           | Card for each student  |
| F             | Request a badge   | Visual Element | Icon lights when student has requested a badge   |

**Classroom Overview**

See an overview of your classroom progress for developing their 21st century skills! You can also check each student for more details.



Search Team

A

Create a new group!

- Georgia Lada

↕

B
- AliciaPerry

↕
- Josephina Slova

↕
- Katarina Kord

↕
- Gabriela Kort

↕
- Emily Freya

↕
- Maggie Rogers

↕

# 19. Create groups

| Element Label | Element Name       | Type         | Description                                       |
|---------------|--------------------|--------------|---|
| A             | Create a new group | Team Card    | Educators can create groups                       |
| B             | Student            | Student Card | Educators can rag and and drop students in groups |



Classroom Overview

See an overview of your classroom progress for developing their 21st century skills! You can also check each student for more details.



A Search Team

Group 1



Danielle Gerogalide

Zach Georgalide

Melissa Cambridge

Group 2



Dorothy Keen

Eloise Thompson

Matt Steward

## 20. Groups overview


| Element Label | Element Name          | Type       | Description                               |
|---------------|-----------------------|------------|---|
| A             | Search Teams          | Search bar | Educators can search a team here          |
| B             | Group name            | Text Link  | Educators can rename the groups           |
| C             | x                     | Icon       | Educators can delete a group              |
| D             | Group Card            | Card       | Take educator to the overview of the team |
| E             | Student Card          | Card       | Take educator to the student profile      |
| F             | Disassemble all teams | Text Link  | Disassemble all teams                     |

### Classroom Overview

See an overview of your classroom progress for developing their 21st century skills! You can also check each student for more details.



 [Print Login Credentials](#)

Search Team 

 Home

 Create a new classroom

 Class 1 


 Class 2 

 Class 3 


 Class 4 

 Class 5 


 **D3 Class 2021** 

 Add student



 Settings

 Credentials

 Logout



Are you sure you want to cancel the teams. All team-building progress will be lost

A   B

## 21. Groups: Disassemble warning


| Element Label | Element Name       | Type   | Description  |
|---------------|--------------------|--------|--|
| A             | I don't want teams | Button | Disassemble all teams, and takes educator back to student's overview |
| B             | Oops, take me back | Button | Return educator back to teams  |


### Classroom Overview

See an overview of your classroom progress for developing their 21st century skills! You can also check each student for more details.



 [Print Login Credentials](#)

Search Team 

 Home

 Create a new classroom

 Class 1 


 Class 2 

 Class 3 

 Class 4 

 Class 5 

 **D3 Class 2021** 

 Add student

 Settings

 Credentials

 Logout



Some students are not in teams.  
Please group everyone.

A

Okay

Georgia Lada



AliciaPerry



Josephina Slova



Emily Freya



Maggie Rogers



## 22. Groups : Not all students are in teams Warning

| Element Label | Element Name | Type   | Description                          |
|---------------|--------------|--------|--------------------------------------|
| A             | Okay         | Button | Takes educator back to team assembly |

### Compare groups

Compare the groups of students to see which group is reflecting and self-assessing 21st century skills more or less.



### Groups

**Group 1** ●

A

**Group 2** ●

### Students

B

Danielle Gerogalide

Zach Georgalide

Melissa Cambridge

Dorthy Keen

Eloise Thompson

### Most Used Skills



Life / Social



## 23. Groups Overview

| Element Label | Element Name | Type  | Description  |
|---------------|--------------|-------|--|
| A             | Group 1      | Card  | Clicking here, takes the educator to the profile of the group                |
| B             | Student      | Card  | Clicking here, takes the educator to the profile of the student              |
| C             | Graph        | Graph | Graph for skill development of the groups based on skill in drop down filter |

Group 1 Profile

Get an insight of your student groups and their 21st century skills.



Students

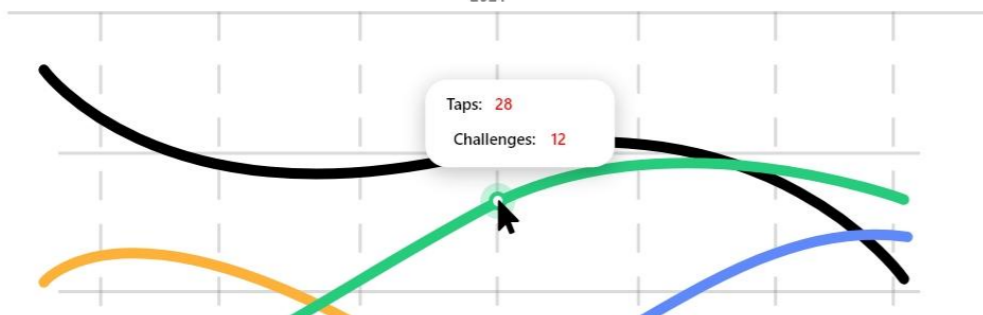
Danielle Gerogalide A

Zach Georgalide

Melissa Cambridge

Skills Curve

2021



## 24. Group Profile

| Element Label | Element Name      | Type     | Description   |
|---------------|-------------------|----------|---|
| A             | Students          | Card     | Clicking here, takes the educator to the profile of the student |
| B             | Skill Curve       | Graph    | Graph for the skill development of the group overall            |
| C             | Latest Example    | Carousel | Latest Visual examples of the students in group                 |
| D             | Skill Development | Card     | No interaction (most developed skills) in the group overall     |



Are you sure you want to delete this student?

**Zach Georgalide**

A

Delete

Cancel

B

## 25. Delete Student Warning

| Element Label | Element Name | Type   | Description          |
|---------------|--------------|--------|----------------------|
| A             | Delete       | Button | Delete student       |
| B             | Cancel       | Button | Don't delete student |



### Problem Solving - Level 1

Award Zach with the Level 1 Problem Solving Badge

**Award** A

B **All Answers** **Portfolio** C

## 26. Award student a badge

| Element Label | Element Name | Type   | Description                                   |
|---------------|--------------|--------|---|
| A             | Award        | Button | Award student the digital Badge               |
| B             | All Answers  | Button | Take educator to the answers of the student   |
| C             | Portfolio    | Button | Take educator to the portfolio of the student |

- [Home](#)
- [Create a new classroom](#)
- [Class 1](#)
- [Class 2](#)
- [Class 3](#)
- [Class 4](#)
- [Class 5](#)

**D3 Class 2021**

- [+ Add student](#)
- [Setting](#)
- [Credentials](#)

**D3 Class 2021**

[← Back](#)

**Settings**

Here you can edit the settings of your classroom!



**A** [Print Login Credentials](#)

**Students**

|                     | <b>B</b>               | <b>C</b>               |                 |
|---------------------|------------------------|------------------------|-----------------|
| Augustine Black     | <a href="#">Rename</a> | <a href="#">Delete</a> | Georgia Lada    |
| Colleen Sunderland  | <a href="#">Rename</a> | <a href="#">Delete</a> | Alicia Perry    |
| Danielle Gerogalide | <a href="#">Rename</a> | <a href="#">Delete</a> | Kevin Kord      |
| Dorthy Keen         | <a href="#">Rename</a> | <a href="#">Delete</a> | Gabriela Kort   |
| Thomas Bansky       | <a href="#">Rename</a> | <a href="#">Delete</a> | George Blue     |
| Vincent Edison      | <a href="#">Rename</a> | <a href="#">Delete</a> | Kelvin White    |
| Zach Georgalide     | <a href="#">Rename</a> | <a href="#">Delete</a> | Zach Georgalide |
| Eloise Thompson     | <a href="#">Rename</a> | <a href="#">Delete</a> | Josephine Slova |
| Emily Freya         | <a href="#">Rename</a> | <a href="#">Delete</a> | Michael Bor     |
| Erin Coral          | <a href="#">Rename</a> | <a href="#">Delete</a> | Lazarus Brok    |
| Melissa Cambridge   | <a href="#">Rename</a> | <a href="#">Delete</a> | Katerina Kame   |

## 27. Settings

| Element Label | Element Name            | Type       | Description                                     |
|---------------|-------------------------|------------|---|
| A             | Print Login Credentials | Text Link  | Take the educator to the Print credentials page |
| B             | Rename                  | Text Link  | Rename a student                                |
| C             | Delete                  | Text Link  | Delete a student                                |
| D             | Add a new Technology    | Text input | Add technology / tool                           |
| E             | Add+                    | Button     | Add the technology that is in the text box      |
| F             | Rename                  | Text Link  | Rename a technology                             |
| G             | Delete                  | Text Link  | Delete a technology                             |



**Portfolio**

Check out the examples of your students to see how they are progressing with their 21st century skills through their projects



A

Level 1

B

**Collaboration**

Collaboration : Level 1 - Example01

**Creativity**

**Problem-solving**

**Life/Social Skills**

**Communication**



27/02/2021

**1** What were you doing in this example of Collaboration?

## 28. All Visual Examples of a student

| Element Label | Element Name  | Type       | Description                   |
|---------------|---------------|------------|-------------------------------|
| A             | Collaboration | Button     | Filter answers based on skill |
| B             | Level 1       | Drop Down  | Filter answers based on level |
| C             | Answer 3      | Visuals    | No interaction                |
| D             | Pagination    | Pagination | Change page for next answer   |

Answers

Check what students are answering to their activities for each skill.



A

B

Level 1

Collaboration

1 How does "developed shared understanding" make you feel?

Satisfied

Focus

Confident

Creativity

2 Name one tool or equipment that helped you develop Collaboration

Robotics (Lego Mindstorms, Arduino)

Life/Social Skills

3 How would you assess yourself as a collaborator today from a scale of 0-4 ?

0 1 2 3 4

A

# 29. All answers of a student

| Element Label | Element Name  | Type      | Description                   |
|---------------|---------------|-----------|-------------------------------|
| A             | Collaboration | Button    | Filter answers based on skill |
| B             | Level 1       | Drop Down | Filter answers based on level |
| C             | Answer 3      | Visuals   | No interaction                |



### Login Credentials

We have generated a unique login code for each student. This is the only login credential that students will need. You can print / save them whenever you need.

A

|                     |             |   |                 |             |   |
|---------------------|-------------|---|-----------------|-------------|---|
| Augustine Black     | A-D-2-5-W-6 | X | Georgia Lada    | A-D-2-5-W-6 | X |
| Colleen Sunderland  | 5-S-R-5-3-G | X | Alicia Perry    | 5-S-R-5-3-G | X |
| Danielle Gerogalide | K-1-2-5-M-L | X | Kevin Kord      | K-1-2-5-M-L | X |
| Dorthy Keen         | Q-E-R-1-9-T | X | Gabriela Kort   | Q-E-R-1-9-T | X |
| Thomas Bansky       | F-V-C-6-W-6 | X | George Blue     | F-V-C-6-W-6 | X |
| Vincent Edison      | A-Z-4-8-B-T | X | Kelvin White    | A-Z-4-8-B-T | X |
| Zach Georgalide     | B-D-2-F-T-6 | X | Zach Georgalide | B-D-2-F-T-6 | X |
| Eloise Thompson     | N-1-H-5-F-6 | X | Josephine Slova | N-1-H-5-F-6 | X |
| Emily Freya         | M-0-J-3-W-6 | X | Michael Bor     | M-0-J-3-W-6 | X |
| Erin Coral          | S-H-2-5-F-6 | X | Lazarus Brok    | S-H-2-5-F-6 | X |
| Melissa Cambridge   | D-2-2-I-5-6 | X | Katerina Kame   | D-2-2-I-5-6 | X |

[Print Login Credentials](#)

B

C

Cancel

Done

D

## 30. Login Credentials

| Element Label | Element Name            | Type      | Description  |
|---------------|-------------------------|-----------|--|
| A             | x                       | Icon      | Delete a student from the list                         |
| B             | Print Login Credentials | Text Link | Print or save as pdf the login credentials of students |
| C             | Cancel                  | Button    | Cancel any changes made to the list                    |
| D             | Done                    | Button    | Save any changes made to the list                      |

### Add a new student

Do you have any new students? Did you forgot to register someone? No worries, add them here!



A  Add + B

Augustine Black C D  
B-5-G-K-L-6  
[Rename](#) [Delete](#)

E [Print Login Credentials](#) F Cancel G Save

## 31. Add a student

| Element Label | Element Name            | Type       | Description  |
|---------------|-------------------------|------------|--|
| A             | Add a new student       | Text Input | Educators can input here the name of a new student             |
| B             | Add +                   | Button     | Educators can input the name of the new student to the list    |
| C             | Rename                  | Text Link  | Educators can rename the student                               |
| D             | Delete                  | Text Link  | Educators can delete the student                               |
| E             | Print Login Credentials | Text Link  | Educators can print the login credentials off the new students |
| F             | Cancel                  | Button     | Cancel any changes (additions)                                 |

### Student Profile

Get an insight of your students and their 21st century skills.



A

Print Login Credentials



**B**  
**Level 1**  
7 / 11 Activities Completed

**C**  
**3**  
Examples

D Delete student

Lvl.1  
Award



**Level 2**  
01 / 11 Activities Completed

**1**  
Example

Lvl.2  
Award



**Level 1**  
11 / 11 Activities Completed

**2**  
Examples

E

Lvl.1  
Award

## 32. Student Profile

| Element Label | Element Name            | Type      | Description   |
|---------------|-------------------------|-----------|---|
| A             | Print Login Credentials | Text Link | The educator can print/save as pdf the login credential of the student                    |
| B             | Level 1                 | Card      | The educator can check out all the answers of the student                                 |
| C             | 3 Examples              | Card      | The educator can check out the visual examples of the student                             |
| D             | Delete Student          | Text Link | The educator can delete the student   |
| E             | Award                   | Button    | The educator can award the requested badge here   |
| F             | Graph                   | Graph     | Skill graph for the development/usage of the skills of the students over a period of time |
|               | Skill                   |           |   |

## INNOVATIVE DIGITAL SOLUTIONS TO ASSESS 21<sup>ST</sup> CENTURY SKILLS IN MAKERSPACES

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### Appendix C – Student Tool Wireframe Annotations

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AssessMake21 Wireframe Annotations for the elements and interactions  
Students Tool

This document annotates the most important interactive elements of the interface.

# ASSESS



# 21



## WELCOME !

Login Code

A

B

Self assess, reflect and develop your 21st century skills in makerspaces

## 1. Login Page

| Element Label | Element Name | Type       | Description  |
|---------------|--------------|------------|--|
| A             | Login input  | Text Input | Students here will input their 6-digit code as their credentials every time they need to login |
| B             | Login        | Button     | Pressing the button logs the user in   |



## First Approach : Challenges and tagging (input) during the Makerspace Activities

Based on the first approach, students are able to input what skills they think they are using during their making activities by clicking (tagging) on the respective buttons. After a number of clicks on each skill, the tool will challenge them with activities related to the skill they have been tagging.



Collaboration



Creativity



Problem-solving



Life/Social skills



Communication



| Element Label | Element Name   | Type                 | Description  |
|---------------|----------------|----------------------|--|
| A             | Logout         | Text Link            | Students can log out from their accounts                     |
| B             | Welcome Banner | Banner with a button | Students can take a tour explaining all elements of the tool |
| C             | Skills Tab     | Menu Tab             | Students can navigate to the Skills page                     |
| D             | My Portfolio   | Menu Tab             | Students can navigate to the My Portfolio page               |
| E             | My Badges      | Menu Tab             | Students can navigate to the My Badges page                  |
| F             | Examples       | Menu Tab             | Students can navigate to the examples of artifacts           |
| G             | Definitions    | Menu Tab             | Students can navigate to the definitions of each skill       |
| H             | <Skill>        | Label                | no interaction   |



H

**Collaboration** 1 ●●●●●○○○ 2 3 4 ∞ J K

**Creativity** 1 2 ●○○○○○○○○ 3 4 ∞ J K

**Problem-solving** 1 2 3 ●●●●●●○○ 4 ∞ J K

**Life/Social skills** 1 2 3 4 ○○○○○○○○○ ∞ J K

**Communication** 1 ●○○○○○○○○ 2 3 4 ∞ J K

| Element Label | Element Name | Type           | Description  |
|---------------|--------------|----------------|--|
| I             | Progress Bar | Visual Element | Students can progress every time they answer one challenge. -Each dot represents a challenge. Upon the completion of all challenges on each level, the student can request a badge in order to progress  |
| J             | Index Hand   | Icon Button    | Students can input (“tag”) the skill they feel they are using by tapping/clicking here   |
| K             | Camera       | Icon Button    | Students can take a picture of an example of that skill. If the user has already taken the maximum amount of pictures he is allowed, then the button becomes inactive (light grey) If they never used that, then it is feeded as an activity in the challenges [check technical requirements for the amount of challenges] |

## Pressing the 'Show me around' Button

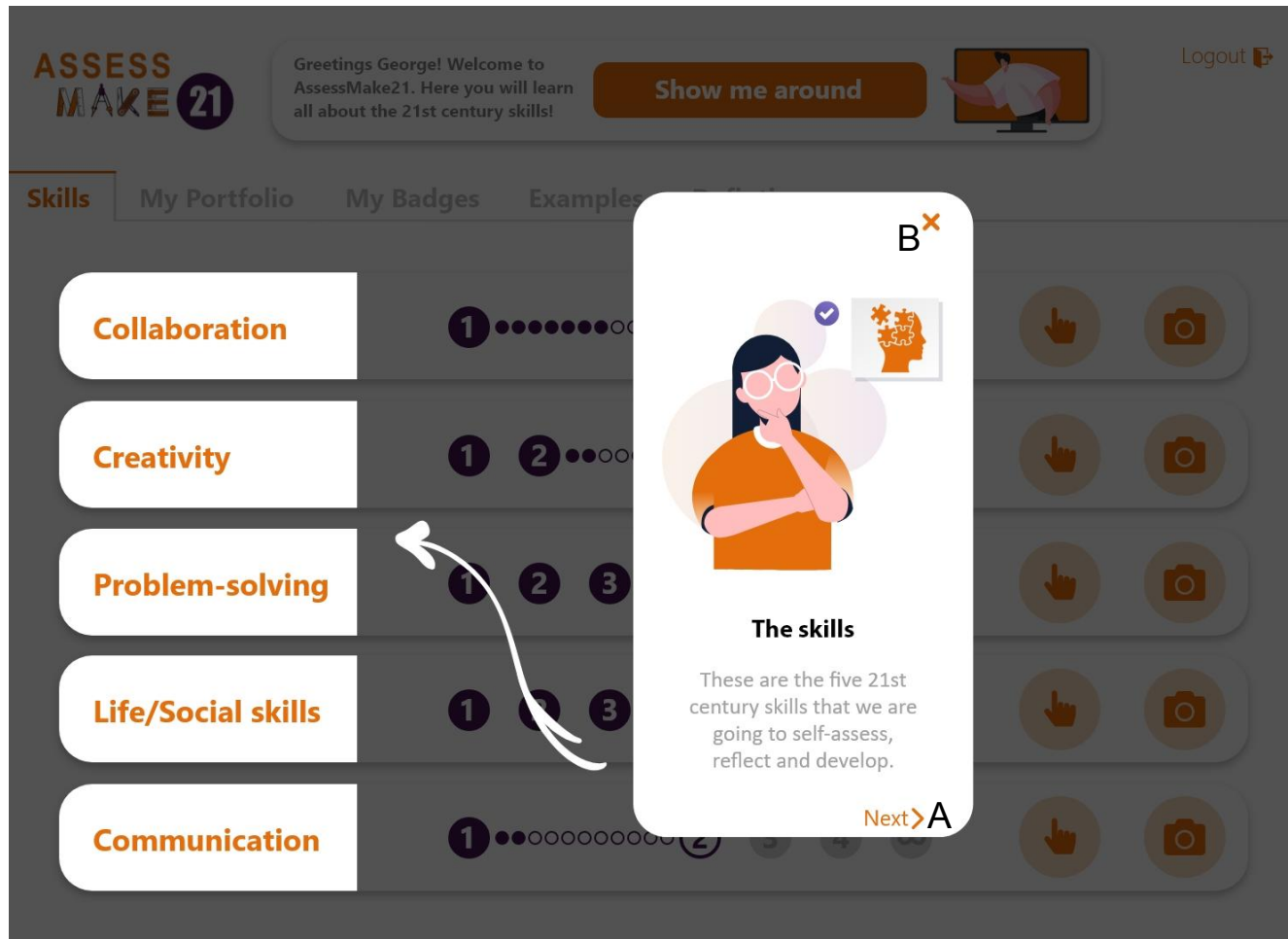
By pressing the "Show me around" Button the students will be able to take a guided tour to learn how the tool works and how to interact with each element

The following Wireframes show the tour step-by-step

Greetings George! Welcome to AssessMake21. Here you will learn all about the 21st century skills!

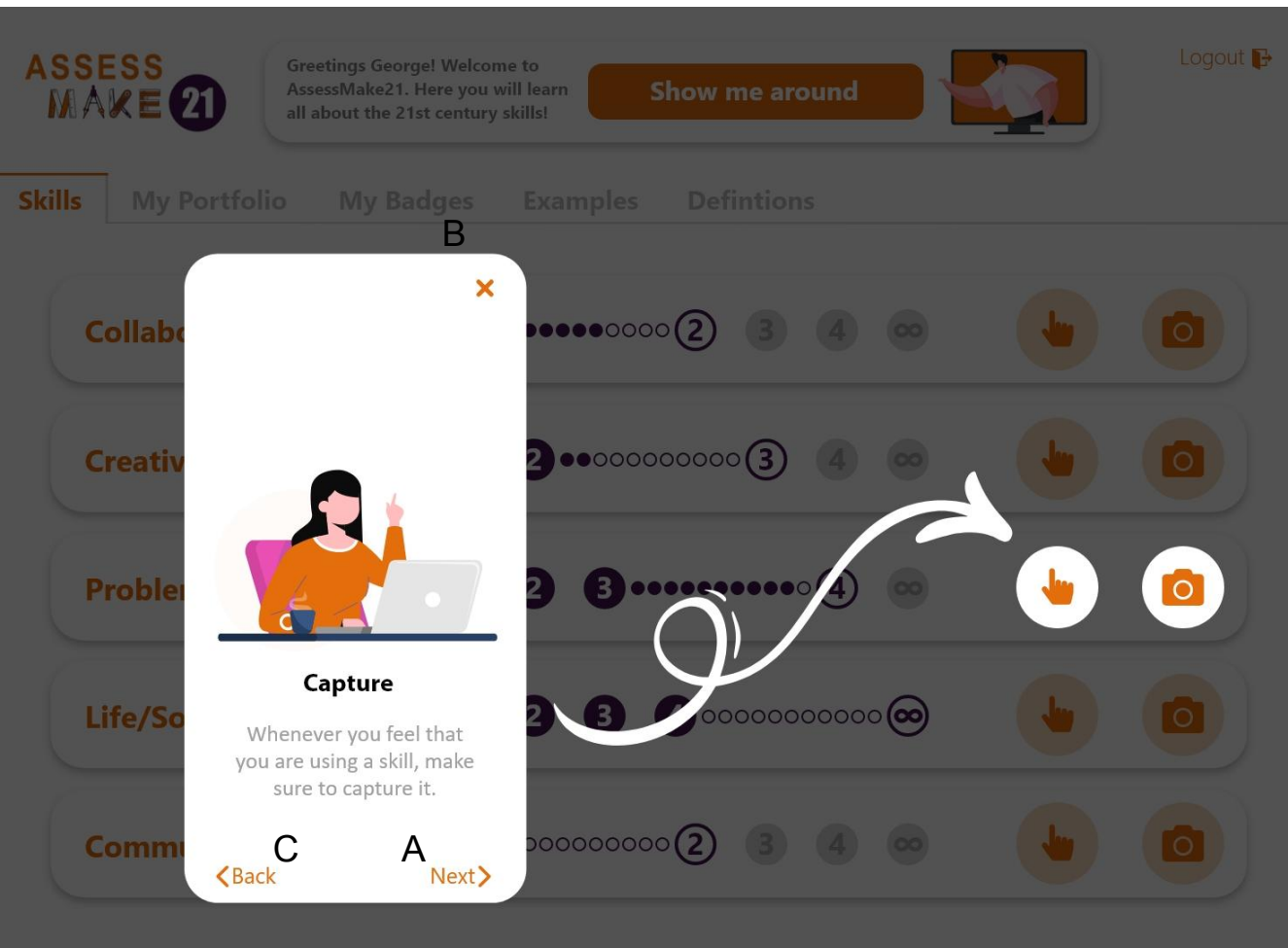
**Show me around**





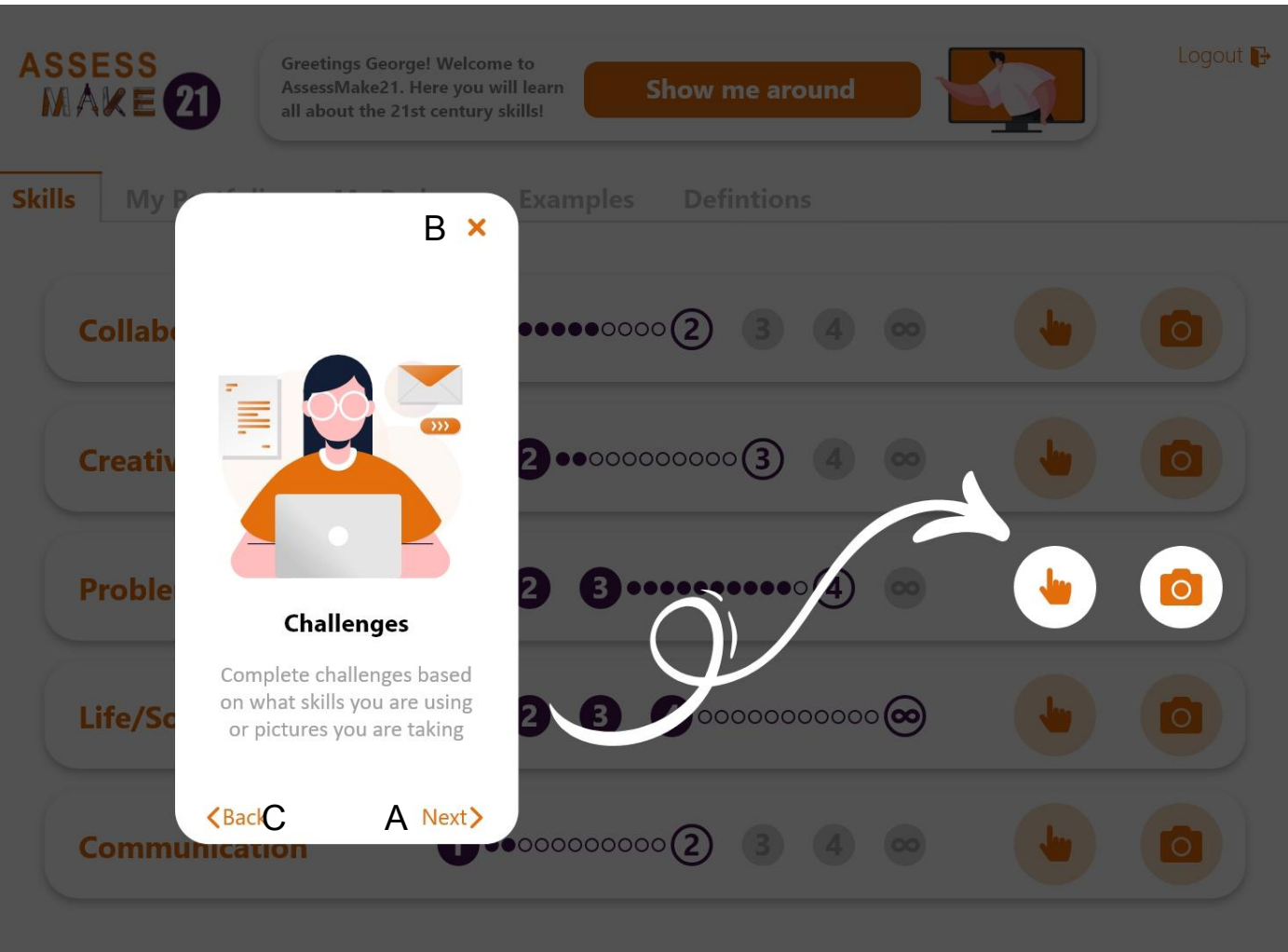
## Guided tour of the tool

| Element Label | Element Name | Type      | Description                        |
|---------------|--------------|-----------|------------------------------------|
| A             | Next         | Text Link | Takes the user to the next element |
| B             | X            | Icon Link | Exit Tour                          |



## Guided tour of the tool

| Element Label | Element Name | Type      | Description                          |
|---------------|--------------|-----------|--------------------------------------|
| A             | Next         | Text Link | Takes the user to the next element   |
| B             | X            | Icon Link | Exit Tour                            |
| C             | Back         | Text Link | Take the user to the preview element |



## Guided tour of the tool

| Element Label | Element Name | Type      | Description                          |
|---------------|--------------|-----------|--------------------------------------|
| A             | Next         | Text Link | Takes the user to the next element   |
| B             | X            | Icon Link | Exit Tour                            |
| C             | Back         | Text Link | Take the user to the preview element |



**B** ✕

**Collect Badges**

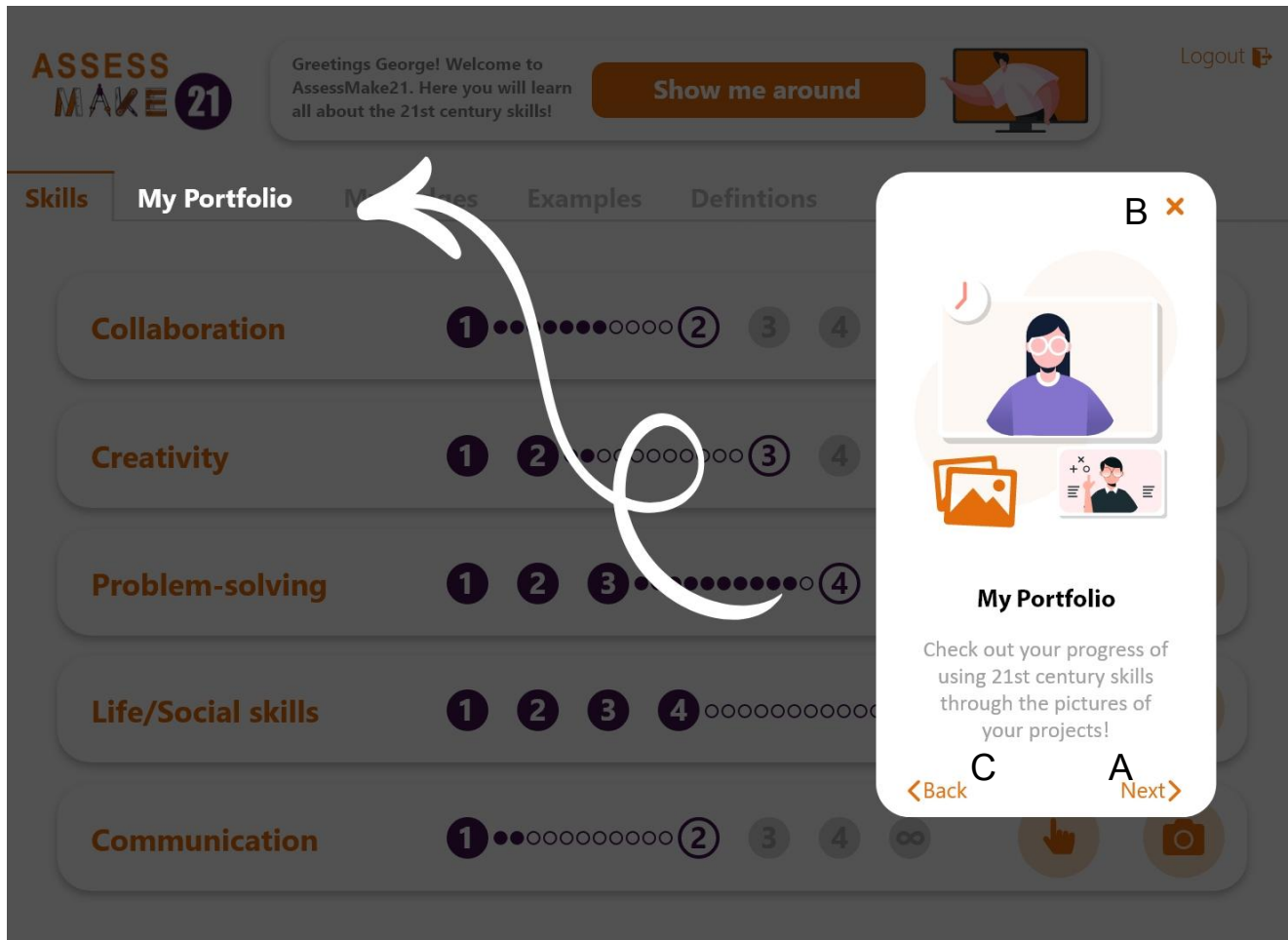
Progress through the levels to collect all the badges, by completing challenges.

<Back **C** **A** Next >

## Guided tour of the tool

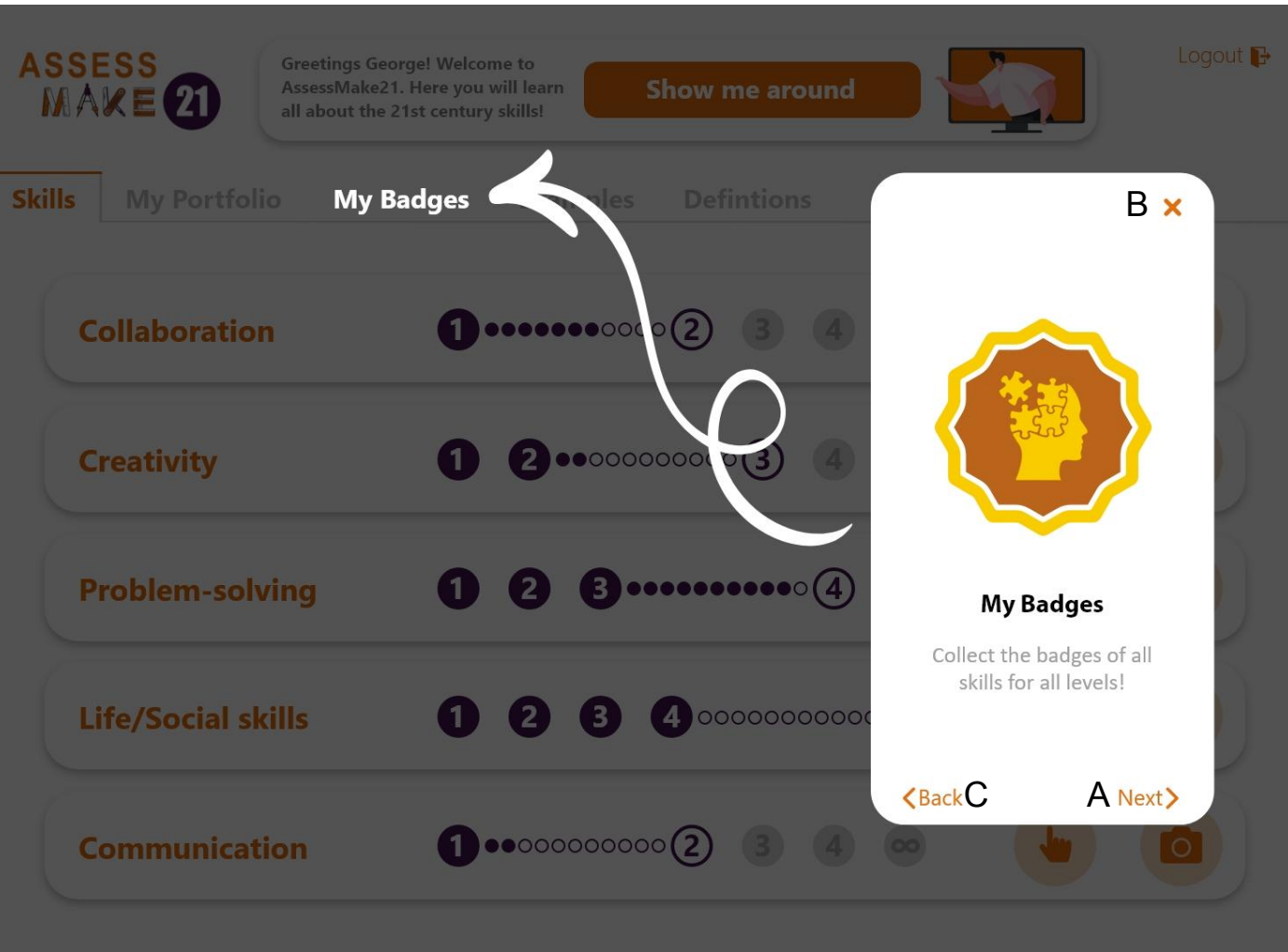
| Element Label | Element Name | Type      | Description                          |
|---------------|--------------|-----------|--------------------------------------|
| A             | Next         | Text Link | Takes the user to the next element   |
| B             | X            | Icon Link | Exit Tour                            |
| C             | Back         | Text Link | Take the user to the preview element |





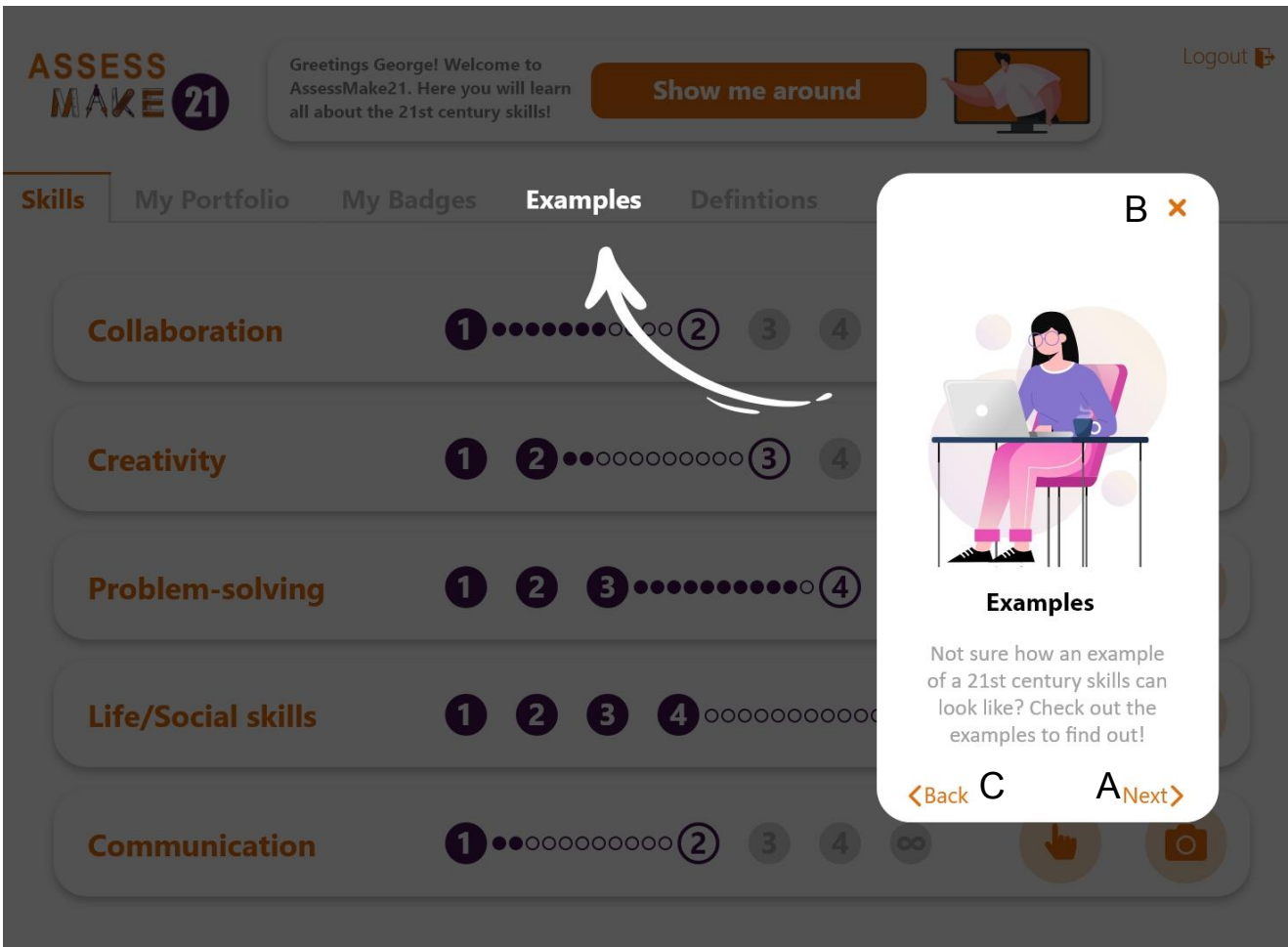
## Guided tour of the tool

| Element Label | Element Name | Type      | Description                          |
|---------------|--------------|-----------|--------------------------------------|
| A             | Next         | Text Link | Takes the user to the next element   |
| B             | X            | Icon Link | Exit Tour                            |
| C             | Back         | Text Link | Take the user to the preview element |



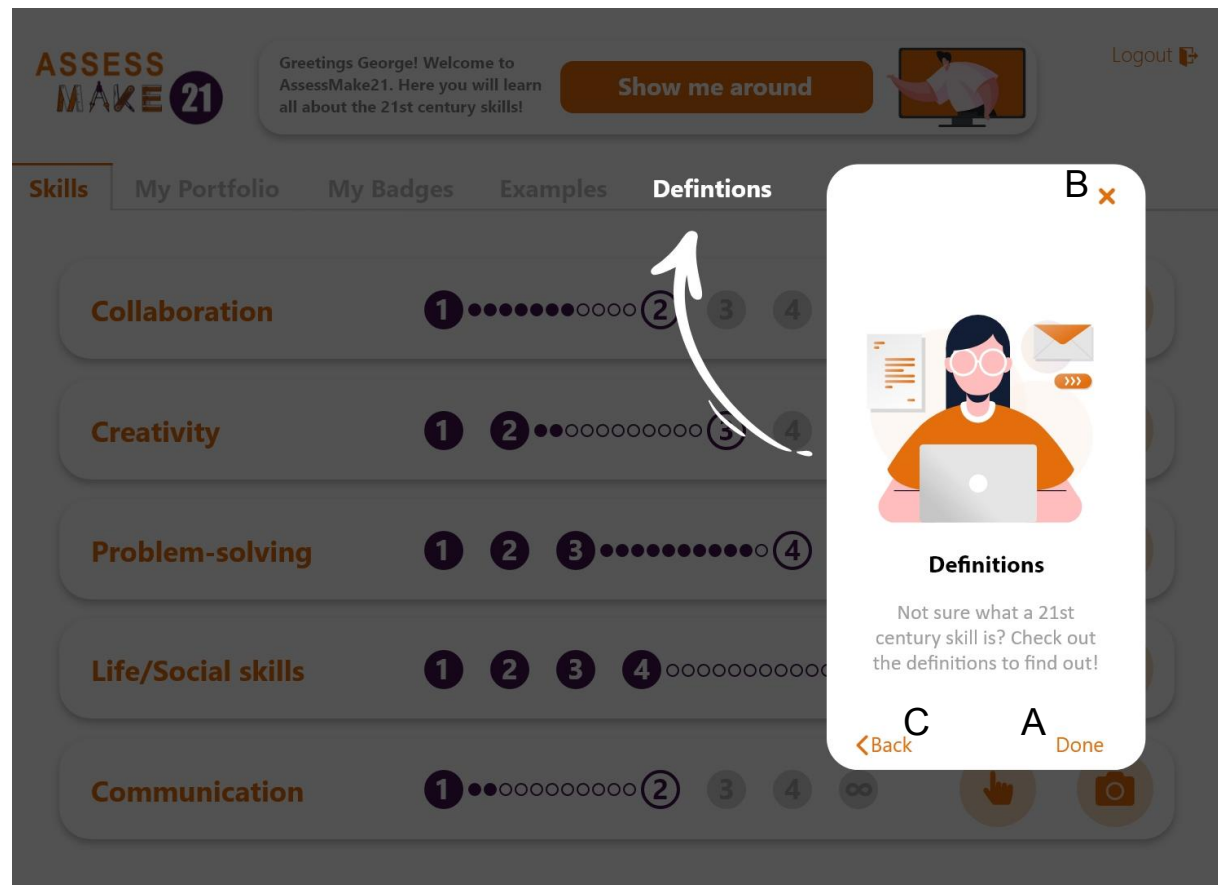
## Guided tour of the tool

| Element Label | Element Name | Type      | Description                          |
|---------------|--------------|-----------|--------------------------------------|
| A             | Next         | Text Link | Takes the user to the next element   |
| B             | X            | Icon Link | Exit Tour                            |
| C             | Back         | Text Link | Take the user to the preview element |



## Guided tour of the tool

| Element Label | Element Name | Type      | Description                          |
|---------------|--------------|-----------|--------------------------------------|
| A             | Next         | Text Link | Takes the user to the next element   |
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## Guided tour of the tool

| Element Label | Element Name | Type      | Description                          |
|---------------|--------------|-----------|--------------------------------------|
| A             | Next         | Text Link | Takes the user to the next element   |
| B             | X            | Icon Link | Exit Tour                            |
| C             | Back         | Text Link | Take the user to the preview element |



Collaboration



Creativity



Problem-solving



Life/Social skills



Communication



## When the student reaches the “infinite level” on all skills

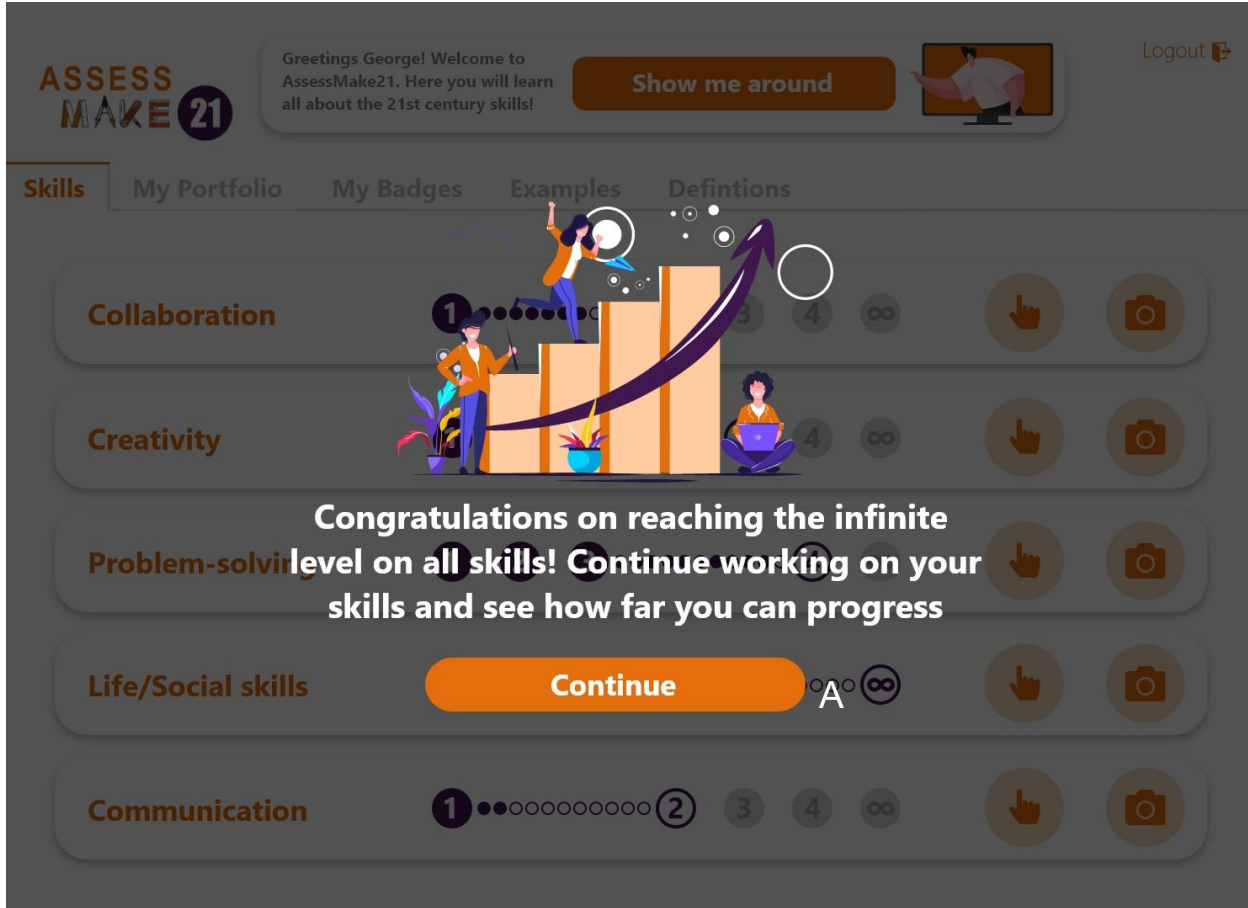
When the student reaches the infinite level on all skills, the user interface changes visually.

The progress bars disappear, since the student has completed all 4 levels.

Instead, the student sees the “infinite” progress bar, which gradually fills up, every time s/he completes a challenge.

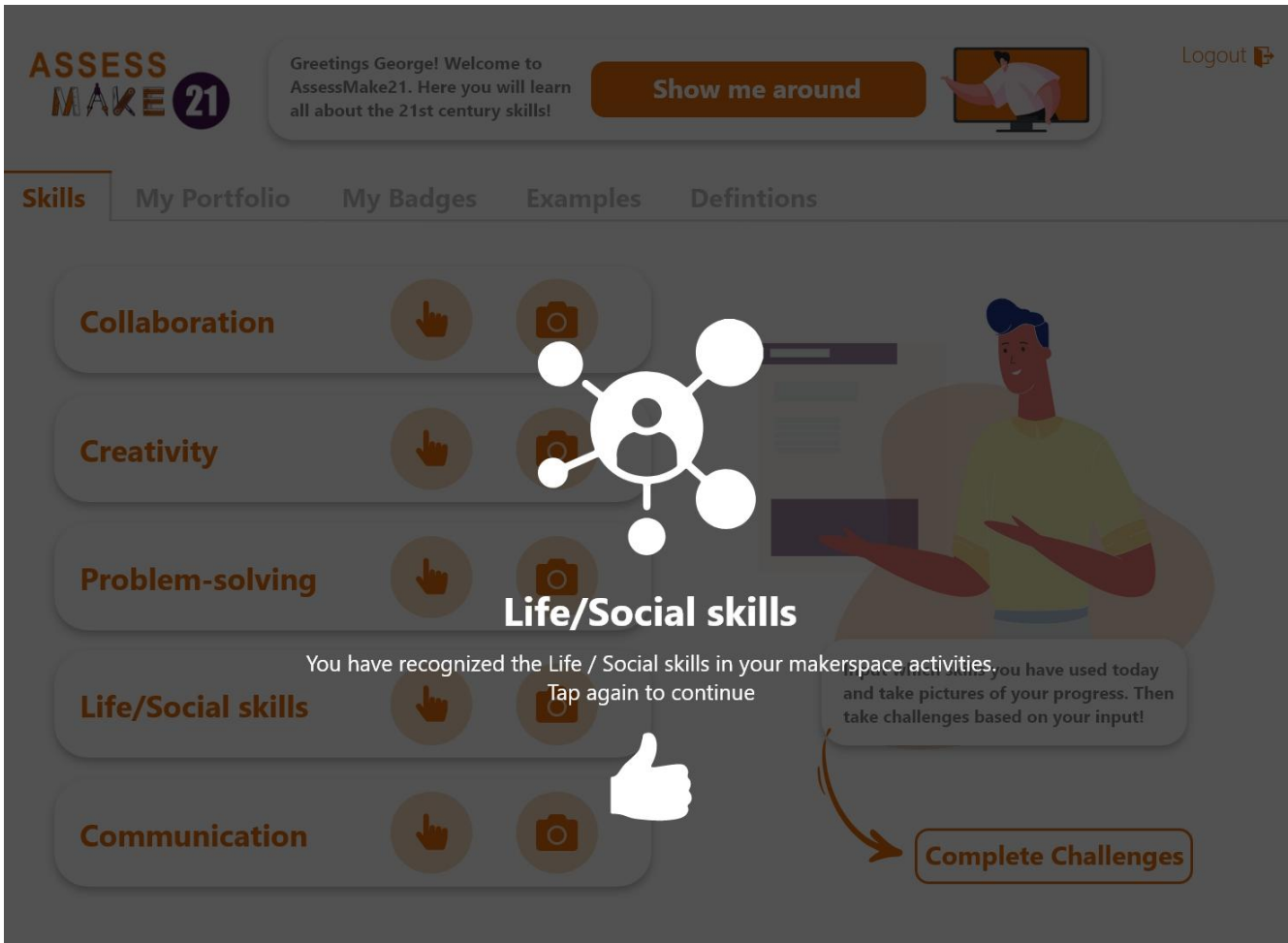
If the bar is full, it starts to fill up again with more opaque/darker colours every time the student completes a new challenge.

This creates the satisfaction of progression in a never ending experience



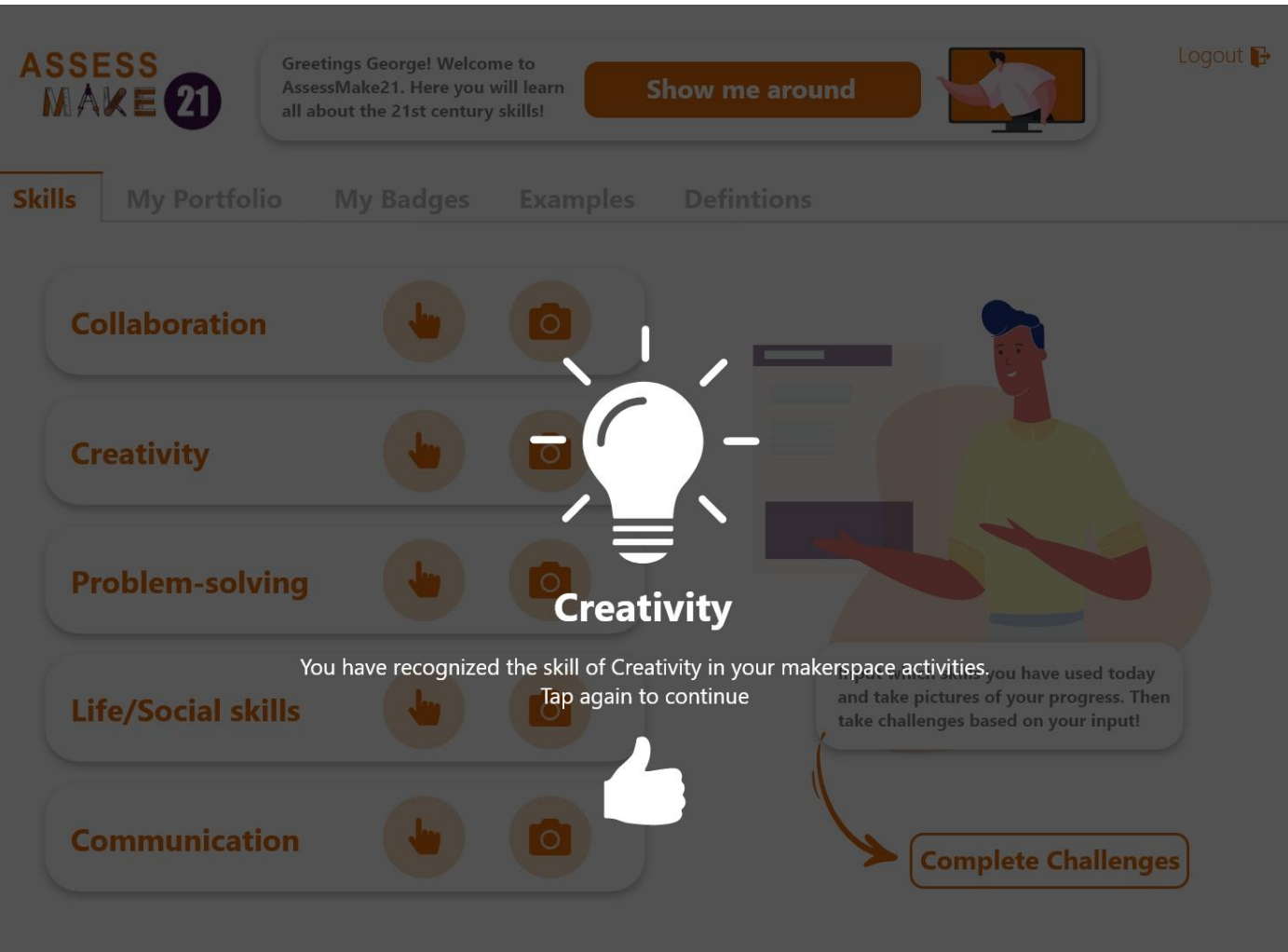
## Acknowledgment for reaching infinite level on all skills

| Element Label | Element Name | Type   | Description                               |
|---------------|--------------|--------|---|
| A             | Continue     | Button | Continues to the infinite level interface |



## Acknowledgment for Tagging a skill

| Element Label | Element Name         | Type           | Description  |
|---------------|----------------------|----------------|--|
|               | Life / Social Skills | Visual Element | <p>When a student clicks on a skill and then tags it, s/he gets an acknowledgment that s/he has successfully tagged a skill.</p> <p>Clicking anywhere the visuals disappear and the student continues using the tool</p> |



## Acknowledgment for Tagging a skill

| Element Label | Element Name | Type           | Description   |
|---------------|--------------|----------------|---|
|               | Creativity   | Visual Element | When a student clicks on a skill and then tags it, s/he gets an acknowledgment that s/he has successfully tagged a skill.<br><br>Clicking anywhere the visuals disappear and the student continues using the tool |



Collaboration

Creativity

Problem-solving

Life/Social skills

Communication

**Problem-solving**

You have recognized the skill of Problem-solving in your makerspace activities.

Tap again to continue

Makerspace activities have used today and take pictures of your progress. Then take challenges based on your input!

Complete Challenges

## Acknowledgment for Tagging a skill

| Element Label | Element Name    | Type           | Description   |
|---------------|-----------------|----------------|---|
|               | Problem-Solving | Visual Element | When a student clicks on a skill and then tags it, s/he gets an acknowledgment that s/he has successfully tagged a skill.<br><br>Clicking anywhere the visuals disappear and the student continues using the tool |



Collaboration



Creativity



Problem-solving



Life/Social skills



Communication



You have recognized the skill of Collaboration in your makerspace activities. Tap again to continue



makerspace activities you have used today and take pictures of your progress. Then take challenges based on your input!

Complete Challenges

## Acknowledgment for Tagging a skill

| Element Label | Element Name  | Type           | Description   |
|---------------|---------------|----------------|---|
|               | Collaboration | Visual Element | When a student clicks on a skill and then tags it, s/he gets an acknowledgment that s/he has successfully tagged a skill.<br><br>Clicking anywhere the visuals disappear and the student continues using the tool |



Collaboration



Creativity



Problem-solving



Life/Social skills

You have recognized the Life / Social skills in your makerspace activities.

Tap again to continue

Life/Social skills



Communication

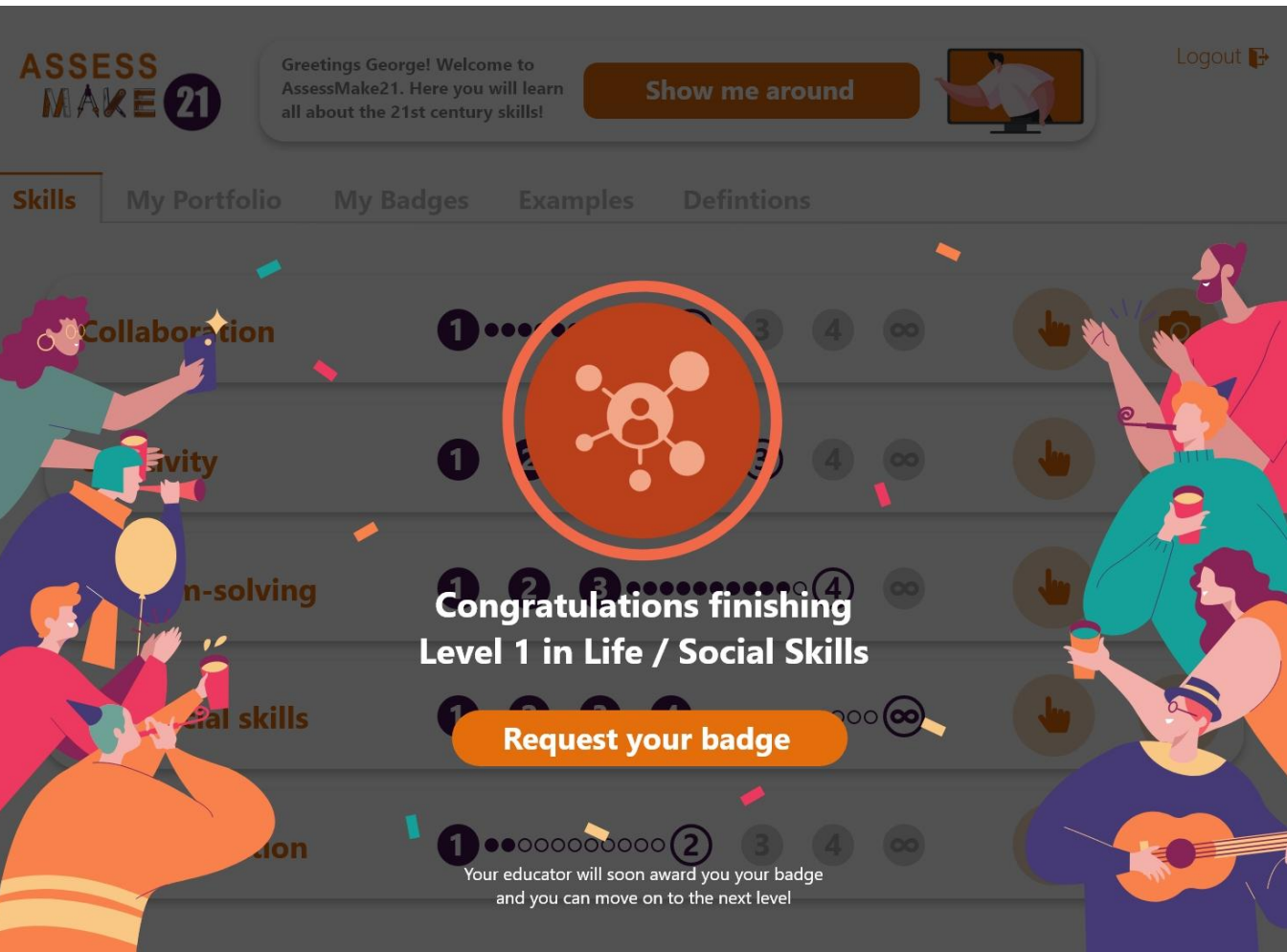


Take pictures of your progress. Then take challenges based on your input!

Complete Challenges

## Acknowledgment for Tagging a skill

| Element Label | Element Name  | Type           | Description   |
|---------------|---------------|----------------|---|
|               | Communication | Visual Element | When a student clicks on a skill and then tags it, s/he gets an acknowledgment that s/he has successfully tagged a skill.<br><br>Clicking anywhere the visuals disappear and the student continues using the tool |



## Acknowledgment for finishing a level of a certain skill

| Element Label | Element Name         | Type   | Description  |
|---------------|----------------------|--------|--|
| A             | Request badge button | Button | <p>When a student finishes a level s/he gets a celebratory acknowledgment and then by clicking the button s/he can request a badge from the educator.</p> <p>When the badge is awarded the student-can continue to progress onto the next level of the skill</p> |

## Second Approach : Tagging(input) During Makerspace Activities / Challenges at the End

With the second approach of the tool the students are able to tag skills during their Makerspace Activities when they feel that they are using 21st century skills.

At the end of the classroom they can take a series of challenges based on what skills they have been tagging the entire time.

For this reason a dedicated interface (slightly altered) is needed



Collaboration



Creativity



Problem-solving



Life/Social skills



Communication

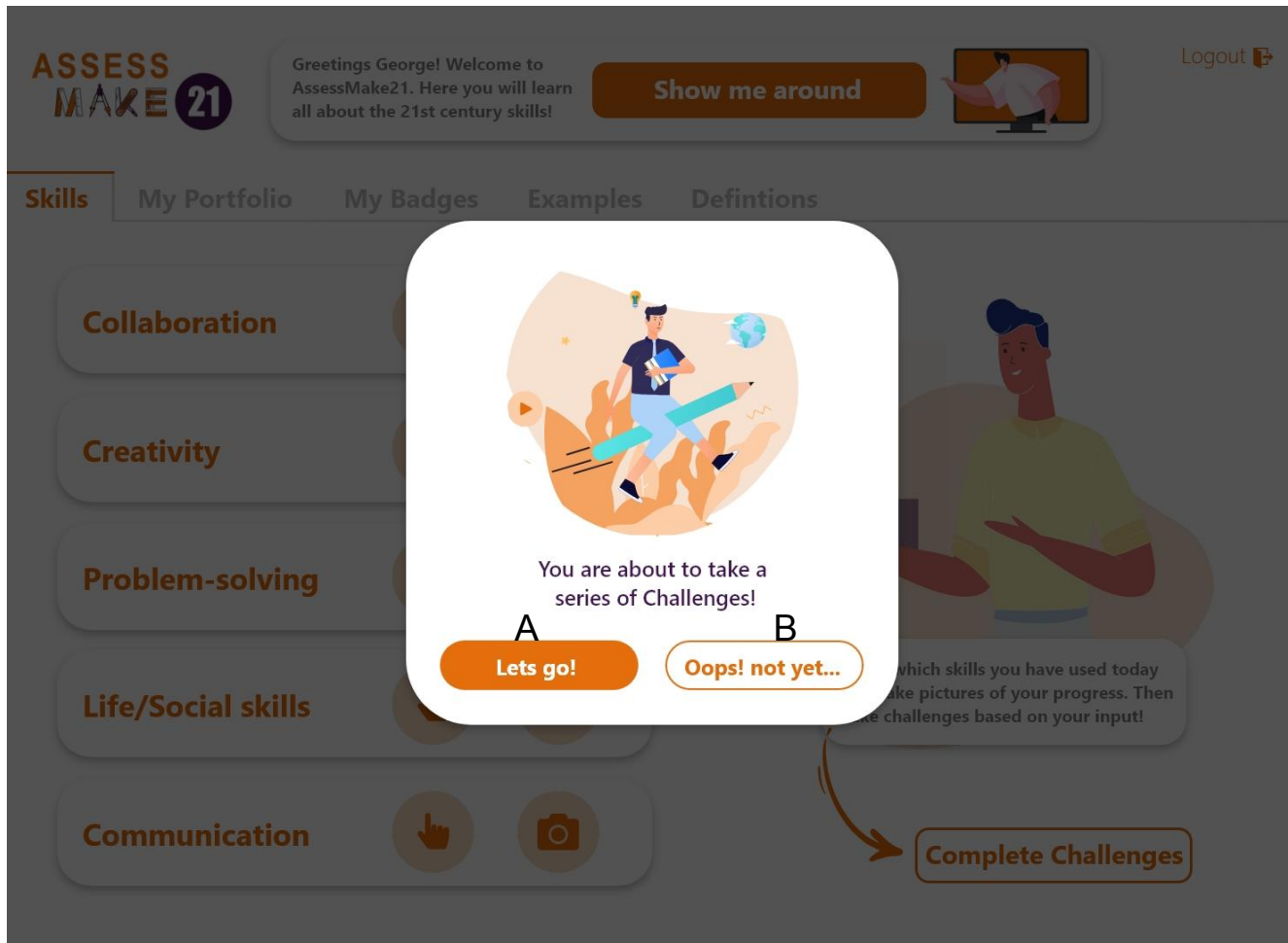


Input which skills you have used today and take pictures of your progress. Then take challenges based on your input!

Complete Challenges B

Interface for the **second approach** (tagging during making activities, while leaving challenges for the end of the making activities)

| Element Label | Element Name    | Type        | Description   |
|---------------|-----------------|-------------|---|
| A             | Index           | Button Icon | Students can press each button to “tag” a skill   |
| B             | Take Challenges | Button      | At the end of their classroom they can press ‘take challenges’. This leads them to take a series of challenges based on what they have tagged during their making activities. |
| C             | Camera          | Button Icon | Students can take pictures of their examples (as artifacts of their projects) for that skill  |



This is a warning window to let the students know that they are going to start taking challenges based on their input (avoiding like this any misclicks)

\* the same applies for both two approaches that give the activities at the end

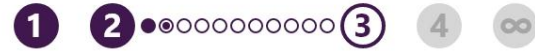
| Element Label | Element Name     | Type   | Description                                |
|---------------|------------------|--------|--|
| A             | Lets go!         | Button | Take the student to a series of challenges |
| B             | Oops! not yet... | Button | Keep user in the page                      |



Collaboration



Creativity



Problem-solving



Life/Social skills

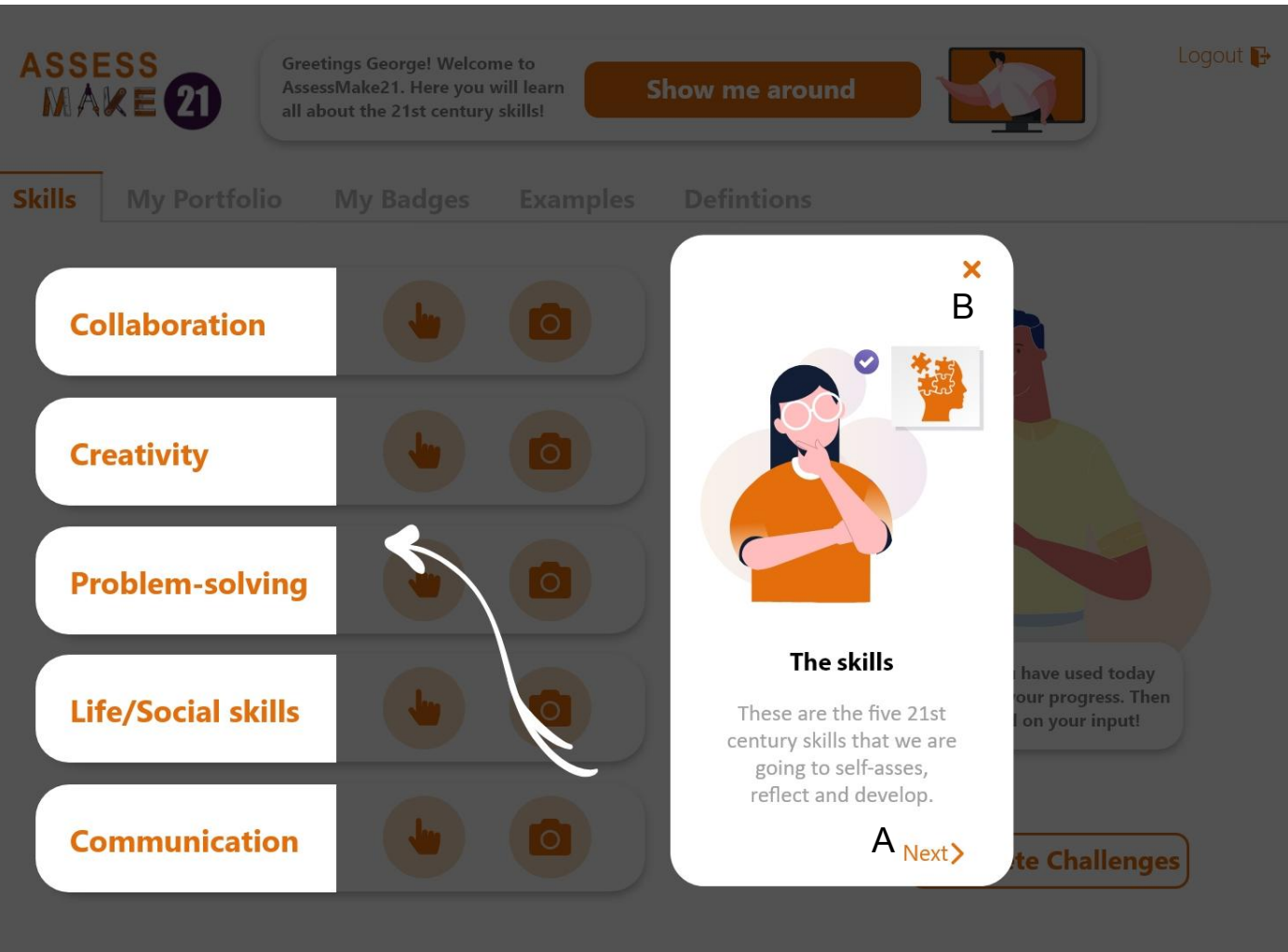


Communication



Interface for the **second approach** (tagging during makerspace activities, ) after they have completed their challenges and they get to see their progress

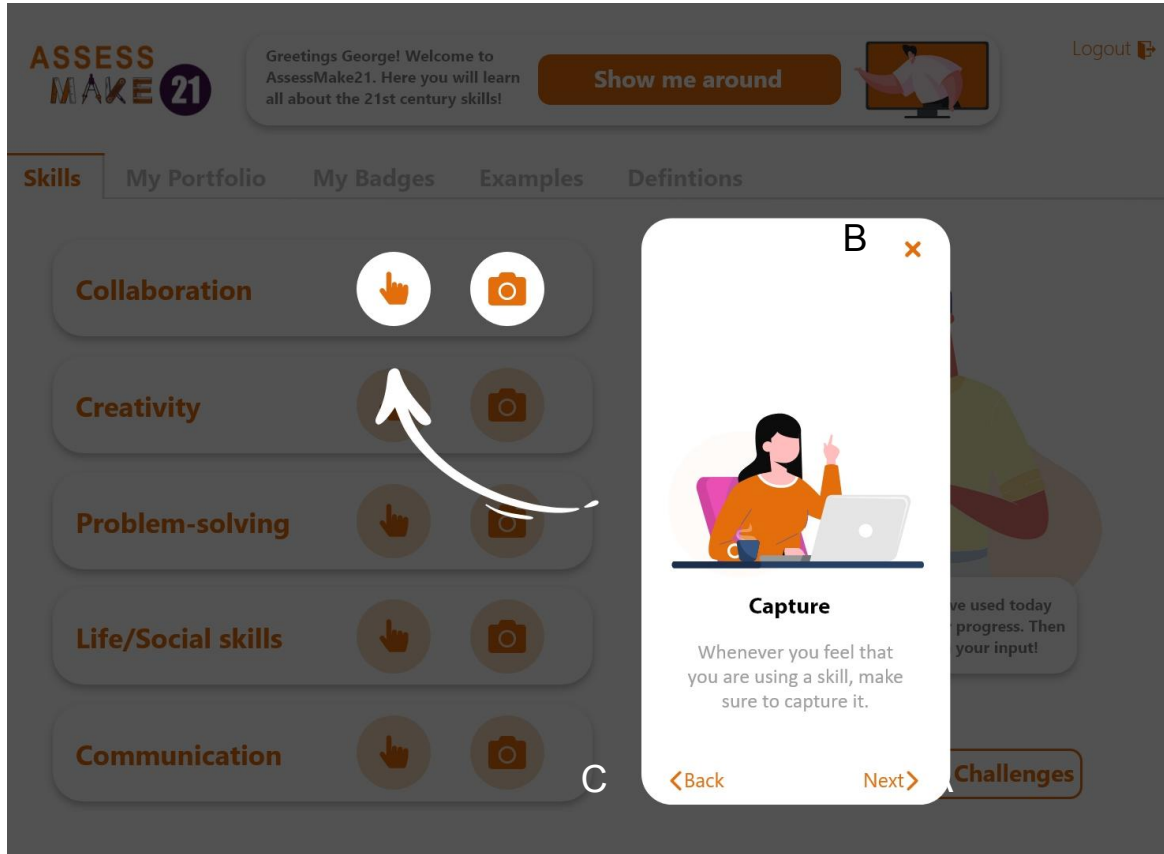




## Guided tour of the tool

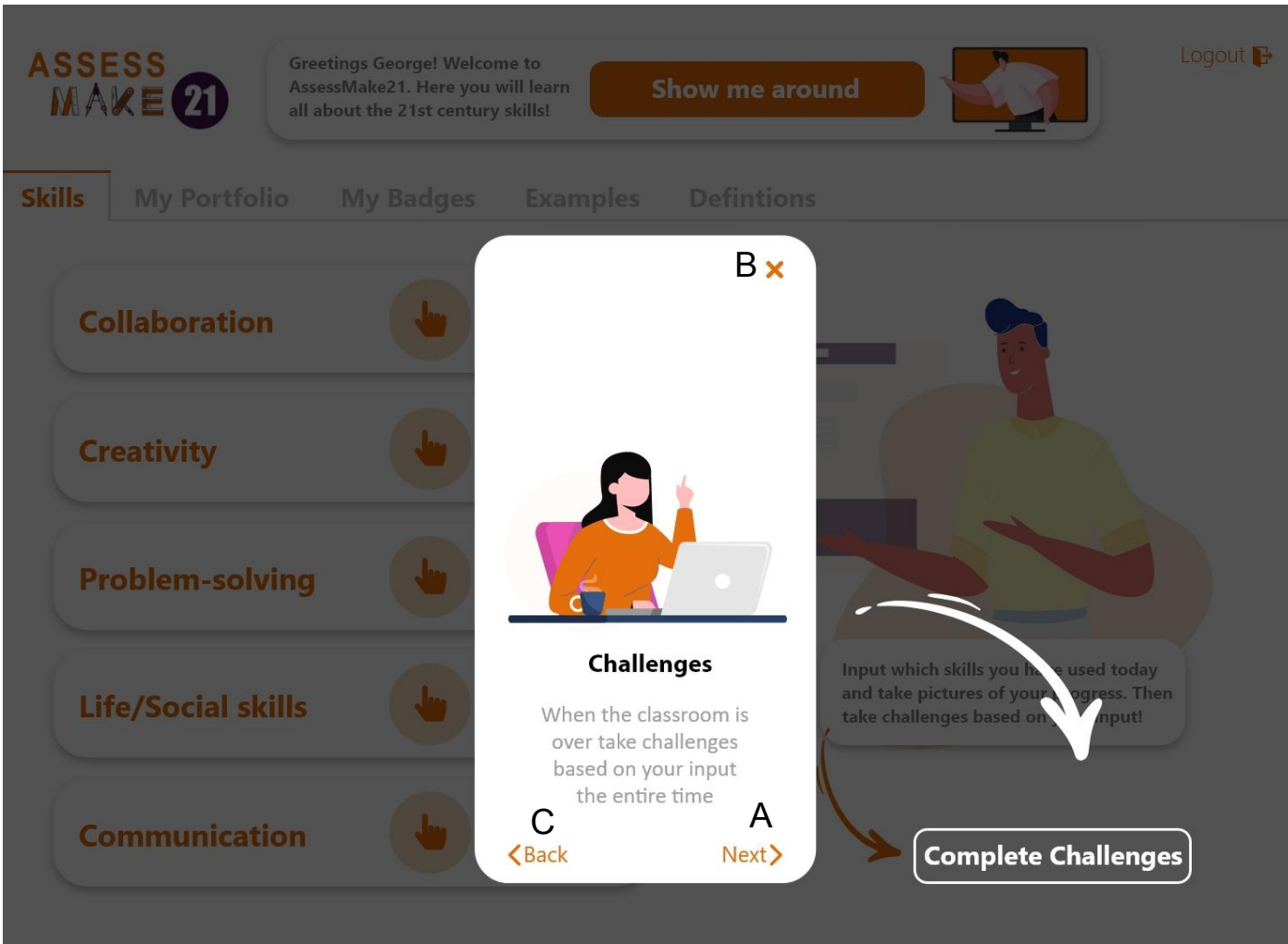
| Element Label | Element Name | Type      | Description                        |
|---------------|--------------|-----------|------------------------------------|
| A             | Next         | Text Link | Takes the user to the next element |
| B             | X            | Icon Link | Exit Tour                          |

the guided tour is the same for all approaches except the elements of interaction



## Guided tour of the tool

| Element Label | Element Name | Type      | Description                          |
|---------------|--------------|-----------|--------------------------------------|
| A             | Next         | Text Link | Takes the user to the next element   |
| B             | X            | Icon Link | Exit Tour                            |
| C             | Back         | Text Link | Take the user to the preview element |



## Guided tour of the tool

| Element Label | Element Name | Type      | Description                          |
|---------------|--------------|-----------|--------------------------------------|
| A             | Next         | Text Link | Takes the user to the next element   |
| B             | X            | Icon Link | Exit Tour                            |
| C             | Back         | Text Link | Take the user to the preview element |



< Back

Based on the skills you used during your making session you will complete the following challenges



Collaboration

3

challenges



Creativity

0

challenges



Problem Solving

A

3

challenges



Life / Social Skills

2

challenges



Communication

1

challenges

Start

B

Before students start doing activites the get an overview on how many activities they will take base on what they were doing during the classroom

| Element Label | Element Name | Type   | Description  |
|---------------|--------------|--------|--|
| A             | Skill Label  | Label  | Clicking on the label shows how many times they used that skill (see next slide) |
| B             | Start        | Button | Take student to the sequence of challenges                                       |



< Back

Based on the skills you used during your making session you will complete the following challenges



Collaboration

3

challenges



Creativity

0

challenges



Problem Solving

3

times used this skill



Life / Social Skills

2

challenges



Communication

1

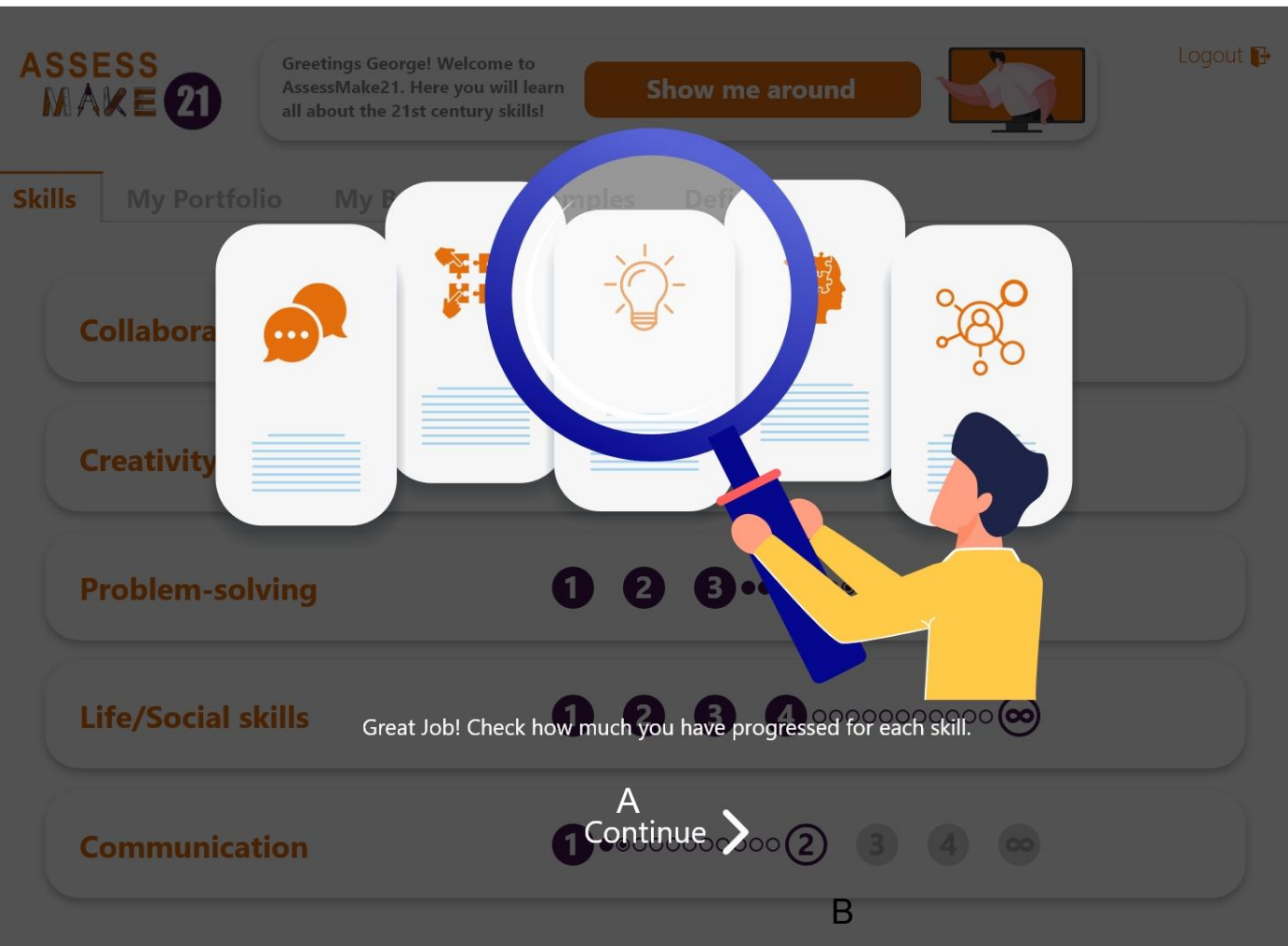
challenges

Start

B

Before students start doing activites the get an overview on how many activities they will take base on what they were doing during the classroom

| Element Label | Element Name | Type   | Description   |
|---------------|--------------|--------|---|
| A             | Skill Label  | Label  | Clicking on the label shows how many activities they will take on that skill (see previews slide) |
| B             | Start        | Button | Take student to the sequence of challenges  |



After students finish the activities they are greeted here, explaining what they are seeing

| Element Label | Element Name | Type      | Description   |
|---------------|--------------|-----------|---|
| A             | Continue     | Text Link | The visuals hide revealing the progress of the levels |

## Third Approach: Challenges and Tagging (input) using Scale Bars at the end

With the third approach, the students are able to use a scale bar to rate the 21st century skills they believe to have used (and to what extent) after completing their Makerspace activities.

Following that, they will take a series of challenges based on their tagging input.



Rate which skills you have used today and in what extend. Then complete some challenges for them.



Collaboration

A lot

A



Next >

B

Interface for the **third approach** (tagging/challenges at the end of the makerspace activities)

| Element Label | Element Name | Type      | Description   |
|---------------|--------------|-----------|---|
| A             | Scale Bar    | Scale Bar | Students can rate which skills they believe to have used during their makerspace activities and in what extend using the Marzano Scale Bar 0-4 (0 as default) |
| B             | Next         | Button    | Take student to the next skill to rate  |





Rate which skills you have used today and in what extend. Then complete some challenges for them.



Creativity

Sometimes

A

0

2

4

< Back

Next >

B

Interface for the **third approach** (tagging/challenges at the end of the makerspace activities)

| Element Label | Element Name | Type      | Description   |
|---------------|--------------|-----------|---|
| A             | Scale Bar    | Scale Bar | Students can rate which skills they believe to have used during their makerspace activities and in what extend using the Marzano Scale Bar 0-4 (0 as default) |
| B             | Next         | Button    | Take student to the next skill to rate  |



Rate which skills you have used today and in what extend. Then complete some challenges for them.



Life / Social skills

All the time

A

0

4

4

< Back

Next >

B

Interface for the **third approach** (tagging/challenges at the end of the makerspace activities)

| Element Label | Element Name | Type      | Description   |
|---------------|--------------|-----------|---|
| A             | Scale Bar    | Scale Bar | Students can rate which skills they believe to have used during their makerspace activities and in what extend using the Marzano Scale Bar 0-4 (0 as default) |
| B             | Next         | Button    | Take student to the next skill to rate  |



Rate which skills you have used today and in what extend. Then complete some challenges for them.



Interface for the **third approach** (tagging/challenges at the end of the makerspace activities)

| Element Label | Element Name | Type      | Description   |
|---------------|--------------|-----------|---|
| A             | Scale Bar    | Scale Bar | Students can rate which skills they believe to have used during their makerspace activities and in what extend using the Marzano Scale Bar 0-4 (0 as default) |
| B             | Next         | Button    | Take student to the next skill to rate  |



Rate which skills you have used today and in what extend. Then complete some challenges for them.



Not at all A

0 0 4

Interface for the **third approach** (tagging/challenges at the end of the makerspace activities)

| Element Label | Element Name    | Type      | Description   |
|---------------|-----------------|-----------|---|
| A             | Scale Bar       | Scale Bar | Students can rate which skills they believe to have used during their makerspace activities and in what extend using the Marzano Scale Bar 0-4 (0 as default) |
| B             | Take Challenges | Button    | Take student to the overview of activities  |



< Back

Based on the skills you used during your making session you will complete the following challenges



Collaboration

3

challenges



Creativity

0

challenges



Problem Solving

A

3

challenges



Life / Social Skills

2

challenges



Communication

1

challenges

Start

B

Before students start doing activites the get an overview on how many activities they will take base on what they were doing during the classroom

| Element Label | Element Name | Type   | Description  |
|---------------|--------------|--------|--|
| A             | Skill Label  | Label  | Clicking on the label shows how many times they used that skill (see next slide) |
| B             | Start        | Button | Take student to the sequence of challenges                                       |



< Back

Based on the skills you used during your making session you will complete the following challenges



Collaboration

3

challenges



Creativity

0

challenges



Problem Solving

3

times used this skill



Life / Social Skills

2

challenges



Communication

1

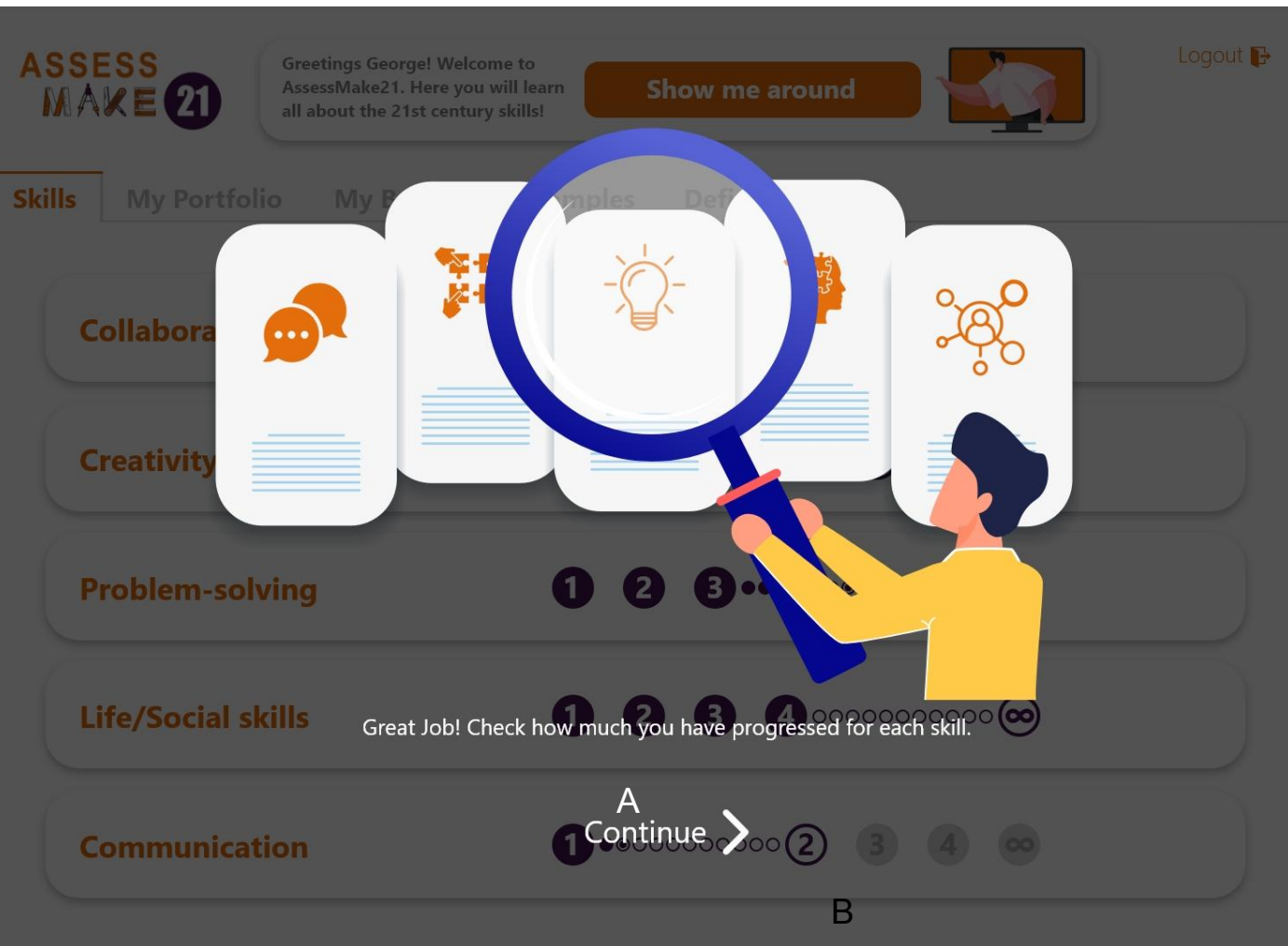
challenges

Start

B

Before students start doing activites the get an overview on how many activities they will take base on what they were doing during the classroom

| Element Label | Element Name | Type   | Description   |
|---------------|--------------|--------|---|
| A             | Skill Label  | Label  | Clicking on the label shows how many activities they will take on that skill (see previews slide) |
| B             | Start        | Button | Take student to the sequence of challenges  |



After students finish the activities they are greeted here, explaining what they are seeing

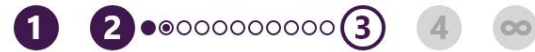
| Element Label | Element Name | Type      | Description   |
|---------------|--------------|-----------|---|
| A             | Continue     | Text Link | The visuals hide revealing the progress of the levels |



Collaboration



Creativity



Problem-solving



Life/Social skills

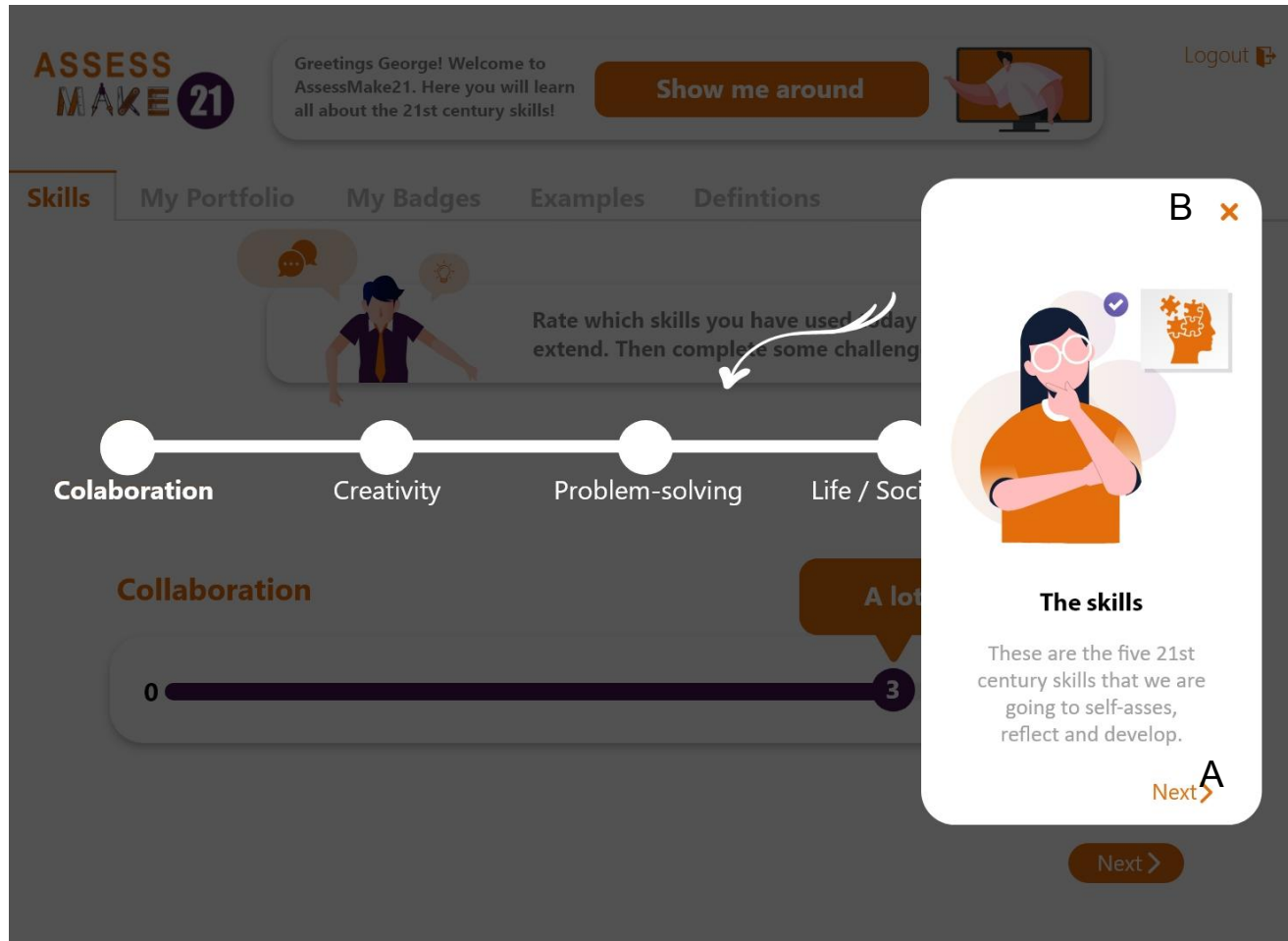


Communication



Interface for the third approach after they have completed their challenges and they get to see their progress





## Guided tour of the tool

| Element Label | Element Name | Type      | Description                        |
|---------------|--------------|-----------|------------------------------------|
| A             | Next         | Text Link | Takes the user to the next element |
| B             | X            | Icon Link | Exit Tour                          |

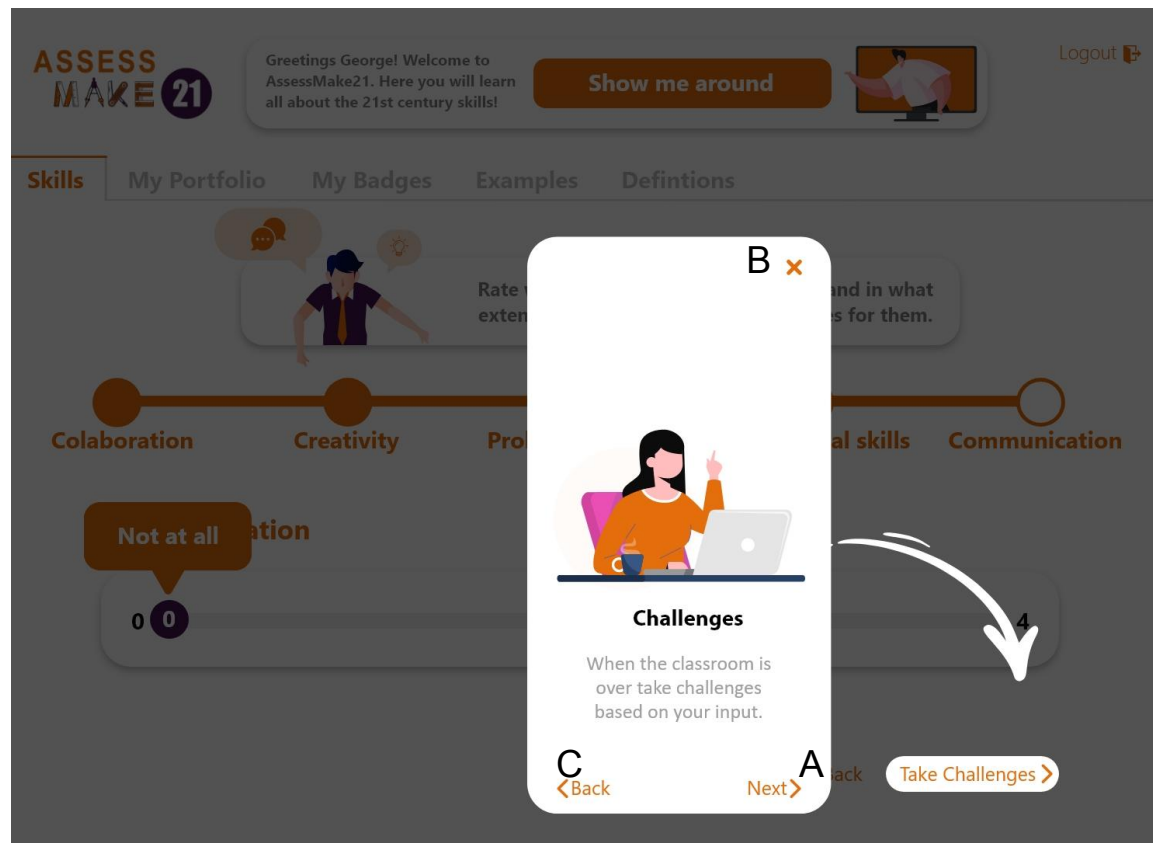
the guided tour is the same for all approaches except the elements of interaction

The screenshot shows the ASSESS MAKE 21 interface. At the top, there is a navigation bar with 'Skills', 'My Portfolio', 'My Badges', 'Examples', and 'Defintions'. A 'Show me around' button is visible. Below the navigation, there are skill categories: 'Collaboration', 'Creativity', 'Problem-solving', and 'Life / Social'. A progress bar for 'Collaboration' is shown with a value of 3. A guided tour overlay is active, featuring a 'Capture' button and navigation links 'Back C' and 'Next A'. The overlay also contains a description: 'At the end of your classroom rate in which skills and in what extend you were using them.'

## Guided tour of the tool

| Element Label | Element Name | Type      | Description                          |
|---------------|--------------|-----------|--------------------------------------|
| A             | Next         | Text Link | Takes the user to the next element   |
| B             | X            | Icon Link | Exit Tour                            |
| C             | Back         | Text Link | Take the user to the preview element |

the guided tour is the same for all approaches except the elements of interaction



## Guided tour of the tool

| Element Label | Element Name | Type      | Description                          |
|---------------|--------------|-----------|--------------------------------------|
| A             | Next         | Text Link | Takes the user to the next element   |
| B             | X            | Icon Link | Exit Tour                            |
| C             | Back         | Text Link | Take the user to the preview element |



A

Collaboration

Creativity

Problem-solving

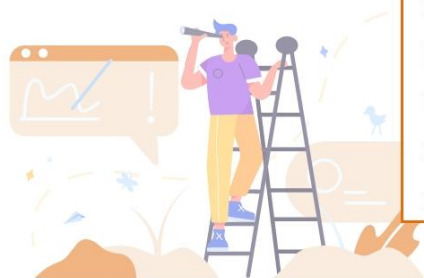
Life/Social Skills

Communication

B

Choose Level 

- Level 1
- Level 2
- Level 3
- Level 4
- Level ∞



C Choose a level to see your examples

## My Portfolio

| Element Label | Element Name                       | Type        | Description  |
|---------------|------------------------------------|-------------|--|
| A             | <Skill>                            | Button      | Pressing on each skill, students are able to choose a level and then see their examples on a specific skill on a specific level. |
| B             | Choose Level                       | Select menu | Select menu that filters the examples based on the levels in each skill  |
| C             | Choose a level to see your example | Image       | A description on what the student is expected to do on this page, and a placeholder image if nothing is selected.                |



Collaboration

Creativity

Problem-solving

Life/Social Skills

Communication

A

Collaboration : Level 1 - Example01

During our making session I was able to collaborate with other students to brainstorm ideas for our project

B

C

27/02/2021

Collaboration : Level 1 - Example02

I contributed with my classmates in building a city made out of cardboards. I connected my house with my friends in

28/02/2021

Choose Level

Level 1

Level 2

Level 3

Level 4

Level ∞

D



E < 1 2 3 >

## My Portfolio

| Element Label | Element Name     | Type       | Description   |
|---------------|------------------|------------|---|
| A             | Title            | Text       | The title of each example   |
| B             | Explanation      | Text       | The answers that students provided for the example  |
| C             | Date             | Text       | The date of the image uploaded  |
| D             | Artifact Picture | Image      | The image that students uploaded. Clicking on the image displays an enlarged version in a lightbox view |
| E             | Pages            | Pagination | Students can navigate through pages to see more examples  |



A

Collaboration

Creativity

Problem-solving

Life/Social Skills

Communication



Choose a 21st century skill to see your badges

B

## Badges Page

| Element Label | Element Name | Type       | Description                |
|---------------|--------------|------------|----------------------------|
| A             | <Skill>      | Button     | Filtering badges per skill |
| B             | Explanation  | Image/text | no interaction             |



Collaboration

**Creativity**

Problem-solving

Life/Social Skills

Communication



A

Creativity  
Level 1



Creativity  
Level 2



Creativity  
Level 3



Creativity  
Level 4

## Badges Page

| Element Label | Element Name | Type  | Description   |
|---------------|--------------|-------|---|
| A             | Badges       | Image | Each badge represents the completion of a level within a certain skill / no interaction |



Take a picture of your example

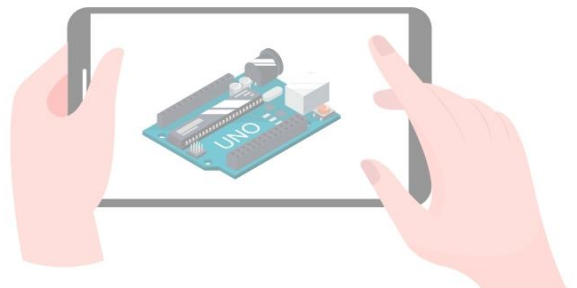
C

—OR—



Upload a picture of your example

D



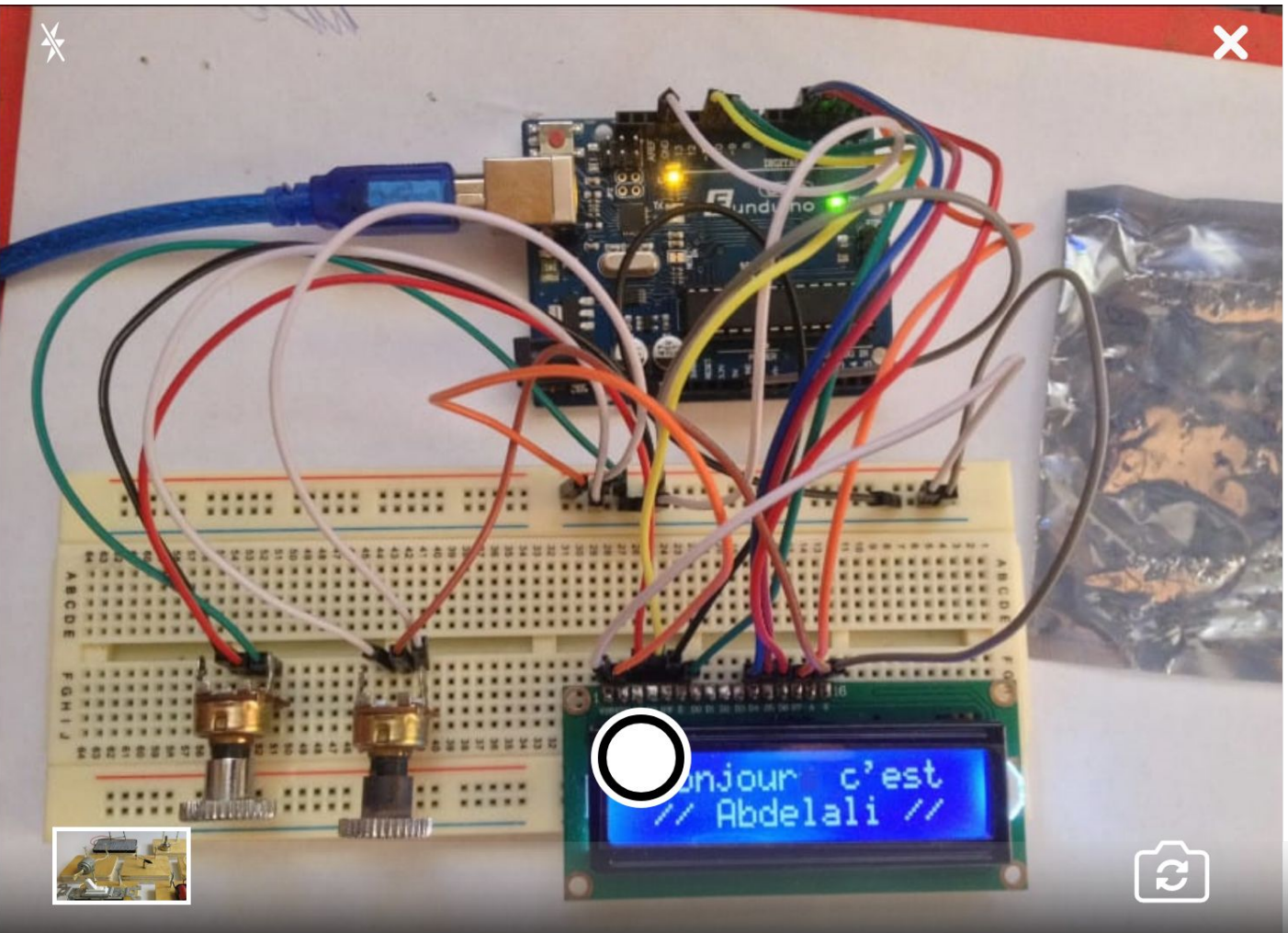
E

Take a picture of your project as an example of developing your 21st century skill and reflect on it

## Show your example

| Element Label | Element Name                     | Type             | Description  |
|---------------|----------------------------------|------------------|--|
| A             | “Show your example” Title        | Text             | The title of the page  |
| B             | Back                             | Text Link        | Back button that takes the students back                               |
| C             | Take a picture of your example   | Text & Icon Link | Clicking here allows the students to take a picture using their device |
| D             | Upload a picture of your example | Text & Icon Link | Clicking here allows the students to upload an image from their device |
| E             | Explanation                      | Text & Image     | Text and visuals explain to the students what they are expected to do  |





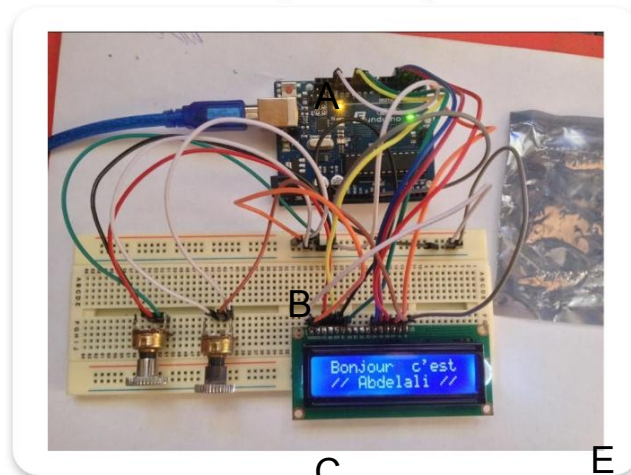
The student takes a picture



< Back D



Is the picture okay?



D

No, retake

Yes >

## Show your example

| Element Label | Element Name | Type      | Description   |
|---------------|--------------|-----------|---|
| A             | Back         | Text Link | Go back   |
| B             | Wizard       | Graphic   | Break the challenge in 4 parts to avoid cognitive overload. Users can revisit specific part by clicking the number (always previews actions not steps that did not complete yet). |
| C             | Picture      | Image     | No Interaction  |
| D             | No, Retake   | Button    | Retake the picture  |
| E             | Yes          | Button    | Continue to the next part of this wizard  |



A



What were you doing in this example of creativity ?

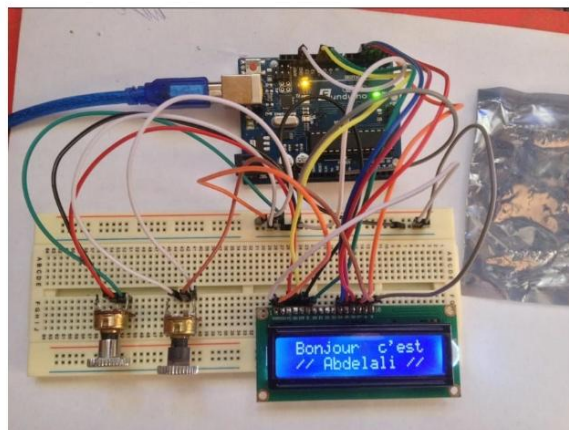
B

E

< Back

Next >

D



C

## Show your example

| Element Label | Element Name         | Type      | Description   |
|---------------|----------------------|-----------|---|
| A             | Wizard               | Graphic   | Break the challenge in 4 parts to avoid cognitive overload. Users can revisit specific part by clicking the number (always previews actions not steps that did not complete yet). |
| B             | Activity             | Text Box  | Open Ended Question   |
| C             | Image of the example | Image     | Picture of the image that the student took  |
| D             | Save                 | Button    | A button that saves the input from the student and takes him/her back   |
| E             | Back                 | Text Link | User can go to the preview part of the challenge  |



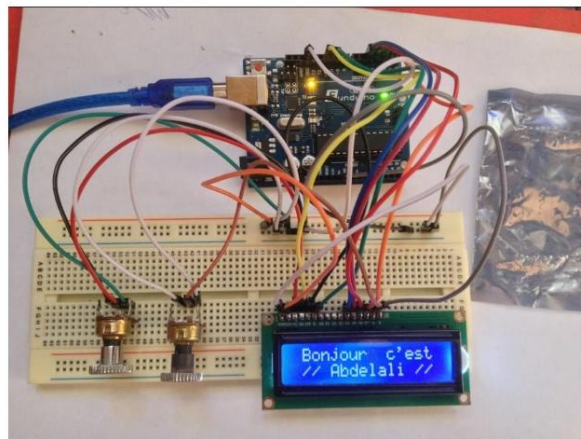
How is it a good example of creativity

B

D

E

< Back Next >



C

## Show your example

| Element Label | Element Name         | Type      | Description   |
|---------------|----------------------|-----------|---|
| A             | Wizard               | Graphic   | Break the challenge in 4 parts to avoid cognitive overload. Users can revisit specific part by clicking the number (always previews actions not steps that did not complete yet). |
| B             | Activity             | Text Box  | Open Ended Question   |
| C             | Image of the example | Image     | Picture of the image that the student took  |
| D             | Save                 | Button    | A button that saves the input from the student and takes him/her back   |
| E             | Back                 | Text Link | User can go to the preview part of the challenge  |

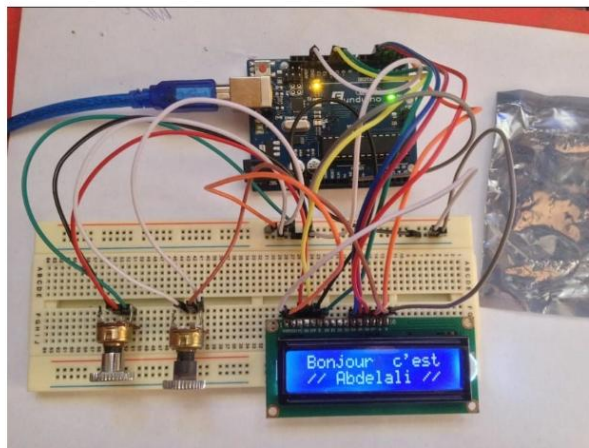


Rate how good an example of creativity it is.



E  
Back

D  
Save



## Show your example

| Element Label | Element Name         | Type      | Description   |
|---------------|----------------------|-----------|---|
| A             | Wizard               | Graphic   | Break the challenge in 4 parts to avoid cognitive overload. Users can revisit specific part by clicking the number (always previews actions not steps that did not complete yet). |
| B             | Activity             | Scale Bar | Students rate how good this example is using Marzano scale (0 default)  |
| C             | Image of the example | Image     | Picture of the image that the student took  |
| D             | Save                 | Button    | A button that saves the input from the student and takes him/her back   |
| E             | Back                 | Text Link | User can go to the preview part of the challenge  |



Collaboration

A

Creativity

Problem-solving

Life/Social Skills

Communication



B

Choose a 21st century skill to see an example

## See Examples

| Element Label | Element Name | Type         | Description  |
|---------------|--------------|--------------|--|
| A             | <Skill>      | Button       | By clicking on a button, students can select the examples they wish to view under a specific skill |
| B             | Instructions | Image / Text | No interaction   |



A

Collaboration

Creativity

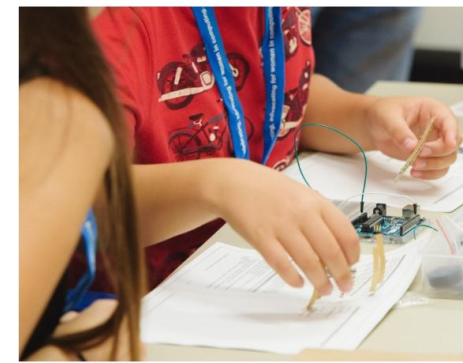
Problem-solving

Life/Social Skills

Communication

B

This is a good example of collaboration with my group, because we are all focused on our work with the Arduino, we contribute equally and share our ideas.



C

**Definition**

Collaborative learning is an active form of learning between two or more individuals that work together in a physical or virtual environment. Group members continuously attempt to build and maintain a shared understanding of the problem they are working to solve.

D

## Examples

| Element Label | Element Name | Type            | Description  |
|---------------|--------------|-----------------|--|
| A             | <Skill>      | Button          | Students can choose from which skill they want to see an example of                              |
| B             | Context      | Text            | Provides a description for the image   |
| C             | Picture      | Image           | No Interaction   |
| D             | Definition   | Collapsible Tab | Give the definition of the skill to support the example. Collapsible to avoid cognitive overload |
| E             | Pages        | Pagination      | Users can see another different example  |



Collaboration

A

Creativity

Problem-solving

Life/Social Skills

Communication



B

Choose a 21st century skill to learn more about it

| Element Label | Element Name | Type        | Description  |
|---------------|--------------|-------------|--|
| A             | <Skill>      | Button      | Students can learn more about each skill (definitions, elements, outcomes) |
| B             | Instructions | Image /Text | No interaction placeholder image if nothing is selected                    |





A

Collaboration

Creativity

Problem-solving

Life/Social Skills

Communication

**What is Collaboration?**

Collaborative learning is an active form of learning between two or more individuals that work together in a physical or virtual environment. Group members continuously attempt to build and maintain a shared understanding of the problem they are working to solve.

B

Collaborative learning is developed through these dimensions.

Develop shared understanding



Contribute collectively



Regulate the work of the group

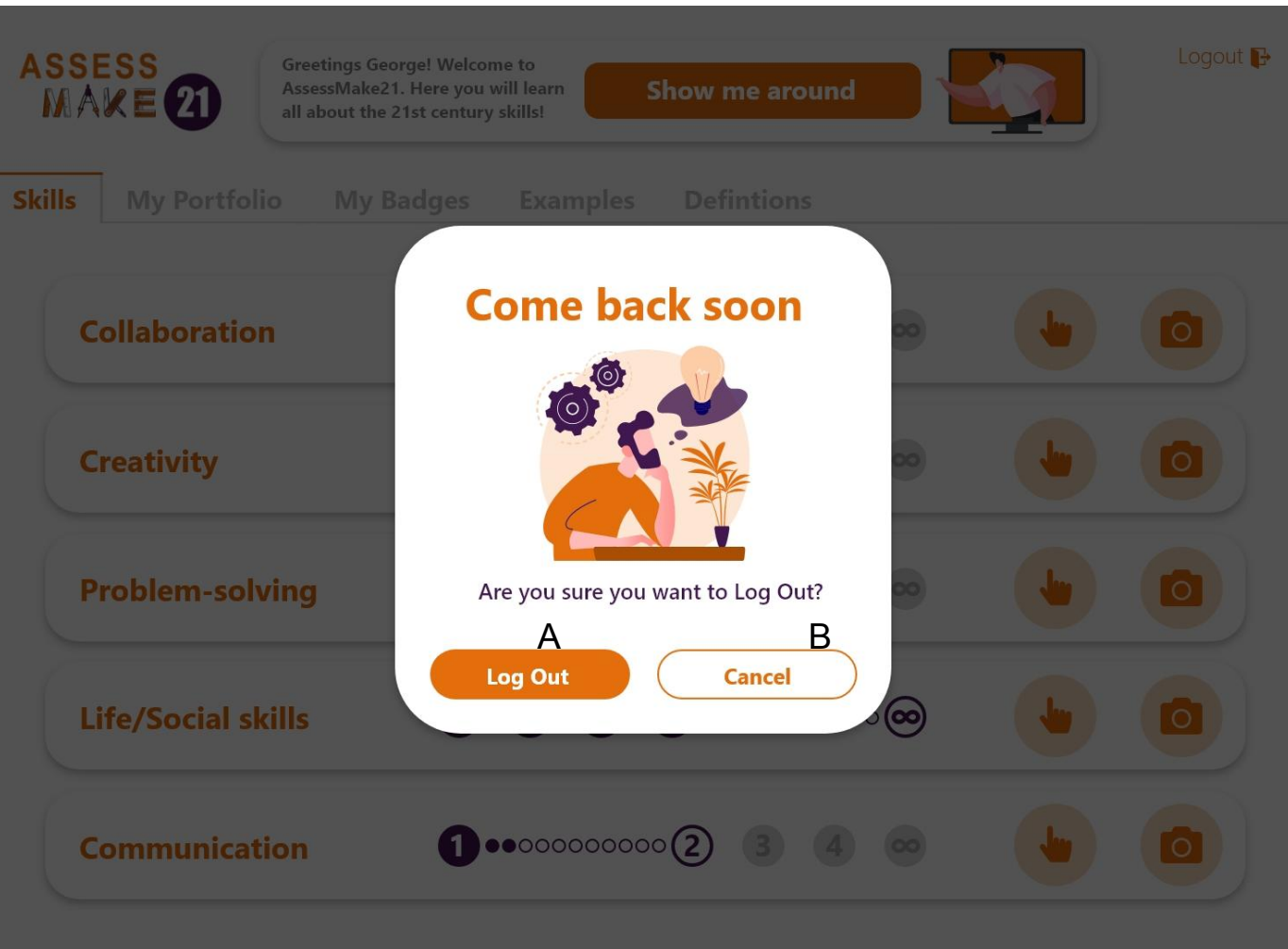


Develop good relationships with others and a sense of well-being in a group



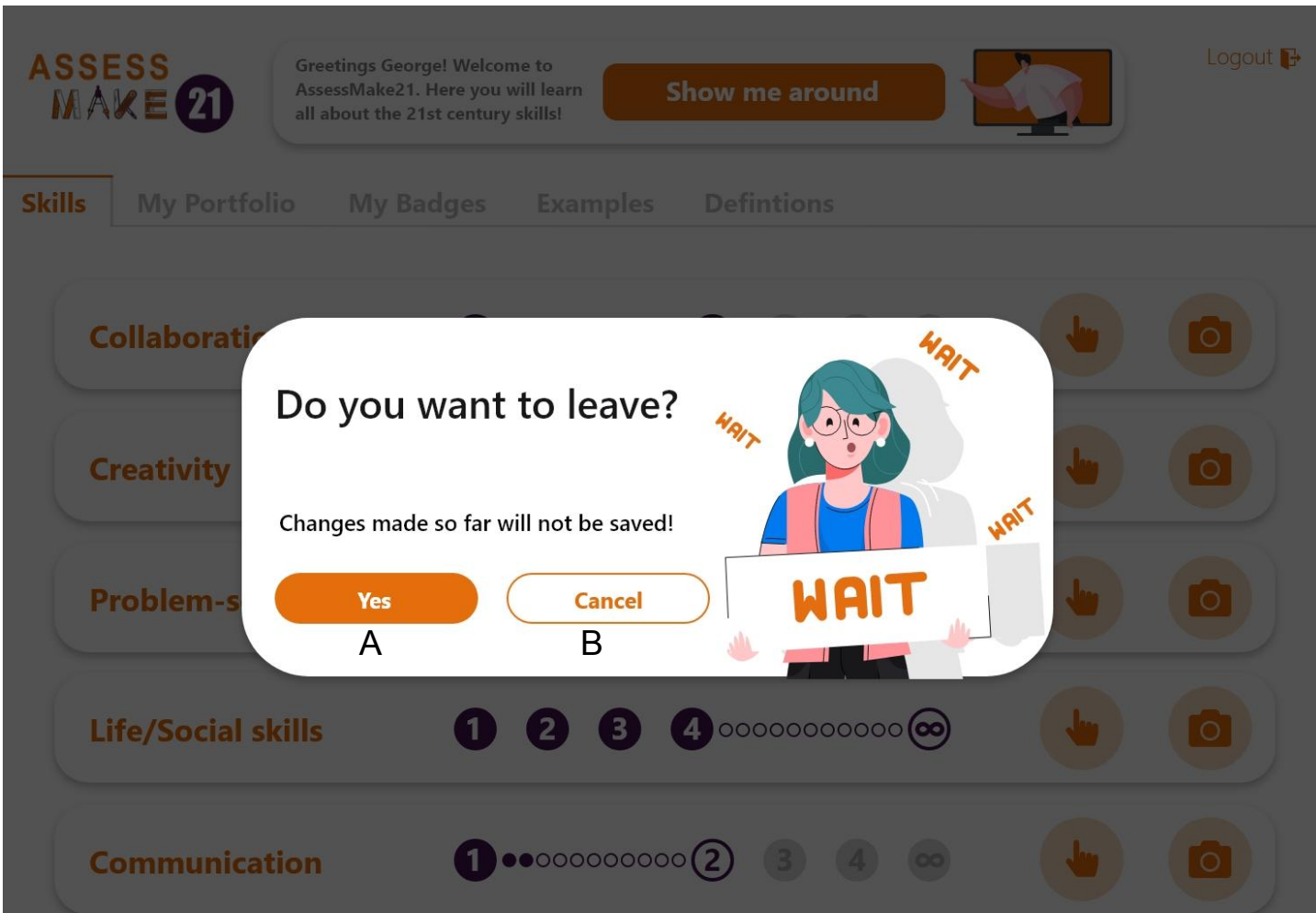
C

| Element Label | Element Name | Type      | Description  |
|---------------|--------------|-----------|--|
| A             | <Skill>      | Button    | Students can learn more about each skill (definitions, elements, outcomes) |
| B             | Body Text    | Text      | Context for the image  |
| C             | Dimensions   | Accordion | Collapse all the outcomes of each dimension to avoid cognitive overload    |



This is a warning window to let the students know that they are trying to log out. Avoiding any misclicks on the Log out Button

| Element Label | Element Name | Type   | Description         |
|---------------|--------------|--------|---------------------|
| A             | Log Out      | Button | Log out the user    |
| B             | Cancel       | Button | Keep user logged in |



This is a warning window to let the students know that any changes will not be saved if they leave a certain activity. (For example not completing a challenge, not taking a picture etc)

| Element Label | Element Name | Type   | Description                       |
|---------------|--------------|--------|-----------------------------------|
| A             | Yes          | Button | Allow user to leave from the page |
| B             | Cancel       | Button | Keep user in the page             |



How would you assess yourself as a collaborator today from a scale of 0-4? A



A Done >

## Challenge

| Element Label | Element Name | Type          | Description                               |
|---------------|--------------|---------------|---|
| A             | Instructions | Text          | No interaction                            |
| B             | Scale        | Marzano Scale | Students rate from 0-4 (0 to be default)  |
| C             | Done         | Text Link     | Complete the challenge by pressing "Done" |



How did this tool help you develop Collaboration? Share this moment here.

A

A tool or equipment that helped me develop Collaboration was ...

B

Done > C

## Challenge

| Element Label | Element Name     | Type      | Description                               |
|---------------|------------------|-----------|---|
| A             | Instructions     | Text      | No interaction                            |
| B             | Student's Answer | Text Box  | Students answer an open ended question    |
| C             | Done             | Text Link | Complete the challenge by pressing "Done" |



How does "developed shared understanding" make you feel? A

Happy

Ambitius

Stressed

Week

Bored

Anxious

Focused

Honest

Satisfied

Empathetic

Overwhelmed

Angry

Compassionate

Confident

B

## Challenge

| Element Label | Element Name     | Type            | Description                                      |
|---------------|------------------|-----------------|--|
| A             | Instructions     | Text            | No interaction                                   |
| B             | Multiple choices | Tick Box Labels | Answers that students can choose from (multiple) |
| C             | Done             | Text Link       | Complete the challenge by pressing "Done"        |



Name one tool or equipment that helped you develop Collaboration **A**

Robotics (Lego Mindstorms, Arduino)

**B**

Circuits (Micro:bit, etc.)

Digital Fabrication (Laser cutter, 3D printer, etc)

Other

**C** Done >

## Challenge

| Element Label | Element Name     | Type                | Description                               |
|---------------|------------------|---------------------|---|
| A             | Instructions     | Text                | No interaction                            |
| B             | Multiple choices | Radio Button Labels | Answers that students can choose from     |
| C             | Done             | Text Link           | Complete the challenge by pressing "Done" |



Take a photo with your device or upload a picture that best describes Collaboration from today's project in the makerspace.



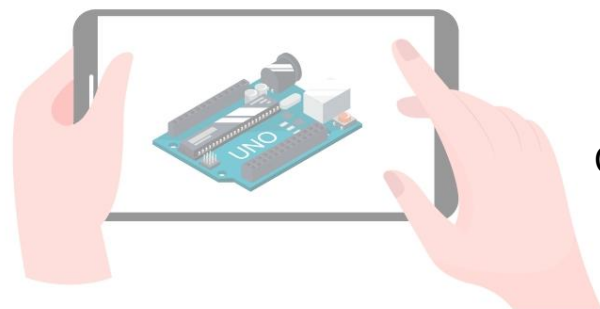
Take a picture of your example

—OR—



Upload a picture of your example

A



C

Take a picture of your project as an example of developing your 21st century skill and reflect on it

B

D [I already did / I don't have an example give me a different challenge](#)

## Challenge

| Element Label | Element Name     | Type         | Description   |
|---------------|------------------|--------------|---|
| A             | Photograph       | Button       | Students can take pictures using the device's camera  |
| B             | Upload           | Button       | Students can upload pictures  |
| C             | Instructions     | Image / text | No interaction  |
| D             | Change Challenge | Text Link    | Students can swap this activity with a different one if they feel that they don't have something to show or they didn't really progressed based on the last example they uploaded |



# ASSESS



# 21

## WELCOME !

Login Code

A D 2 0 2 1

⊗ Sorry the login code isn't right.  
Ask your educator for your code

Login

Self assess, reflect and develop your 21st century skills in makerspaces

Wrong Log in code warning