

Introducing Game Jams for Ecology and Citizenship Education in High School Classes

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Abstract: This paper deals with the preliminary results of some applied game jam events integrated with the Citizenship and Civic education project in some Italian high schools. In Italy GBL is not systematically used as a didactic tool, especially in secondary school and game jamming is not well known nor used. A set of specifically designed game jam events called (EcoGJ - the game jam for ecology) were implemented in Italy during the 2022/2023 school year. The game jam format was designed to promote the discourse about climate change and ecosystems, and implemented to demonstrate how a more student-centred didactic approach can be used at school to foster collaboration and team working skills. Students in the 15-16 target age from different high schools have been involved in the EcoGJ format. Outcomes have been recorded with a survey and with on-field notes. Preliminary results show as game jams had a positive impact on students, encouraging them to use critical thinking and team working as well as activating them in discussing ecology and climate change issues. Notwithstanding, some critical points emerged both for students in terms of engagement and knowledge. It seems that game jams can be a valid working method to teach and learn new skills, as well as increase students' self-confidence and their desire to learn more about complex issues such as climate change. Further explorations are needed to find the most adequate way to introduce game jamming in high school and the best format to use these events in the most effective way to foster students' engagement in learning and to help them in deepening their scientific-based knowledge in ecology and climate change.

Keywords: Game jam, Game-based learning, Ecology, Education, High school

1. Introduction

Games hold the potential of promoting people learning because they are motivational, are drill and practice, are content mastery, and they can promote 21st-century competencies (Jan, et al., 2015, Mingfong and Gaydos, 2016). Embedding games as part of the lessons is the pillar of the Game-Based Learning (GBL) teaching approach. In GBL, games chosen by teachers for specific educational purposes, are played to help students in reaching defined learning outcomes in terms of disciplinary contents or skills or both (Shaffer et al., 2005). This didactic approach has constantly emerged and been implemented as a student-centred learning technique (Plass et al., 2015) highly effective at different school grades and for a great number of disciplines and skills. Considering the principle of "learning by doing" as expressed by Dewey and considering the gaming world inhabited by players and by game developers, other uses of games can be included in the GBL approach such as game development and game jamming. This paper it is used the definition of game jam as described by Kultima (2015) as "*an accelerated opportunistic game creation event where a game is created in a relatively short time frame exploring given design constraints, with the end results shared publicly.*" From an education perspective, game jam can be considered as an expression of a broader constructionist learning paradigm, in which learning happens through creating concrete artifacts (Papert and Harel, 1991; Kafai and Burke, 2015) fostering learning in multiple areas (Whitton, 2018). As indicated by Meriläinen et al. (2020), three are the specific themes explored by game jam learning: game development skills; STEM/STEAM skills; personal and interpersonal skills including work-related skills. Several papers explicitly discuss the potential of game jams in promoting STEM or STEAM learning (Fowler et al., 2016, Pollock, Murray, and Yeager, 2017), concluding that game jams have the potential to successfully engage young learners in scientific disciplines, to promote the deep learning of scientific contents, and to increase participation in both STEM subjects and careers. Furthermore, a game jam is an effective tool for student inclusion and is a peer-to-peer education experience in which each participant can contribute also using creativity and a wide set of personal skills usually underused in the daily school context. Environmental and Sustainability Education (ESE) is STEM-based but needs additional skills, like problem-solving, problem analysis, system thinking, and cooperation abilities, to be efficiently learned and applied in daily life and from a future perspective. Finally, game jam can be helpful in encouraging students to deal with sustainability and climate change issues, just as it can be effective in fostering the new and complex skills requested to deal with future environmental and global challenges. In Italy, the GBL approach is debated at the academic level but not systematically implemented at school as part of the didactic approaches and as part of pre-service and in-service teachers' education (Vezzoli Y., and Tovazzi A., 2018). Generally, in Italy at primary school, it is effectively used to boost learning of some contents and to facilitate life skills emergence in students. At the middle school level, GBL tends to be used less in disciplinary content learning, but it remains useful to exercise skills. GBL is even less

used at the high school level and the university level. In the last years, some experiences have been conducted at primary and middle school levels in digital environments (Bottino et al., 2009, Cecchinato et al. 2019) mainly for language and math learning, logical competencies, or engagement (Benigno et al., 2010, Bottino et al., 2014, Cinganotto L., 2019). Nonetheless, while this research is proceeding, a complete review of the state of the art of GBL implementation in Italy is missing such as a comprehensive study of the reasons why it is not used from teachers' perspective. If GBL is not yet well rooted in Italian schools, less is done with game jamming which is mostly unknown to the teachers, and it is a new concept also at the academic level. Nevertheless, considering other studies occurring in the European scenario (Aurava and Marilainen, 2020, Nousianen et al., 2018) it can be assumed that the reason for the resistance to the GBL and game jamming can be resumed in some points: lack of knowledge of GBL principles and game jamming as education tools, difficulties in finding adequate spaces in schools, the time needed to organize and implement a game jam session, inflexibility of curricula and educational outputs required by the Italian school system for each subject. On the other hand, the tentative to produce some change in the Italian school is in place and a good number of courses for in-service teachers are being implemented together with an attempt to strengthen the network between school and academic research to foster innovation and reach the European educational goal for the future. In this tight opening, the first research line in collaboration with the school is growing, and this research is part of this new line.

The overall objective of this research is to understand what educational outputs can have and how game jamming can be applied in ESE at the high school level. To achieve the overall objective, some sub-questions came from the main one. In this paper the focus is on the specific theme of the educational outputs derived from the main research purpose, split into two sub-questions: a) What skills game jamming can boost in students, and in what measure this process is conscious in students, and b) How the level of engagement in ecology can be influenced by a dedicated game jam event. To offer a preliminary answer to these questions, the design of the game jam format and the measured educational outcomes of a first trial of an event held over three days in January 2023 at Liceo Scientifico "Leonardo da Vinci" in Trento (Northeast of Italy) are presented. It is first presented the applied game jam's format, the educational aims, and the placement in the curriculum, then preliminary results in terms of skills and learning outcomes are discussed, based on the qualitative content analysis of questionnaires filled in at the end of the game jams and integrated with the fieldnotes and observations done during the sessions.

2. Research Questions

In European schools are in place significant experiences to introduce game jamming as a didactic approach, particularly in STEM disciplines and ESE. However, this method is not well known or applied in Italy and less at the high school level. To contribute to the implementation of game jamming at the high school level particularly in ESE in Italian schools, the whole research aims at exploring how to implement game jams. In this paper, two main sub-questions are investigated:

- What skills can a game jamming boost in students?
- Scientific knowledge in ecology can be improved by a dedicated game jam event.

3. Methods and Format

In the school year 2022-2023 an experimental educational format, based on game jam, was designed and tested in three high schools in the Trentino Alto Adige region (Northeast of Italy). A total of, seven classes, around 150 students in the target age 14 – 16 years old, and 14 teachers were involved in the research project. This paper is presented preliminary results from data collected in 2022/2023 in three classes of the Liceo Scientifico "L. da Vinci" in Trento (Trentino Alto Adige -Sud Tirol region, Northeast of Italy).

Quali - quantitative research methodology was used favouring a holistic approach to have a more detailed and closer to the reality idea of the effects of the tested educational format. To conduct the research a set of assessment tools was developed: pre- and post-questionnaires (with open and closed-ended questions), field notes and semi-structured interviews. A metacognitive analysis was stimulated in students, using a dedicated and open-ended questionnaire to guide them in self-assessing their experience and improvement in soft and working skills, engagement and enjoyment, and disciplinary knowledge. For this paper were used student's answers to the open-ended questions referring to the metacognitive analysis at the end of the game jam experience. Qualitative data were analysed using MAXQDA-22, qualitative data analysis software, and descriptive analysis techniques. In descriptive analysis, collected data are interpreted by summarizing in view of defined categories and subcategories. A set of categories were initially defined by a deductive process and used to build up the questionnaire. Questionnaire results were processed with a qualitative content analysis

approach. After the data analysis emerged a set of specific subcategories defined in an inductive way to better illustrate the student’s answers. The set categories might be changing in the future, however, table 1, are presented the categories, subcategories, and their meaning as used in the present paper to investigate and discuss the results.

Table 1: List of Categories, Subcategories, and Their Explanation, as used in Analysing Students Answers to the Metacognitive Questionnaire Adopted to Assess What Skills Were Solicitated and how Students Perceived Their Changes Before and AFTER the EcoGJ LAB

Category	Subcategory	Category description
Social skills	Group and you	Interaction sustaining engagement/attention.
		Intragroup acquaintance – openness and trust.
	Communication	Accounting for different perspectives and reaching agreement.
		Communicating ideas in positive and clear way.
		Hearing from others with a positive approach.
Working skills	Problems/solutions	Testing and finding problems in the prototype.
		Understanding the causes of the problems.
	Bridging theory and practice	Relating learning to previous experience.
		Seeing connection theory-praxis
	Timing/self-organization	Going beyond difficulties in organizing time and activities.
		Getting bogged down in minutiae.
		Increasing the attitude in meeting deadlines.
	Group working	Favouring group working as leader or supporter.
		Learning as shared experience + Resolving problems as a team.
		Overcoming conflict by management of divergencies.
Scientific/technical knowledge	Ecology contents	Understanding the meaning of ecosystem.
		Reaching precise and science-based definition of climate change.
	System thinking	Identifying ecosystem elements and inter relations.
		Understanding effects/consequence of hidden/unknow relations in ecosystems.
	Technical contents	Choosing specific mechanics to simulate/explain ecosystems.
Choosing specific game elements to vehiculate scientific contents.		
Personal skills	Participation	Investing high level of intellectual energy.
		Increasing motivation to participate actively - Time investment.
	Emotions/regulation	Enjoyment and happiness as a baseline.
		Managing positively the fatigue due to engagement/requirements.

The experimental format tested, called EcoGJ LAB – the game for ecology (EcoGJ LAB hereafter), was included in the Citizenship and Civic Education (CCE). Accordingly, with CEE discipline, the aims of the EcoGJ LAB format were to stimulate student reasoning about ecology, deepening the scientific principle of climate change causes and effects on ecosystems. The structure of the EcoGJ LAB was defined by the researchers in close collaboration with teachers to fit better the CEE needs and school time limits. Each EcoGJ LAB experimental event was organized in two parts: i) an introduction to the board games and game mechanics and ii) the proper Game jam event. The rules of the EcoGJ (based on Musil et al., 2010, Fowler et al., 2013; Fowler 2016) are illustrated in Figure 1. Each team, with no more than six students, were composed by teachers and researchers to have well-balanced groups and to facilitate the participation and inclusion of students with special needs. At the end of the event, a public presentation and the playtest of the prototype were made by each group in the presence of a panel composed of two teachers, two external students and one researcher. At the end of the game jam, the

prototypes were evaluated together with other criteria (clarity of the oral exposition, quality of the group work, accuracy of the scientific contents), and teams were awarded.

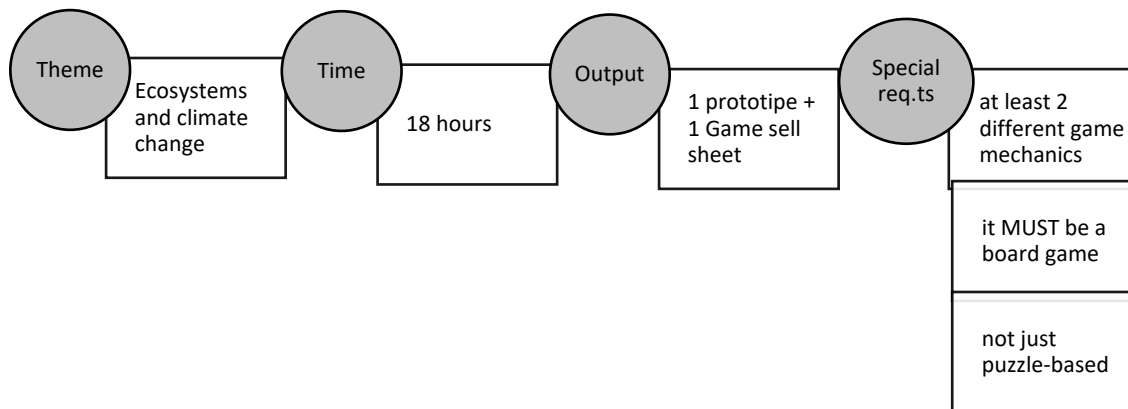


Figure 1: The Game Jam Rules and Limits for the EcoGJ LAB format as Developed and Adopted During the Testing Phase

4. Ethical Considerations

All students and their parents were informed in advance about the aim and the procedures of the study, and participation was voluntary. To protect privacy, and following data protection restrictions, data were collected in a semi anonymization way, using randomized codes, any other additional data were collected about the students except the age. Analysis of thinking-aloud protocols were performed with anonymized transcripts.

5. Results

In this preliminary investigation, data from 3 classes are reported. A total of 62 students aged 15–16 years old were involved. Incomplete questionnaires were withdrawn, and 54 questionnaires were considered valid for the analysis. The number of answers and comments in which students highlighted a change in perception of their 4 key skills level are reported in Figure 1. From a general perspective, it can be assumed that a broad range of skills was perceived as strongly applied during the game jam and increased at the end of the event. Students identified personal skills, such as the confidence in being part of the group and positive communication with others, and working skills, group working, and the ability to bring theory in praxis and problem solving especially, as the most practised and remarkably increased after the game jam event. All 54 students agreed to highlight a change in their social skills, with a slight difference in the perceived change in positive feelings as a group member (54 students) and assertive communication (44 students). It results that students are not aware of their communication skills before the game jam, but after the event, they could perceive the differences. Proper communication in their mother tongue inter pares and in technical discourses, and fluency in public speaking of the game was the most important communication skills perceived as increased after the game jam by the students.

In some cases, shy students were ready to go beyond their comfort zone, communicating and discussing in a group to share ideas and find common solutions to problems. Also, a change in working skills is reported, and specifically, 33 times mentioned as dealing with problems and finding applicable solutions was an ability highly solicited during the game jam. A total of 29 students recorded that the ability to organize the time to meet deadlines and the management of the group in working together was constantly challenged. Students recognized as group working skill was highly practised, and it was also perceived as positively increased. It emerges from the student’s answers that most of them are ready to overcome personal resistance to group working if they have a common goal. They revealed that group working is most effective than working on your own, particularly in analysing problems more accurately and finding the better solution to grasp the goal. It also appears clear that the positive feeling associated with group work is the key to sustaining students’ engagement in the EcoGJ. A total of 20 students also pointed out how the ability to use the theory in practical problems was a relevant skill exercised during the whole EcoGJ -LAB.

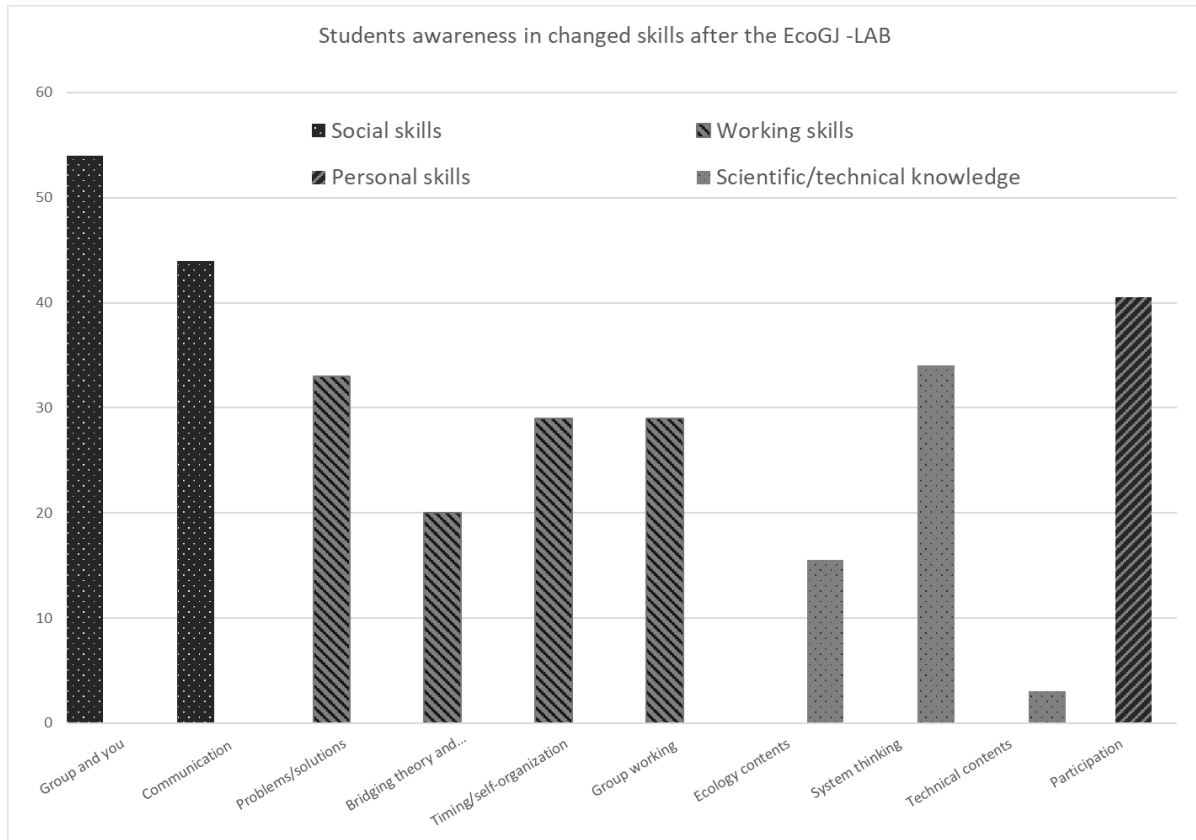


Figure 2: Graph Illustrating the Students Answers to the Metacognitive Questionnaire and the Distribution of Replies Among Skills Categories and Subcategories

Concerning the question about how the level of engagement in ecology can be influenced by a game jam event and specifically by EcoGJ LAB, an increase of interest is generally pointed out by the students. An increase in interest is demonstrated by the increase in scientific and technical knowledge mainly reached independently by students deepening ecological content to develop game prototypes. Generally, all the groups had discourses about climate change, causes and impacts on ecosystems, and possible concrete solutions to apply now in future scenario-building approaches. Fieldnotes reveal that students' in-depth research on sustainability and climate change was considerable during the event, the debate between them was heated, and in most of the prototypes, the link between ecology concepts and game mechanics was clear and explicitly declared during the presentation. Results showed that 34 students noted a change in their approach to analysing the ecological question highlighting a certain preference for adopting a more systemic approach. Moreover, 16 of them allowed that there was also an increase in their scientific knowledge in ecology but reach a certain ability in dealing with game mechanics and ecology in developing the game results hard for almost all the students. Finally, 40 students reported a very high level of engagement for all the game jam events highlighting both positive feelings increasing and negative feelings, such as fatigue and some sense of frustration, as part of the general level of engagement. Some of the students recognized that the game jam event was helpful in unlocking some hidden skills such as creativity, artistic and manual abilities and this was more relevant for fragile students who had the opportunity to be active and gain a higher level of self-esteem stimulating their interest in learning.

6. Discussion and Conclusions

This study aimed to give preliminary insights about the effect of the EcoGJ -LAB, a special game jam event developed, on students' skills and their ecology knowledge. Students displayed positive and agreeable attitudes toward the impact of the EcoGJ-LAB event on their learning and skills improvement. Concerning the first research question, these results confirm the potential of game jams in unlocking students' skills. Being game jam a co-creation event these results showed how, in an educational context, it can be effectively used to enhance students' engagement in some disciplines, to support inclusion, and to boost some key skills such as problem-solving skills, creativity, group working, critical thinking, and metacognitive processes. Especially in problem-solving skills, students reported an increase in their ability in analysing the problem in a kind of reverse engineering process and they adopted a try-and-test approach to find the best solution.

The EcoGJ LAB format appears to be effective also in stimulating students to use some key 21st-century skills like critical and system thinking. Learning in a game jam set results to be close to a building-patch work in which each student is responsible to reach, apply and exercise some skills in a personal way and by creating a concrete manufactured object as demonstrated also by other experience (Musil et al. 2010, Preston et al 2012). These findings are aligned with the literature, a great number of papers and trials confirm that game jams are effective tools for young students in unlocking their group working and communication skills such as are relevant in promoting engagement in education activities in a non-formal context (Aurava and Meriläinen, 2021, Reng et al., 2013 and Smith and Bowers, 2016)

Concerning the question about how the level of engagement in ecology can be influenced by a game jam event and specifically by EcoGJ LAB, an increase of interest is recorded by the students. Many students highlighted a growing interest in discussing ecosystem services and how they are linked to the effects of climate change. The potential of game jam in stimulating students to STEM discipline and in encouraging the in-depth discussion on climate change seems to be confirmed by the results and is aligned with the growing literature on this topic (Beça et al., 2018, Mago et al., 2019). In conclusion, EcoGJ -LAB can be considered a format belonging to the wider set of constructivist didactic activities, which can provide permanent learning, active participation, learning by doing, effective learning, fun learning, and the development of creativity. The EcoGJ LAB format is suitable, customisable especially the theme, and a potent pedagogical working method to teach STEAM and other 21st century skills. However, the nature and consequences of integrating game jams in a national formal school context require further exploration, especially about the issue of how it can be combined in formal education.

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