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Online team working with emerging technologies in a university math class

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Abstract

This work presents a new approach devoted to recreating a team working situation in a STEAM university mathematics class by using Engageli, an e-learning platform for real-time online higher education courses. A particular experience is considered, in order to understand the core tenets to construct a fruitful online group activity in mathematics. The success of such an activity depends on both the usage of an intuitive software user-friendly and the creation of suitable and stimulating learning paths. The analysis is based on the well-known SWOT analysis concerning the students' comments, integrated by the answers of four multiple choice questions and the analytics provided by Engageli. The outcome of the work suggests that the online experience has potential, but further improvements are needed.

Keywords: *team working; math class; emerging technologies; STEAM courses.*

1. Introduction and theoretical background

Active learning methodology allows students achieve higher conceptual understanding compared to other students, who study the same courses according to the traditional learning approach (Pundak et al., 2010). The main reason is that student-directed instruction favors the development of conceptual knowledge (Gamer & Gamer, 2001). In particular, group working activities improve many educational aspects such as students' involvement, development of cooperation and collaborative qualities, meaningful learning, and achievements in conceptual and quantitative tests (Pundak et al., 2010). However, some studies (e.g., Andrà et al., 2020a) show that, in mathematics, a good performance with groups is all but easy to foster, because self-confidence and confidence-in-peers are fundamental in the group dynamics and in the task understanding.

Moreover, instructors resort online resources for their teaching inside and outside the classroom, to place the student in the central role of the learning process. Such a trend is rooted in the continuous spreading of technology on the educational field: from online resources that students can obtain in a few clicks almost on every topic, to the e-learning platforms, and the relatively new Massive Open Online Courses (MOOCs) (Andrà et al., 2020b). Despite many e-learning platforms provide collaborative activities, e.g., Persuall (https://perusall.com/), the way promoting group work online is still an open issue in educational field because it depends, for instance, on the learners (van de Sande, 2011).

Nevertheless, such a need, that was quite limited in the past, became more and more relevant in the last two years when the remote teaching was the predominant educational format. Technology provides the technical way to reach students in synchronously, thanks to web-conference platforms. However, many teachers migrate online turning student-centered lessons into teacher-centered (Brunetto et al., 2021).

This paper concerns the designing, setting and delivering group work activities through web-conference platforms, focusing on the students’ perspective and feedback.

To that end, our theoretical background is based mainly on the “SWOT Analysis”, that stands for ‘strengths’, ‘weakness’, ‘opportunities’ and ‘threats’ analysis. This tool is usually used for strategic planning and strategic management in organizations (Gürel and Tat, 2017). Although such analysis is strongly related to business field, we adapt its four components to the educational field, because understanding a ‘story’ involves evaluating the strengths, weaknesses, opportunities, and threats (Gürel and Tat, 2017). Therefore, we adapt the four SWOT components to the educational field. More precisely, we consider the lesson delivered remotely as an ‘experience’, composed of several elements, such as the task, the interactions and the platforms. In our context, *strength “S”* and *opportunity “O”* are positive components of the experience itself and its elements, which are related to a characteristics and condition of an element that add value “S” and are more advantageous

"O" compared to something else. Whilst *weakness "W"* and *threats "T"* are negative components, that concern to elements that remove value "W" and jeopardize "T" the experience (Gürel and Tat, 2017).

2. Research methods

In this work, data was collected during the university first year course named "Elements of Mathematics" that involves linear algebra and calculus. The whole course is a one-semester long mathematics course (September-December) devoted to Architecture students. The total number of students enrolled is about 164, with 65% of female students. The course is 14 weeks long and split in two equal parts according to the topics (*Linear Algebra* and *Calculus*). The students attended 3hrs of lectures delivered online, and 3hrs of tutoring/exercises delivered in presence and streamed online. The institutional web-conference platform is Cisco-WebEx meetings (https://www.webex.com/), integrated within the LMS of the university. The structure of the course and the web-conference platform are the same as the previous year, but this academic year (2021/22) instructors explored one of the newest platforms, called *Engageli* (https://www.engageli.com/), with the cooperation of Engageli developers, who are interested in improving the platform taking into account the opinions of both students and instructors.

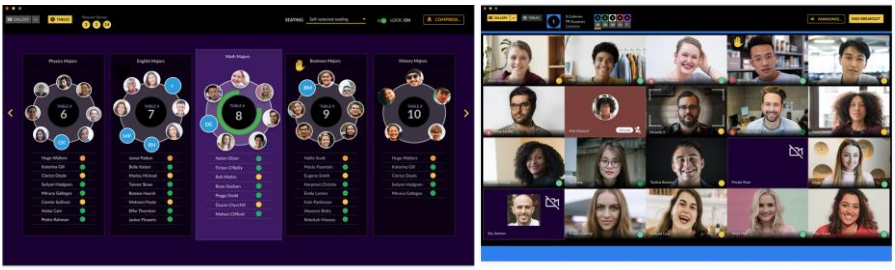


Figure 1. Engageli's layout in tables mode (on the left) and the classical layout of almost all online platforms with windows of share cameras (on the right). Source: by Engageli.

Engageli is an online software launched at the end of 2020, which proposes a e-learning platform for real-time online courses (Adams, 2020). The most important feature that differentiates Engageli from others web-conference platforms is certainly the function "*tables*". Even if the classical online platforms have a function that allows a breakout groups, with Engageli such a division seems more likely to a face-to-face classroom experience (see Figure 1). Indeed, during the session, the instructor could keep blocked such a division choosing to speak to the all audience or just dropping to one table (typically with a size of at most ten attendants) coordinating the work according to the needs of the specific group. Since practically most of the used online platforms tend to be optimized for one-to-many lectures, Engageli seems to be of particular interest, especially for delivering online group work activities.

This led us to formulate the following research questions: *To what extent Engageli allows students to collaborate in online math classes?*

2.1. Data gathering

Our pilot study is based on a learning experience delivered in December 2021 and described in detail in the next section. Students were informed by email about the experimental use of the new web-conference platform (Engageli) and the need of collect their feedback about the whole learning experience. Their feedback was collected at the end of the lesson by Socrative (https://www.socrative.com/).

The recorded lesson and the analytics provided by Engageli are part of data. The class was attended online by 63 students. The survey contained four multiple choice questions (reported below) answered by around 45 students, and the open question "*leave a comment about the activity on the Engageli platform"* was replied by 35 students.

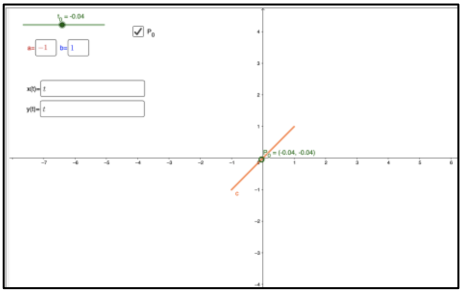
2.2. The learning experience

The learning experience proposed was about *Parametric Equations*. This topic is a novelty for the most majority of the students of the course. Parametric equations are another way to represent geometrical object, such as lines, functions, and curves, with respect the first approach based on the Cartesian form. In this new formalization, we exploit a variable (called "parameter"), which represents a sort of "time" describing the evolution of the figure on the plane (but also on the three-dimensional space). For instance, the Cartesian equation of a circumference is $x^2 + y^2 = 1$, while a possible parametric form (the parametrization is not unique) is given by following expression:

$$\begin{cases} x(t) = \cos(t) \\ y(t) = \sin(t) \end{cases} \text{ with } t \in [0,2\pi].$$

In the previous years, this topic was taught as a frontal lecture, but for this AY (20/21) the experience was designed according to the "optimal experience" principles (Liljedahl, 2020): 1) clear goals every step of the way, 2) immediate feedback on one's actions, and 3) a balance between the ability of the doer and the challenge of the task. We use the fact that such a subject is not so studied before, and it is possible to formulate more challenging tasks, which could require the cooperation between the students to solve the problems. Moreover, this topic has both a computational part and a conceptual part. The latter can be developed by using also interactive software as GeoGebra (https://www.geogebra.org/), thanks to which the students can try to understand the dynamics of parametric equation by comparing the graphical results and adjusting them by keeping in mind the suggestions of their colleagues.

For the sake of clarity, we report in Figure 2 the first task (out of three) of the experience, as shown it involves the usage of GeoGebra.



Set in [the predesigned] GeoGebra's layout the following equations:

$$\begin{cases} x(t) = 2\cos(t) - 1 \\ y(t) = \quad 1 - \cos(t) \end{cases} \qquad \text{with } t \in [0, \pi].$$

Then, address the following questions:

1) What kind of geometrical object do you get?
2) What are its extremes?
3) How much does such a geometrical object measure?
4) For which value of t_0 *do we get the point* $P_0 = (-1,1)$*?*

Figure 2. GeoGebra's layout with the parameter settings on the left. Source: by authors.

3. Data analysis and results

The *Engageli analytics* report the number of interactions (in terms of chat messages) between the participants, distinguishing between the number of messages sent to the instructors and within tables. There were 63 participants to the lecture and 37 messages within tables and 1 message toward the instructors. The data show that there could be the potential to provide a cooperative learning activity based on the collaboration between the students. However, we see in the following lines that this number of interactions is revealed to be still not sufficient for an optimal experience.

The analysis of students' feedbacks is summarized in Table 1, where we report the number of comments that belongs to the four SWOT components (a comment may contain statements concerning all the four components). Nevertheless, some comments do not contain useful information (e.g., "nothing to say").

Table 1. Summary SWOT scheme of students' outcomes.

Strengths	Weaknesses	Opportunities	Threats
8	9	6	6
5	8	5	9

Source: by authors.

For instance, the comment C1 "it is interesting because allows mates to collaborate for solving the task" is labeled as "S" and "O" because the student recognizes positive value to the platform Engageli and the condition in which can be used. On the other hand, the comment C2 highlights "W" and "T": "quite complicated and 'unstable' on the web-browser. I do not think it offers more option with respect the usual lesson on WebEx that is more intuitive and stable". Indeed, the comment refers on two elements of the experience: the student does not recognize a value of the task ('usual lesson') and the tool ('unstable') is negative compared with the usual platform. Moreover, the following comment C3 contains "S", "O" and "T": "the platform is based on the strong idea to interact and discuss with mates, but I prefer WebEx for the usual lesson", the student recognizes the positive value of the platform for the group work activity, but the threat rises when the lesson is the usual. We think that such preference can be explained by the comment C4 concerning "O" and "W": "I don't like the experience due to technical problems, the idea is good, but the platform is less user-friendly".

To dig deeper into this aspect, we focus on the responses to multiple choice questions. Figure 3 shows the students' feedback about the platform. Most of them perceived this web-based platform as not user-friendly because of the technical issues during the lesson. Analyzing the records of the lecture, we figure out that there were two main problems: 1) audio issues, and 2) internet connection, revealing that the problems do not depend on the platform itself.

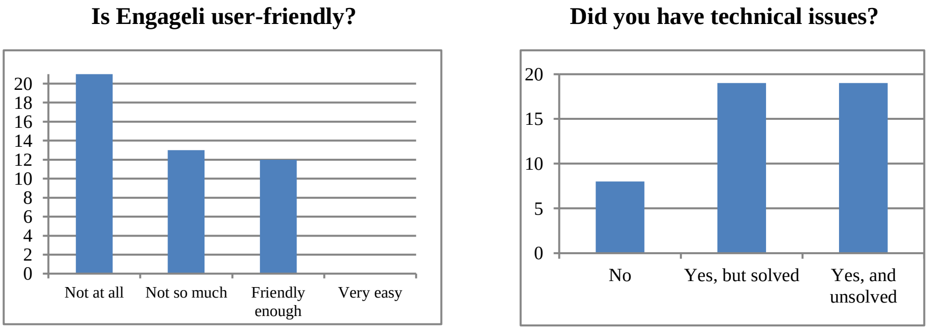


Figure 3. Histograms providing the number of students selecting the corresponding answer. Source: by authors.

Moving back to the whole experience, students' responses (see Figure 4) show that the majority did not have an optimal experience due to the lack of interactions, as the comment C5 witness: "the experience was interesting, but I did [the task] by myself due to technical problems". This student highlighted an opportunity "O" that is threated by the audio issues "T". On the other hand, some students liked the experience because they interacted with mate, as proved by the message within the tables.

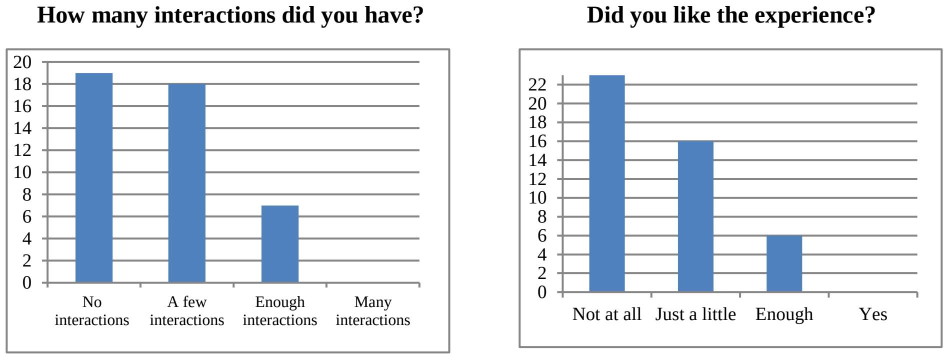


Figure 4. Histograms providing the number of students selecting the corresponding answer. Source: by authors.

4. Discussion and conclusions

This pilot study aims to prove the specific possibility to construct a suitable team-working activity for mathematical contents by using emerging technologies. The preliminary results highlight some technical difficulties that still occur despite almost two years of remote learning (“W” and “T”). Clearly, these difficulties, which are due to both the usage of a new platform and the typical technical issues of the online lectures (as the internet connection and the older computer hardware), contribute to limit the learning experience. However, beyond the technical difficulties, a good experience is allowed also for math classes, where the use innovative learning methodologies is still much less used. Despite Engageli has the strength and the opportunity to emulate online the in-presence class characteristic, instructors must not be mistaken that anything changes, because the medium is changing. Such a change brings the weakness due to the difficulties linked to the usage of a new software and the threat regarding the low-quality internet connection and the lack of hardware requirements. It is important to notice that many of the insights presented in this work can be translated to other online activities that has intrinsically most of the characteristics analyzed.

The case study presented in this work is based on a typical teacher-centered activity, redesigned (and not just migrated) to exploit the platform strength and opportunities (“S” and “O”). The data can be interpreted in terms of “instrumental genesis” (Béguin & Rabardel, 2000). The SWOT analysis allows to identify the two dimensions of the “instrumentalization” (potentialities and constrains) of the artefact, that is both the platform and the task. Moreover, the analysis shed a light on the “utilization scheme” by observing how students interact and how they feel in the use of the platform. We observed the first stage of instrumental genesis, where difficulties arise physiologically. Nevertheless, the specific team-working feature developed by Engageli’s staff allow us to conclude that Engageli is undoubtedly an intriguing option for proposing a more cooperative experience also for STEAM, but instructors must commit themself to design suitable tasks and should cooperate with the software developers to produce an optimal experience. To conclude, we argue that further interactions with the platform will enhance the utilization scheme and, as consequence, the online team working learning experience.

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