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Esqueda-Merino D., Mondragón D., Calvillo-Corona L.A., Aldana-Pérez C.A., Chong-Quero J.E. (2021) "Speed-Dating" as a Learning Method in Online Synchronous Classes. In: Camarinha-Matos L.M., Boucher X., Afsarmanesh H. (eds) Smart and Sustainable Collaborative Networks 4.0. PRO-VE 2021. IFIP Advances in Information and Communication Technology, vol 629. Springer, Cham. https://doi.org/10.1007/978-3-030-85969-5_63

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Abstract. Since COVID-19, many educational institutions have focused their attention towards remote digital synchronous learning. While this new kind of learning brings some advantages, it also brings new challenges like keeping the students focused and engaged in the courses being given. Through this paper we introduce a learning strategy based on some of the principles of speed-dating, a tool that has been explored in the entrepreneurship world for networking, in order to maintain the students' focus in the class activities and topics. The proposal was tested in a Process Automation course for Chemical and Biotechnology Engineers, which is usually not one of their preferred ones due to its complexity in relation to other courses. A framework for incorporating the activities in other courses is presented, along with preliminary quantitative and qualitative results to evaluate its efficacy.

Keywords: Higher Education, Educational Innovation, Professional Education, Learning methods, Gamification.

1 Introduction

Due to the lockdowns implemented as a consequence of the Covid-19 pandemic, the teaching methods have been forced to evolve enormously, not only with the change from a face-to-face environment from the classroom to a virtual environment from home through a screen, but also essentially in the way of teaching. Despite efforts from universities and professors, such as the investment in educational software and the restructuring of the courses, the level of attention of the students is limited in comparison to a traditional lecture. For this reason, educators need to continuously propose ideas that can capture their attention.

From the beginning of the Covid-19 pandemic, students' learning has been affected due to various factors such as a decreased attention span, technology and internet connectivity problems, work overload, and inadequate support from instructors and colleagues [1]. However, the commitment of both students and teachers has remained during the pandemic [2], which is the reason behind new learning methods compensating for some of the previously indicated factors. As an example, *Active*

Learning is used by interwinding lecture time with questions or activities in which students participate in the acquisition of their own knowledge [3]. Moreover, *Gamification* [4] assists in this objective by attracting the students' attention by means of activities or games, in which badges, awards, achievements and/or markers are used for evaluation [5]. That is why several unusual implementation strategies have been adapted to be used appropriately and obtain the benefit expected of them (*e.g.* the scavengers hunt method). These methods have been effective in different environments, such as business teaching, which is why the present work is interested in the use of *Speed Dating* [6] as a case of Active Learning and Gamification.

With the development of new collaborative tools supported by the Internet and mobile computing, new organizational ways are emerging as a result of the challenges faced by the learning fields. For instance, the web provides a space for communities to practice and share their learnings after a training has been given [7]. In this sense, students working remotely are analogous to collaborative networks in certain aspects: autonomous entities distributed geographically, collaborating towards a common academic goal, with interactions supported by computer networks.

Thus, new perspectives have been established in educational programs to achieve innovative solutions that make the best use of virtual community connections and professional capacities [8][9]. Lacking a correct implementation has contributed to students struggling in virtual classes to keep their focus, especially when the class is highly demanding, while collaborative work has turned mainly into meetings to define individual task planning for reaching a goal (e.g. a homework assignment). Within this virtual collaborative network context, a question arises: how can we promote real collaboration in an effort to keep students interested in the class?

This paper aims to present structured planning in the implementation of the active learning method based, on the speed dating model, with the purpose of improving the learning and teaching experience with a more strategic and useful approach for professors, in order to better capture the attention of students. The paper is presented as follows: the method is briefly presented in section 2, section 3 provides a case-study with details in the implementation as well as preliminary results based on that case-study, and section 4 opens the discussion on the usefulness of the method.

2 Method

The learning method proposed here for online synchronous classes is based on a tool that has been widely used recently in the Entrepreneurship world: *Speed-dating*. In this context, it is used mainly to pitch ideas to investors by assigning them randomly to entrepreneurs for a couple of minutes to get to know each other. During these sessions, different pairs of entrepreneurs-investors alternate, which might lead to further collaborations whenever interest has been raised by any of the parties.

In the context of *online classes*, this method is used as an approach to compensate for the missing interaction between professors and students during traditional in-classroom classes, where the professor can make sure everyone is working on practical exercises. Instead of that, several activities (hereby named “Speed-Dating Activities” or “SDA”) were carried out in each class, where students were separated randomly into small sessions (i.e. Zoom’s breakout rooms) so that they could work together. The professor would also switch between sessions to solve any questions related to the activities, whether students proactively called the professor, or the professor randomly visited the teams in the allocated time to validate comprehension.

Moreover, a *gamification* strategy was also combined so students would keep the interest in the activities. For this objective, special *tokens* were proposed so that students could earn depending on their faultlessness and their response time. While the ultimate goal is to have the right answer in order to get more points, a quicker response might foster a more active collaboration in order to get more points.

As expressed by [8], incentives in collaborative networks help to pro-actively engage participants. Thus, these *tokens* are recommended to be exchangeable for something that incentives the students. In this way, during the random sessions, students would motivate and help each other during the SDA with the understanding of the topics that were previously presented in class. Some practical recommendations regarding these tokens are:

- To avoid discouragement, make sure you supply enough tokens for everyone. For example, on every exercise, you could give the maximum number of tokens to the team sending the right answer first. Then give one less token to the next team with the right answer and so on. After all the right answers have been awarded tokens, consider giving some to those teams that had the right procedure but a wrong answer (e.g. due to a wrong sign).
- To reduce the number of people not working, keep teams small and allow students to leave out people who don’t work (e.g. those that leave their computer connected even if they are not there or that don’t participate).
- To reduce the disadvantage of slow internet connections: promote analytical thinking (so that activities require a good understanding of the topics and some time to develop them), request as evidence low-size files (such as pictures, text or PDF), and avoid that the students know beforehand the upcoming activities (*e.g.* by uploading the slides with the exercise before you present them).

In this way, an active collaboration within a small group of students occurs organically by exploiting the concept of *learnativity* [10], as long as at least two of the students in the team care about doing the activity properly. It is also important to keep teams small so that there is a lesser chance of any student being idle.

3 Case Study: Process Automation

The methodology previously described was tested during the August-December 2020 semester at Tecnológico de Monterrey. This course, aimed at undergraduate Chemical and Biotechnical Engineering students, introduces topics related to modeling and control of industrial processes, as well as the design, analysis and use of logic control strategies. A total of 25 students (out of 27 enrolled in the course) accepted to participate in this experimental study by correlating their grades to the SDA points.

As part of the overall learning strategy, students had to develop different activities throughout the semester including:

- 32 SDA, in random teams of maximum 3 students
- 14 exams, individually-graded
- 9 homework assignments, in teams of 3 (formed by the students during the first session)
- 1 individual homework assignment

The final grade was calculated considering 3 periods of evaluation: first and second period would have a 30% impact on the final grade, while the third term would have a 40% weight. In each term, exams would be worth 60% and assignments 40%.

The general instructions for the SDA were as follows: every session 9 teams would be created with Zoom's Breakout Rooms. During the sessions, specific instructions would be given regarding the specific SDA. Each team would work for a period of 10-20 minutes in order to earn so-called "Automaton Coins" (AC), which were assigned from 9-0 as described in section 2. For most of the exercises, students would require between 10 to 20 minutes to complete the activity, although they could decide if they would send the answer right away or after the class ended, as long as the professor didn't start reviewing other students' results. This would give them a chance to finish even if they would earn less AC.

The SDA would be a collection of activities including hand-solved practical problems and software-based practices (see Table 1). Exams on their own would be both theoretical and practical, and related to the topics seen in class (with a few of them having similar exercises to the ones developed in the SDA or homework assignments). Exams took random questions from an exam bank, making it a unique experience for each individual. On their side, homework assignments required a certain level of research from the students in a way to reinforce the general learning.

Table 1. Activities carried out for the Process Automation course

SDA	Homework Assignments
Introduction to Process Automation	
- Discuss characteristic parameters and variables of a fan - Identify control-oriented variables of a fan and if it has feedback control - Obtain transfer function from differential equations - Solve Laplace transforms in Matlab - Solve differential equations using Laplace Transform with Matlab - ZPK form and pole-zero graph using Matlab of given systems	- Real-life applications of Automatic Process Control - Examples of Open-loop and Closed-loop systems including game from SpaceX - Infographic explaining specific case of partial-fraction expansion,
Dynamic Modeling of Processes	
- Reduce Transfer Function (TF) with Matlab - Reduce TF with Block Diagram Algebra - Mason's rule exercise (1 easy/1 medium/1 hard) - Convert block diagram to signal-flow graph - Find open-loop parameters from a first-order TF - Obtain phase lag and lag time from practical example - Get gain values from second-order system with time constraints - Validate approximation of two TFs - Obtain TF and response to step-input in mixed tank heater - Simulate response of non-interacting tanks in Simulink - Find block diagram and TF of interacting tanks	- Control-oriented block diagrams found in research article - Model's parameter identification with Matlab and Simulink - Identify stability conditions of specific exercises,
Continuously modulated controllers	

- Obtain Padés approximation for systems with dead-time - Routh-Hurwitz criterion exercise - Find a range for gain K to validate stability of a system - Obtain frequency of oscillation to make a system marginally stable - Determine PID-controller parameters via oscillation method	- Research PID-related tuning strategies in articles
Batch sequences	
- Understand logic gates with logic.ly - Research differences between XOR, XNOR, OR, NOR. - Validate De Morgan's Theorems with logic.ly - Find minterms and maxterms of a function - Obtain function and diagram from truth table - Simplify function using Karnaugh maps - Obtain a truth table from minterms, draw logic circuits and simplify using only NAND gates.	- Design logic system and validate with Simulink - Use TinkerCAD to display numbers in 7-segment display
Logic Control Systems	
- Simulate pneumatic circuit in FluidSim and record it	- Virtual commissioning with Factory IO and WinSPS.

Through these activities (see Figures 1 and 2), students used different software packages from their own homes (i.e. Factory IO, Matlab Simulink, FluidSim, TinkerCAD), and they even watched live the remote operation of a laboratory with Programmable Logic Controllers (PLCs). Concepts of Industry 4.0 can be important enablers of collaborative networks [11] and are highly valued by both students and industrial partners [12]. This gives students a sense of a practical approach in those activities as it would happen in a real working environment. Additionally, the overall learning experience was complemented with programming examples, illustrative videos, quizzes, and a conference from an automation expert in the beer industry.

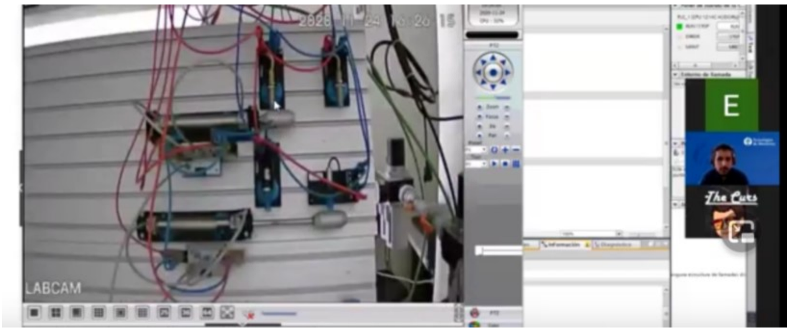

Fig. 1. Remote laboratory setup consisting of cylinders being controlled by PLCs. Remote desktop software and a webcam allowed to execute the code in real-time.

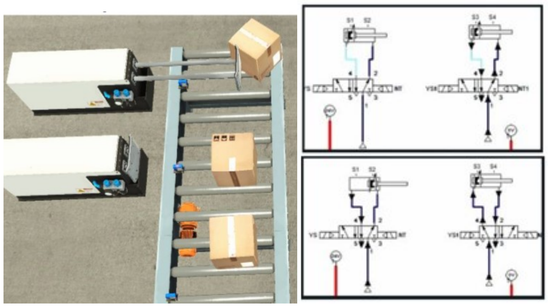

Fig. 2. Specialized software complemented the learning experience.

3.1 Qualitative Results

In order to have the Voice-of-the-Students represented in decision-making at different levels, the University does an online survey every semester in which professors and certain school managers are evaluated by students in an anonymous manner. While not mandatory, students are very much encouraged to do it. This online survey happens at two moments during the semester: during the first-term evaluations, and about two months later, before the final-term evaluations.

These surveys ask 12 questions related to aspects such as the methodology of the class, commitment of the professor, professor-student interactions, challenge of the course, and it even calculates the Net Promoter Score (NPS) of the professor. Quoting [13], NPS "is a unique metric that quantifies the response to a single direct survey question: How likely are you to recommend this service?" This question measures a customers' satisfaction based on experiences, and provides valuable feedback to improve existing products and services offered by a company.

Professors can check on the results some weeks after the surveys have been collected. In this way, the comments that were related to the methodology were analyzed: during the first-term, several students indicated the class was well-planned with an encouragement to teamwork, yet they considered the time for the SDA was leaving out more detailed explanations of the topics (e.g. "I think the number of activities is excessive, which makes the explanations very quick sometimes").

For the final survey, all comments made in relation to the SDA were positive, and the NPS of the professor increased from 8.35 (calculated with 17 opinions, first-term) to 9.04 (including 26 opinions, end of semester). Students kept on pointing out that the classes were very dynamic and organized, but now they indicated that the constant evaluations made the topics more entertaining and easier to understand.

3.2 Quantitative Results

For this part, an analysis between the AC awarded to each student and their overall grade was made. In Figure 3 (left side) we can see the relationship between these grades in the experimental group. It is important to state that this grade was before any additional points due to accumulation of AC were given.

On the right side of Figure 3 it can be seen a comparison of the normal distributions of grades happening between the Process Automation course with a control group (CG, in red) and an experimental group of the same class with 14 students, not having SDA implemented (EG, in blue).

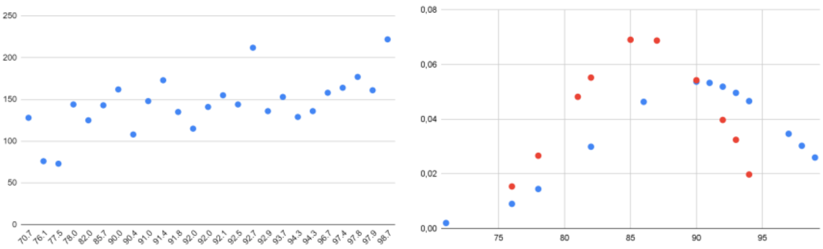

Fig. 3. Left) Horizontal axis: final grade of the students in the experimental group on a scale from 0 to 100. Vertical axis: AC points awarded to each student. As 32 activities were proposed, the maximum number of AC a student could get was 288.
Right) Gaussian distribution of grades between the CG (red) and the EG (blue).

From these results, it can be noticed that there seems to be a potential correlation between the final grade and the AC awarded throughout the semesters' activities within the experimental group, even if there are some exceptions (which might be associated with regular teamwork assignments). Moreover, it can be appreciated that some grades shift towards higher values in the experimental group, which could potentially relate to a higher engagement in the class.

4 Conclusions and Discussion

As the lockdown context has forced educators to find new ways to foster participation, teamwork and understanding of the topics, in contrast to traditional oral lectures, this methodology presents an approach to promote student's engagement and active participation of collaborative networks of students, inspired by the entrepreneurship activity of Speed-Dating.

While the concept was only applied in a single class and can't be conclusive, both qualitative and quantitative results showed a trend into students having a benefit by this kind of interaction: the grade of the students was higher than a regular group of the same class in the digital format, and also, once they got used to the methodology, they expressed it to be a highly dynamic class in which collaboration was promoted.

The results align to the research question aiming to increase the engagement of the students. The fact that the experiment was done in a complex class to the students just contributed to a rather optimistic outlook on the approach. Particularly, the regular exams and homework assignments allowed us to validate the learning outcome for this class: an understanding of industrial process regulation, as well as the skill to apply basic and advanced control strategies to solve problems in industrial process automation and logic control problems.

The next steps are to test this concept in other engineering classes, define roles for the students during the activities with specific tasks, and finally evaluate the methodology in face-to-face classes to see if it still provides a benefit for them.

Acknowledgments. The authors would like to acknowledge the financial support of Writing Lab, Institute for the Future of Education, Tecnologico de Monterrey, Mexico, in the production of this work. Additionally, the authors would like to acknowledge the financial support of NOVUS Grant with PEP No. 19016, *TecLabs, Tecnológico de Monterrey* in the production of this work. Finally, we would also like to thank the students who willingly participated in this study.

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