JIGSAW IN THE TIME OF PANDEMIC

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ABSTRACT

Based on our positive, but limited experience with Jigsaw at the university level, half a year ago we initiated a more extensive experiment with a larger sample of students, and incorporating changes that relate back to some negative comments we have received during the previous course. Jigsaw is a collaborative inquiry-based learning technique that works by dividing the learning material into different tasks and the class into different groups. What set out to be a controlled experiment in increasing motivation and participation through collaboration, turned into a much more complex scenario due to the arrival of the Covid-19 pandemic, which gave us some interesting results to report. We have seen more positive results this year than the last: the number of students that felt that Jigsaw requires more effort than traditional methods has fallen, they consistently thought that Jigsaw improved teamwork, and they felt they have learned more from their expert peers as the experiment advanced. Some of the results may be due to the confinement forcing people stay indoors, with no social outings and fewer distractions – so more time to study. Another factor that may be relevant are the implicit expectations that were set by the confinement about distance learning and the need to cooperate.

KEYWORDS

Autonomous Learning, Collaborative Learning, Active Learning, Jigsaw, Blended Learning

1. INTRODUCTION

During the 2018-2019 academic year we adapted the Jigsaw methodology to the structure of the *Cloud computing and distributed systems for videogames* course, offered during the 3rd year of the design and development of videogames degree at the University of Girona, Spain. This was motivated by a desire to increase the students´ interest and participation in class and complement the purely technical skills with skills that relate to decision making, analysis, and teamwork. To assess the results not only quantitatively, we asked the students to take a series of surveys during the course of the Jigsaw experiment. The results were encouraging, and there were several comments that deserved closer attention. Given that this class only consisted in 12 students, we decided to repeat the experiment with a larger class, while applying only a few, rather small, modifications. Then the one-in-a-decade change came unexpectedly – Covid-19 – and what was supposed to be a controlled case study became an unprecedented one, with interesting, but hard to prove correlations.

The *Cloud computing and distributed systems for videogames* course is a rather technical course, of the type that usually relies on incremental building of knowledge, but it does lend itself to learning various topics independently. One of the concerns we had in the previous year with the Jigsaw method was that, after a certain age, students are already settled into their roles as leaders or followers which, in turn, could make it harder for them to work in collaborative environments that lack hierarchy. Nevertheless, some of the comments did show that sometimes students prefer to work with colleagues of their own choosing – and we assume that this is because of a known group dynamics where people easily assume their roles.

Just like last year, we decided to apply the Jigsaw method to only part of the course contents to limit the possibility of negative outcomes for those students that don´t adapt to this approach. We applied the same approach to the same course and contents, but with several new aspects: the number of students increased from 12 to more than 30, and we gave the students some initial guidance before starting the Jigsaw activity, in the form of a 10 minutes introduction to the Optical Networking topic. Lastly and drastically different from last year, due to the COVID-19 pandemic, an initial activity in the classroom during the first week was followed by activities at distance using videoconference tools, in a blended fashion. The impact of these aspects provided new knowledge, interesting enough to be shared.

2. BACKGROUND

The purpose of learning is to acquire knowledge and problem-solving skills and peak the students´ curiosity to continue this process. Every student has a different personality, strengths and weaknesses, interests, and background. They therefore learn at different rates and with different incentives but being engaged is fundamental to learn and retain. More often than not, comparing notes and ideas with colleagues is positive, and cementing positive behavioral changes – such as teamwork – is important.

2.1 Collaborative Learning

Collaborative learning techniques are based on student cooperation to achieve a common goal and come with the challenge of explaining concepts to fellow groupmates. Due to this, students develop their communication, argumentation, and debating skills, rather than not only being guided by their teachers. The focus is shifted to working in groups, where instructors are facilitators rather than dispatchers of knowledge (Zarei, 2016). Cooperative learning also considers that the students can learn better by doing and by working in groups, than by receiving the information from the presentations of the instructor (Slavin, 1995) (McConnel, 1996) (Jones, 2007) and (Pow Sang, 2016).

The social aspect of learning was highlighted by Bruner, who introduced the concept of reciprocity in learning as an incentive (Bruner, 1966). Theoretical studies and practical applications have shown that the students' performances in school can become better if the course combines traditional teaching with modern techniques, which implies that traditional methods will be partially or fully modernized. (Johnson 2014) cites as a learning challenge the development of interpersonal relationships that affect personal identity. Additional elements of cooperative learning are a) face-to-face verbal interaction, b) individual accountability, c) group processing and d) appropriate grouping. All of them are particularly relevant to enhancing social skills in higher education (Kaufman 1997). In (Terenzini 1994) it is shown that individualized and collaborative approaches are more effective than traditional (lecture) approaches because they respond better to differences in students' levels of preparation, learning styles, and rates; the authors support to the use of cooperative learning at the university level – not necessarily an initial target. As in our approach, collaborative learning was used in Science and Technology courses at university level by (Altun 2015).

2.2 Active and Inquiry-Based Learning

Active learning hypothesizes that when students are more involved in active, rather than passive, activities, such as reading, writing, discussing, problem solving, or interacting via questions, they pay more attention. Some studies of specialists in pedagogy and educational psychology have shown that the students are only aware of the lecture about 40% of the time, retain around 70% of the contents presented in the first 10 minutes, and only 20% of those shown in the last 10 minutes (USCTA) (Stuart, 1978). (Guido, 2017) discusses that, when the student is investigating a problem or a question using evidence-based reasoning and creativity, active learning is enriched and becomes inquiry-based learning.

2.3 Jigsaw

In 1978, Elliot Aronson proposed Jigsaw as a collaborative inquiry-based learning technique that works by dividing the learning material into different tasks and the class into different groups (or teams) (Aronson, 1978). In a Jigsaw group, each student has to perform one of the tasks, which will eventually be integrated by the group to conclude the training process. Jigsaw iterates between tasks (expert groups) and team-based work (working groups). The experts work is carried out in groups of increasing size, starting with individual work and ending with all the students that were assigned to a specific task. During the process, students contrast and complement their understanding to reach a common understanding. The jigsaw method is also known as the “mosaic” (Maftei-2011).

A number of investigations support the favorable impact of Jigsaw during the teaching/learning process. (Sharan, 1980) studies the effect of the Jigsaw method on learners' attitudes and achievements, concluding that it helped create interdependence among learners as a result of the learning task being divided up among them. (Zakaria 2016) reports a positive change in the attitudes of the students towards their fellow classmates, an increase in the students' sense of responsibility. (Sahin, 2010) (Durmus, 2008) (Walker 1998) and (Maftei 2011) report an increase in participation and improvements in communication skills.

(Felder, 1998) defines the sequential and global dichotomy learning styles. Most formal education involves presenting material in a logically ordered progression (sequential). Some students are comfortable with this system; they learn sequentially, mastering the material (more or less) as it is presented. Others, however, learn globally, so they may be lost for weeks, until suddenly they "get it". Jigsaw helps to combine the two types of learning and ripping off the benefits: as an expert a student learns sequentially, and as a working team member, globally. Blended learning offers an approach for increasing the impact of both face-to-face learning and online learning as supportive and motivating method for students (Sulisworo 2016).

3. OUR APPROACH

3.1 Case Study

We developed the present study with the thirty 3rd year undergraduates registered in the *Cloud computing and distributed systems* course of the "Design and development of videogames" specialization during the 2020 Spring quarter. The activity was structured around three subtopics that could be independently studied – the same as in the previous year. We selected Optical Technologies because it can be more easily split into independent subtopics: A) Optical fiber properties, B) Optical components and C) Optical networking (Marinescu 2019). Optical Networking stands for an eighth of the course content and grade. The chosen subtopics can be studied in any order, then assembled as Jigsaw pieces. This was a challenge given that in engineering fields, learning is mostly sequential and based on concepts that are already fully understood. The learning process starts with online content search based on a set of keywords that the teacher provides for each subtopic.

3.2 Organization of the Experiment

(Felder, 2003) states fundamental skills such as motivation, positive interaction, cooperation, leadership, decision-making capabilities, tolerance and trust, and the ability to think critically. Following these criteria, we have organized the experiment as follows. The thirty students were organized in two (super)groups, I and II. For each of them, three expert groups were defined for the three subtopics. At the same time, students were organized into four working groups - each consisting of one expert per subtopic, following the suggestions of previous work (Dumus, 2008), (Nooritawati, 2010) (Khine, 2019). The expert groups were randomly formed as a way for students to learn how to collaborate, discuss, and debate with any of the colleagues. Each student was also randomly assigned to a working group. As a notation, student "C2" was assigned to the expert group C, i.e. dealing with subtopic C), and to the working group 2.

3.3 Jigsaw Phases

To carry out the Jigsaw activity, the following phases were planned over the course of three weeks:

Table 1. Phases of the Jigsaw activity

Phase	Activity	Group	In classroom /at distance	Evaluation
1	Every student works individually on the assigned subtopic (A, B, or C), and delivers a short report to the instructor.	Individual	Distance	Report
2	During class, students present their findings (on their assigned subtopics) to their working group members, who worked on different subtopics. Each student is required to take notes of questions, missing points, misunderstandings, etc., to be able to address them in the future phases.	Working	Classroom	None
3	Expert groups meet in small groups building a common understanding of the subtopic and refining their corresponding material. Expert groups can be A1+A2, B1+B2, C0+C1+C2, etc.	Expert	Distance	Report of small expert group
4	During class, each small expert group presents the improved material to the larger working groups consisting of all the members of their teams (e.g. A1+A2, B1+B2, and C0+C1+C2).	Working	Classroom, carried out at distance	None
5	The entire expert group meets and puts together their material for the final version.	Expert	Distance	Final report of the entire group
6	In a "plenary" meeting, the three expert groups present each subtopic. This is the only time when the instructor is present for all the activities, as all previous phases occur in simultaneous presentations.	Plenary	Classroom, carried out at distance	Students presentation, based on their oral skills.

Table 1 shows that during these phases a student alternates between expert and working groups and acts as peer with the expert mates and as instructor to the working group members. The students were informed about the overall structure and activities of Jigsaw, but the new work partners after each phase were announced at the end of that phase. This was meant to get ready to collaborate with any partner without any prejudice based on previous collaboration.

Phases 2, 4, and 6 were initially planned to be carried out in classroom during 15 to 20 min. Due to the COVID-19 pandemic, phases 4 and 6 were carried out using videoconferencing tools.

3.4 Learning Objectives and Evaluation

Among the competences of the course (as defined in the course syllabus), the Jigsaw activity addresses the following learning objectives: a) analyze complex situations and design strategies to address them, b) compile and select information efficiently, c) teamwork and d) decision-making. The goal of this work is to report on a case study rather than setting up to answer an experimental question, which implies delicate ethical issues. The surveys taken by the students are an evaluation tool for the *opinion* of the students with regard to learning with Jigsaw – a first experience for all, versus the traditional method – which they have implicitly used throughout, rather than a tool for the evaluation of the learning outcome.

As in previous work (Marinescu 2019), we could not risk treating individuals as experimental subjects; as a result, to avoid any significant negative impact on the grades of those students who may not find Jigsaw productive for them, we weighted this activity to only count for 10% of the final course grade. For ethical reasons, *all* students were involved in the same activity at the same time, which means we can´t compare the actual learning results with and without Jigsaw, or with other methods. The items to be evaluated and the corresponding phases are detailed in last column of Table 1. The two final plenary meetings (supergroups I and II), were organized in two videoconferencing meetings at a different time, hence the instructor could attend both assessing the students' activity as initially planned. Even if the students are graded individually, students need others for a good mark and therefore this technique requires cooperative working (Altun 2015).

4. RESULTS

We use reports and presentations during the course to quantitatively asses the level to which students acquired the technical target skills and knowledge. At the same time, this evaluation cannot assess aspects such as the level of engagement, the attitude towards their colleagues, the probability that they would use these techniques in the future, etc. These are factors that are easier recorded by surveys, as they refer to opinions and intentions when comparing jigsaw with traditional teaching. Similar to last year´s Jigsaw activity, we surveyed all of the students three times during the course: after phase 3 (1st expert meeting), after phase 5 (2nd expert meeting), and at the end of the activity. Replies were voluntary.

4.1 First Jigsaw Survey

The first survey is a mix of two multiple choice and one free text questions. The multiple choices evaluate the students´ quantitative opinions about the work that was presented by themselves and their team members. The open-ended questions referred to the students´ attitude towards collaborative learning. This survey was taken just after the onset of the Covid-19 pandemics and referred to activities that took place in person. At this point the expert groups had delivered the first report. The questions in the first survey are the following:

1) Rate from 0 (very poor) to 10 (excellent):
   a) In your opinion, which is the level of knowledge of the subtopic that you prepared?
   b) In your opinion, which is the level of knowledge of the subtopic, that other students prepared?
2) The preparation of your topic compared to other students (is: “better”, ·equal”, “worse”).
3) Reply with free text: What aspect of the Jigsaw activity do you a) most like, b) not like.

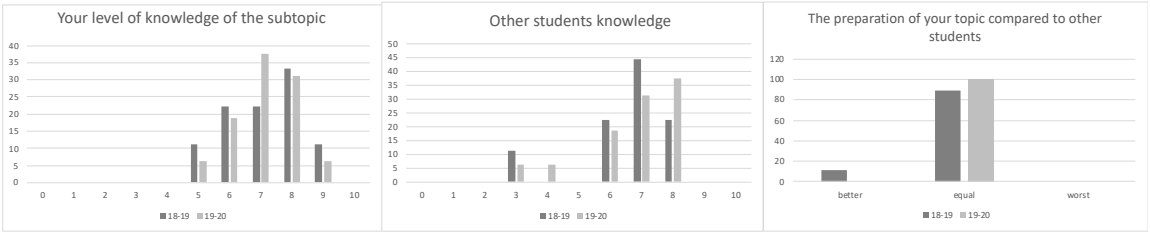

Figure 1. Jigsaw survey 1. The y axis represents the percentage of students

Students considered that, in general, their level of knowledge is good, with a mean of 7.1 (both years) and a standard deviation of 1.27 and 1.02. The distribution is more of a Gauss bell than the results from the previous year given the larger number of surveyed students (last year 9 students, this year 12 students.

For question 1.b students had a similar response as last year, most of them rating the others very closely to their own rating. With more respondents this year, all students perceived that the preparation of their respective topic was “equally good” compared to the others. Last year outlier also disappeared. Looking at the results combined, there is a slight tendency to consider that most of the others have about the same, if not more knowledge after the first expert meeting.

From the replies to question 3.a, it seems that what students liked the most was the fact that they had to look for the information by themselves, understand *small, contained* pieces well by doing research on the topic, then contrast it with their colleagues. The second most cited fact was the teamwork of putting together the content that each has studied separately. Somewhat differently, last year´s comments focused mostly on the social setup of the groups, but putting information together makes one realize details one may have missed.

The negative comments in 3.b are very similar to last year´s, and they refer mostly to the activity being too long and the insecurity of not knowing that you looked up everything relevant, or how to solve a conflict when two students have extracted contradicting information. There were also a few students that wanted to be able to choose their groups – not clear whether because of the particular group dynamics or reluctance to work as a team, when usually you don´t get to choose the members – and one that hadn´t understood the purpose of the activity altogether.

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4.2 Second Jigsaw Survey

After the 2nd session of expert meetings (phase 5), students were requested to answer the following questions with the responses limited to "a lot", "some", a little" or "did not increase":

1. The knowledge on the subtopic that you prepared has increased.
2. The knowledge on the subtopic, that your colleagues prepared has increased.
3. The preparation of your subtopic in relation to the other´s subtopics.

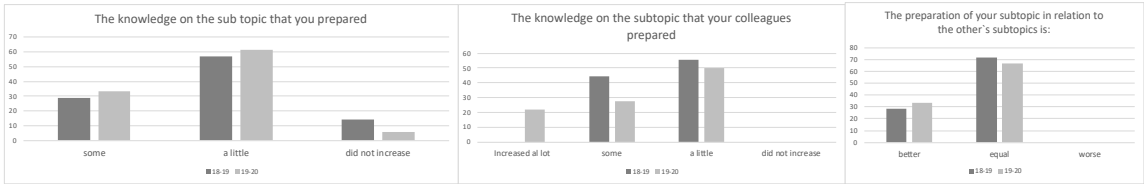

Figure 2. Jigsaw survey 2

The results are rather contradicting those from the previous year, although the differences are minimal. Students report to learn more on the subject they have prepared, after the second expert meeting, relative to the previous year. They also report to have learned considerably more during the second expert group meeting, with about 20% of them having learned "a lot" compared to none last year. Nevertheless, two of the students still reported (in free text) that they don´t feel that the other experts have come up with anything very different after their working group meetings.

These are results for meetings that occurred after Easter week, and thus there may be an effect of paying more attention to work as a result of the confinement, the on-line setting, or both. It is likely that the variation is more connected to the fact that students could not spend time on live social activities and instead studied.

4.3 Third Jigsaw Survey

At the end of the Jigsaw activity, students were asked to fill in a 3rd survey that contains a general question about the technique and two open-ended questions.

1. Compared to traditional classes, how was the Jigsaw experience (more, equal, or less) regarding: a) Effort in the preparation, b) Level of knowledge of one's own subject, c) Improvement in teamwork, d) Satisfaction with others' presentation level and e) Level of knowledge of others´ subject
2. What is your opinion about the Jigsaw technique?: a) Positive comments, b) Negative comments

From the first question we can see that a much lower percentage of students then last year thought that Jigsaw requires more effort than the traditional method. The difference could come partially from a 10 minutes introduction to Optical Communications right before starting Jigsaw. We were happy to see that a lot more students thought that their level of knowledge about the subject they prepared is higher with Jigsaw. This is not surprising given that learning actively is usually more effective than listening to a teacher, if the subject is not prohibitively difficult, but may also be an indirect effect of the confinement, which minimized the distractions.

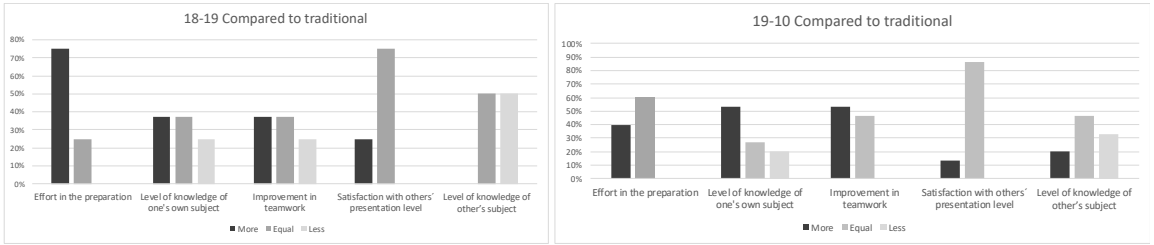

Figure 3. Jigsaw survey 3: the y axis shows the percentage of students that completed the survey

In terms of teamwork, no student considered that this was worse with Jigsaw, while this wasn´t the case last year. It is possible that the expectation of exclusive online collaboration makes people be more effective, and possibly lower their expectations – which would result in higher rating of the same activity. Somewhat surprisingly, some students considered that they have more knowledge of others´ subject with Jigsaw, up from none last year - although even more think the opposite. This survey was taken *after* the final presentations. We hypothesize that this may be the effect of only seeing the material (i.e. slides) and hearing the talks, rather than being present in person and getting distracted by other factors, including faces and body language. We could be observing the opposite result of not seeing a person speaking, when having to process technical information rather than understanding the emotional message.

The *positive comments* are mostly about the fact that students felt that this was a good way to learn a subject, that they have learned a lot about their subtopic, and that this is an interesting type of exercise. One difference from last year is that nobody referred to explaining the material to the others; we don´t know whether their online collaboration was less interactive than it would have been live. Several of the *negative comments* refer back to the first question of the survey: "I don´t think it substitutes the professor´s explanation perfectly", "I feel that I could have learned much more with a (traditional) class", "We don´t understand very well the other subtopics, I would do three different subtopics myself. A last comment was about the group size, which they felt shouldn´t be too large (about 5 or 6 people). This was precisely the case so we understand this is a positive comment

In general, we saw more positive results this year than the last. This could be partially true due to the indirect effects of the confinement, or it may be a better approximation to reality due to pure statistics. In any case, other authors have also commented on the mixed results of the Jigsaw technique. We want to reiterate that surveys relate the *impressions* of students and must be taken as an indication rather than a recipe for success.

5. CONCLUSION

This work presents a study that implements the Jigsaw method with the thirty 3rd year undergraduates registered in the *Cloud computing and distributed systems* course at the University of Girona, Spain. This is a more extensive experiment for the same course as last year, with very minor modifications. The expansion of the Covid-19 pandemic forcefully changed the conditions under which we conducted more than half of the Jigsaw process. This resulted in some interesting outcomes, which are nevertheless not easy to correlate with the effects of confinement, the change to distance learning, or a combination thereof.

Students have generally valued important aspects of learning more positively than last year. Some students still felt that they were not sure whether the information they discovered by themselves was complete and they would have liked to have had more guidance or go through the Jigsaw expert team process for all of the subtopics – a call for an incremental, more traditional learning method, applied in a collaborative team - rather than instructor - context. Some students also proposed to skip the initial individual phase, starting in groups of two or three. This would allow reducing the number of phases from six to four, by skipping the two initial ones. This proposal seems quite realistic at the university level and we consider applying it for next Jigsaw experiences.

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