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Using Competition to Improve Students' Learning in a Project-Based Learning Course: The Systemic Impacts of the Data Science Olympics

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ABSTRACT

In this article, we presented our findings regarding an online project-based learning course, delivered to 64 students from the Federal University of Sao Paulo, Brazil, during the COVID-19 pandemic, in the second semester of 2021. The course had the goal of teaching Project Management by means of a competition (the Data Science Olympics). Our goal was to investigate the systemic impacts of the competition on learning. Data was collected by means of a questionnaire and from comments posted on the teams' websites. We followed a convergent parallel mixed methods approach. We analyzed the data using a causal loop diagram to connect the insights gained with quantitative and qualitative results. Our findings were as follows: 1)The use of competition in a project-based learning centered course helped the students to develop project management and data science skills, and fostered metacognition and knowledge sharing opportunities. 2)The Data Science Olympics increased the students' intrinsic motivation to learn. 3)The project-based teaching practices (scaffolding the students' learning, giving meaningful feedback to the students, and managing the activities) facilitated the students' learning. 4)The problems the students faced throughout the Project (dropouts, communication problems, lack of commitment, difficulty scheduling online team meetings) impacted negatively on the students' motivation.

Keywords: Data Science, Project Management, Project-Based Teaching, Competition, Systemic Impacts

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BACKGROUND

In this article, we discuss the systemic impacts of the combination of competition elements in a project-based learning centered online course. The course “Project Elaboration and Management” was delivered to 64 students of Economics from the Federal University of São Paulo Osasco Campus (thereafter UNIFESP), during the COVID-19 pandemic. The course was developed from October 2021 to January of 2022. Due to the pandemic, there were no face-to face-meetings. The course was developed by means of synchronous meetings and asynchronous activities. During the COVID-19 pandemic, the UNIFESP created a rule that the synchronous meetings were not obligatory. This rule impacted the course, as we will discuss later in this article. The students were divided into 12 teams of six students each (on average) that would work together during 12 weeks. During the first six weeks, the students studied project management concepts, planned their projects, and defined their study strategy (which member of their group should study which topic and when). They also began their studies of the topics included in the Data Science Olympics (Descriptive Statistics, Inferential Statistics, Regression, and R coding). In the following weeks, the teams continued their studies and were challenged together to solve, every week, the “Challenge of the Week” (a set of problems sent by the professor to the teams with the goal of preparing them for the competition. The final Challenge was the Data Science Olympics.

THEORETICAL REVIEW

Project-based learning (thereafter PBL) is an instructional approach in which the students learn by doing while working on a project (Krauss & Boss, 2007) that leads to the creation of a product, a service or a unique result (Project Management Institute, 2018). In PBL-centered courses, the students work in teams, following a master schedule that has well defined deliverables and milestones (Bender, 2012). In a typical PBL centered course, the students have voice and choice (Sahin, 2015): they have freedom to make decisions that include defining the team’s strategy, choosing the team members' roles and responsibilities, and stipulating the project activities.

There are several ways of designing and delivering a PBL centered online course. In our course, we followed the ADDIE model (**A**nalysis, **D**esign, **D**evelopment, **I**mplementation and **E**valuation), a five-phased instructional design model (Figure 1). Ideally, the course is developed sequentially, from the Analysis phase to the Implementation phase (in Figure 1 the boxes represent the phases; the solid lines represent the path the project follows). Note that the Evaluation phase is in the center of the figure, connected to all other phases. This means that the deliverables of each phase are evaluated during the development of the project. However, real-world projects may not be developed in exactly the same way:

sometimes it is necessary to return to a previous phase, to make adjustments and corrections (represented in Figure 1 by the dashed lines).

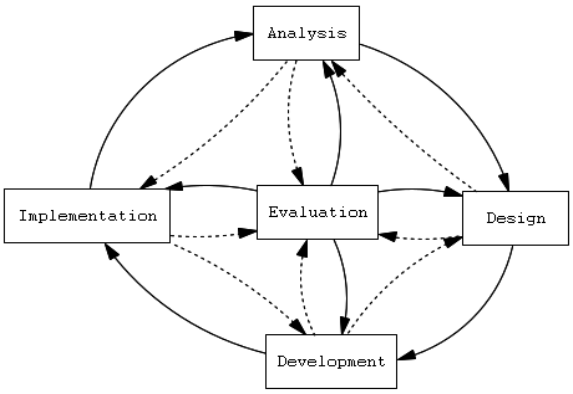

Figure 1. The Addie instructional model (based on Branch (2009) and McConnell (1996))

During the Analysis phase, the professor also defines the project's theme, aligning the learning objectives with the students' background. Researchers point out that the right choice of the project's theme is fundamental to the success of a PBL centered course (Moreira et al., 2011). The project should be interesting, motivating, challenging and meaningful to the students (Markham et al., 2003). The project's theme should be chosen wisely: if the project is very easy to accomplish, the students may lose interest; if it is too difficult, the students may become overwhelmed and stressed (Fregni, 2019). The project's theme therefore impacts the students' motivation which in turn may impact their learning effort (Arantes do Amaral & Fregni, 2022).

During the Design phase, the professor defines the course content and scaffolds the students' learning experience (Larmer & Boss, 2018) . He/She may define the project's schedule, the milestones, and the deliverables. In addition, the professor should create opportunities for sustained inquiry (Arantes do Amaral, 2021; Larmer, 2010). In other words, the students should have enough time to research what they need to learn in order to develop the project's activities (Larmer et al., 2015). More than that, the professor also should scaffold opportunities for the students to reflect on their learning, sharing their learning with their peers (Arantes do Amaral & Fregni, 2021; Rooij, 2009). In addition, the professor should schedule critique and revision activities (Larmer & Boss, 2018) in order to promote long-lasting learning (Fregni, 2019). During the Design phase of an online PBL-centered course, the professor should also choose (or create) the virtual learning environment (thereafter VLE), designing the user interface.

Throughout the Development Phase, the professor (ideally with the support of instructional designers) develops what was defined in the Design Phase. Course management systems (such as Moodle, Google Classroom) and website builders (such as Google Sites, Wix, Weebly) can be used for the development of the VLE.

During the Implementation phase, the course is delivered (Filatro, 2008) following the activities defined in the Design phase.

The Evaluation processes are present throughout the course: the professor (ideally with the support of instructional designers) evaluates the deliverables of each phase and makes the necessary adjustments. He/she also evaluates the students' performance and the effectiveness of the learning experience.

The use of ADDIE to develop online PBL-centered courses helps the instructor to have a better understanding of the students' needs, which helps to design the learning environment more efficiently (Shibley et al., 2011). Moreover, it also helps to develop and evaluate the course in an orderly way (Lu, 2021).

In recent years, competition has been used by teachers in PBL-centered courses to enhance students' interest in learning (Krithivasan et al., 2014) and to develop their skills (Willard & Duffrin, 2003). Although there are studies that reported the use of competition in combination with PBL, it seems that still there is a lack of information about the systemic impacts of this combination in online courses. Our research question then became: *What are the systemic impacts of using competition to improve the students' learning in a project-based learning centered course?* In this article we intended to answer this question.

THE INSTRUCTIONAL DESIGN MODEL

As discussed previously, to design and develop our course, we followed the ADDIE instructional design model (Arshavskiy, 2013). It took one month, previous to the beginning of the course, to develop the Analysis, Design and Development Phases. The Implementation Phase took twelve weeks and the Evaluation occurred throughout the project and one week after the end of the project.

The Analysis Phase

The Analysis phase began one month before the course started and lasted one week. During this phase we collected information about the students who would take the course. We learned that the students would be from the Economics department, most of them fourth-semester students, who had already taken two previous courses of Statistics/R programming and were going to take a course of Econometrics in the next semester. Based on this information, we decided to create a challenge that we called "Data Science Olympics" (thereafter DSO). The idea was that the students would work during twelve weeks in teams of five members, sharpening their skills (studying Statistics and R programming) to compete in the DSO. The preparation for the DSO should be accomplished by means of a project in which they would plan the team-learning strategy, define their roles and responsibilities, and execute their strategy. The DSO was created with the following goals: 1) provide the students the experience of learning by doing (learn Project Management while working on a project), and 2) improve the students' learning by promoting an opportunity for them to review and put into practice what they had learned in previous courses (Statistics and R Programming).

The Design Phase

The Design phase followed the Analysis phase and also lasted one week. During this phase, we decided to follow a project-based learning approach. We structured the course by defining the learning objectives, choosing the number of modules, defining the purpose of each module, the project theme (the DSO), the project's deliverables and the learning outcomes. The course was designed to have 12 modules, one module to be taught per week. Each module had from five to ten short video-lectures (five to ten minutes long). In addition, we designed the course's virtual learning environment (thereafter VLE) and its human computer interface.

The Development Phase

During the development phase we implemented what we had defined in the Design Phase. We created the VLE using Google Sites. We also created a set of 96 video-lectures and assembled the content on the website. In addition, we created a webpage with additional resources (links to free books about Project Management, Statistics and R programming). We worked intensively for two weeks, without the support of instructional designers.

The Implementation Phase

The Implementation phase began at the end of the Development Phase and lasted 12 weeks. During the Implementation phase the course was delivered. At the end of the first week of the course each team of the students created a website with information about their project. Each website had four pages: ***home*** (with information about the project), ***the team*** (with information about the students), ***the weekly activities*** (that would be fulfilled, as the course progresses, with information about what the students accomplished during each week of the project, the problems they faced, the actions they took to solve the problems and reflections about their learning), and ***the documents*** (one page with the links of the contents of the team's project management plans). The students' website had the goal of fostering metacognition (reflection about the learning process).

By the end of the second week, the teams created the first document, the ***project's charter*** (a document with the team structure, roles and responsibilities, the project's goal, the premises and constraints, the major risks and the team's strategy for winning the DSO). At the end of the third week the teams created the ***work breakdown structure*** (a graph that presents the tasks that should be accomplished by the teams). In the fourth week the teams delivered the ***project schedule network diagram*** (a graph that presents the sequences of the activities to be accomplished). In the following week the teams created the ***risk management plan*** (the strategies to mitigate risks) and by the end of the six week, the ***quality management plan*** (the actions that should be taken to guarantee the quality of the processes followed).

In the seventh week, the teams answered the First Challenge of the Week (ten questions about Descriptive Statistics). In the eighth week, they worked on the Second Challenge of the Week (ten questions of data manipulation with R). In the following week (week nine) they answered the Third Challenge (ten questions about Inferential Statistics, proportion hypothesis test). In the tenth week they worked on the Fourth Challenge (ten questions about hypothesis test of means). In the tenth week the teams solved the Fifth Challenge (ten questions about analysis of variance). In the eleventh week the teams worked on the Sixth Challenge (ten questions about Chi-Square and Contingency Tables). In the final week of the course the teams worked on the Data Science Olympic (ten questions about all the topics of the study). The professor analyzed the answers, declared which team had won the DSO and sent a certificate of achievement to the winners.

The Evaluation Phase

Along all of the twelve weeks the teams were required to upload the website with the information about the progress of the projects and with reflections about their learning. The professor evaluated each website every week, sending feedback (in video format) to the students by email. We asked the students to provide us with detailed explanations of what they had learned from watching the videos we created about project management concepts, as well as how they applied their newfound knowledge in their own projects. We evaluated the coherence between their explanations and the actions they took in their projects. Whenever we identified a lack of understanding in a concept, we provided the students with feedback that highlighted the deficiency and offered suggestions for improvement. This feedback was not limited to the text they created on their project's website but also encompassed the actions they were taking. Each group was demanded to follow the professor feedback (by explaining the activities in a more detailed way, by fixing documents errors etc.).

The students who had questions were asked to bring their questions to scheduled weekly synchronous meetings (using Google Meets), in order to share them with all students. Since the meetings were not obligatory (due to UNIFESP's rule), the number of students who attended the meetings varied. At the first meeting almost all students participated, but the number of participants diminished as the course progressed. On average, each meeting had four students.

In the final week of the course, the professor sent a questionnaire to the students. The questionnaire had the goal of gathering information about the students' perceptions about the course. Their answers were used in improving the course that would be offered the following semester.

METHOD

Research design

We followed a convergent parallel mixed method approach. In this approach the quantitative and qualitative data is collected simultaneously. The researcher then analyzes each piece of data separately. After that, the researcher connects the findings of each type of data (Creswell & Creswell, 2018). We used causal loop diagrams to make a systemic analysis (Arantes do Amaral, 2019) of the results.

Participants

Sixty-four students, 41 males and 23 females. The youngest was 17 years old, the oldest 37 years old, and the average age was 20 years old.

Data collection instruments

We collected data from the team's websites and from a questionnaire sent at the end of the course. The questionnaire had eight sets of questions, each with five closed-ended Likert scale questions (APPENDIX 1).

The first set of questions had the goal to measure the students' participation in synchronous activities. The second group aimed to collect data about the students' perceptions about the course management. The third was related to the effectiveness of the project-based learning approach. The fourth set of questions had the objective to gather data about the students' perceptions about the importance of what they have learned. The fifth had the goal of getting information about teamwork. The sixth set of questions aimed to collect data related to the learning effort. The seventh had the goal of gathering information about the ways the students learned. The eighth collected data about what the students learned.

Data analysis procedures

We analyzed the quantitative data by means of descriptive Statistics, using diverging bar charts. The qualitative data was analyzed by means of a language processing method(Yin, 2015). First we collected qualitative data (sentences that represent the students' perceptions about the project) from all teams' websites. Then we disassembled the sentences into small phrases. After that we grouped the similar sentences and created recurrent themes, sentences that aggregate the main ideas of each group. After we performed a systemic analysis, connecting the qualitative and quantitative data by means of a causal loop diagram.

RESULTS

In this section we will present the quantitative results (obtained from the answers to the questionnaire) and qualitative results (obtained from the projects' websites).

Results from quantitative data

The following diverging bar charts (Figure 2 to Figure 9) present the students answers (agreements or disagreements) to the eight sets of questions described previously. The identifiers (names that appear on the charts) are available in APPENDIX 1.

The answers were collected using the five-point Likert Scale, using the following color convention: 1-Totally Disagree (brown bar), 2-Disagree (Light brown), 3-Neither agree, nor disagree (Gray), 4- Agree (Light Green), 5-Totally agree (Green).

Set 1: Answers related to the lack of participation in weekly synchronous meetings

The students' answers to the first set of questions (Figure 2) shows that the majority of the students (86%) did not participate because they thought that the professor's weekly feedback addressed most of their doubts. In addition to that, 58% of the students answered that they saw no need to participate. The data also revealed that another reason for the low participation was that the majority of the students (53%) were also too busy taking other courses and 50% answered that they did not participate because they had no doubts. Only 22% of the students answered that they did not participate due to digital fatigue.

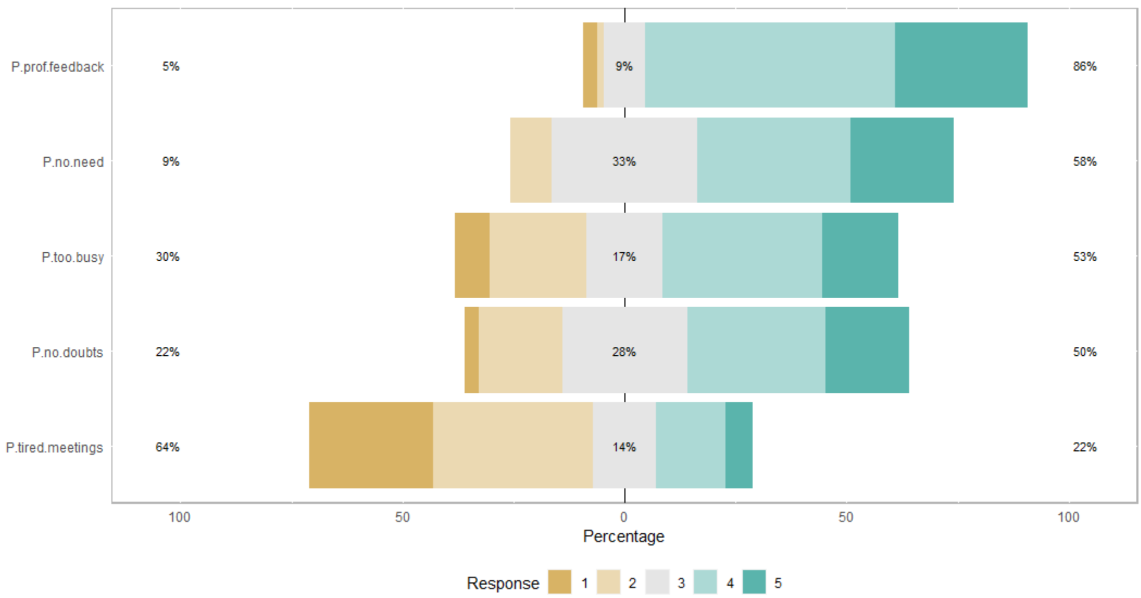

Figure 2. The divergent bar chart of the answers for the first set of questions related to lack of participation in synchronous meetings.

Set 2: Answers related to the course management

The students' answers to the second set of questions (Figure 3) show that for 88% of the students, the professor's feedback was adequate, 82% acknowledge that the course resources (books, video-lectures) were appropriate, 75% recognized that the professor demandingness was fair, 66% admitted that the course workload adequate and 61% acknowledge that the amount of topics covered in the course was acceptable.

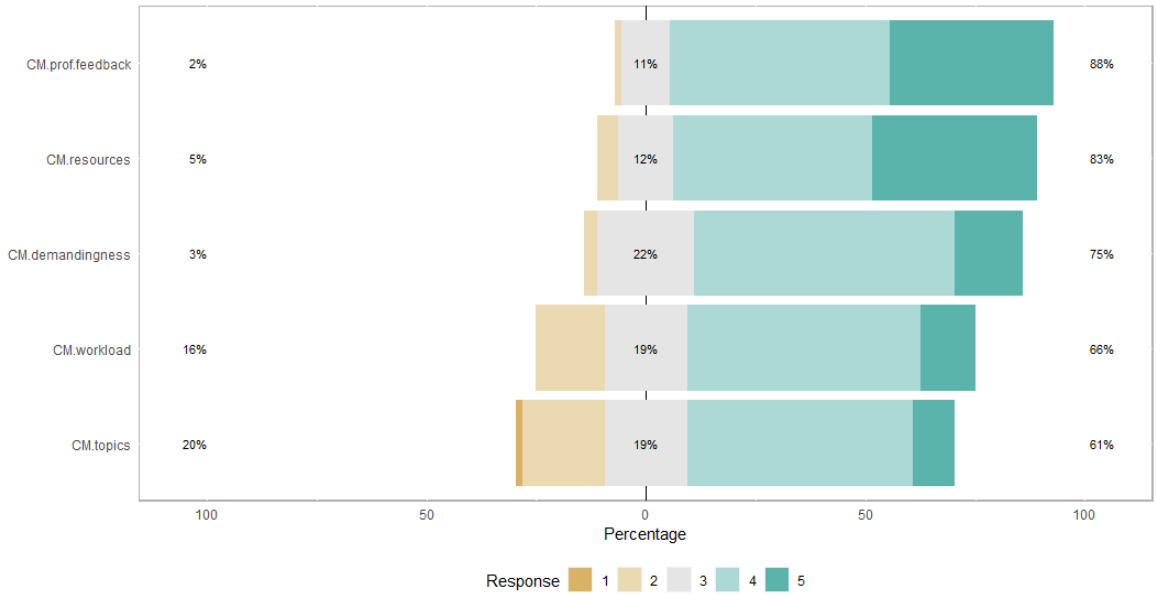

Figure 3. The divergent bar chart of the answers for the second set of questions related to course management.

Set 3: Answers related to the effectiveness of the project-based learning approach

The students' answers to the third set of questions (Figure 4) reveal that, for 86% of the students, the research they did to solve the Challenges of the week facilitated their learning, while 84% acknowledged that they developed R coding and Statistics skills. In addition, 83% of the students acknowledged that the PBL approach led to the development of their Project Management' skills, 81% recognized the PBL approach fostered knowledge sharing between teams and 64% of the students stated that the PBL approach increased their skills to work on real-life projects.

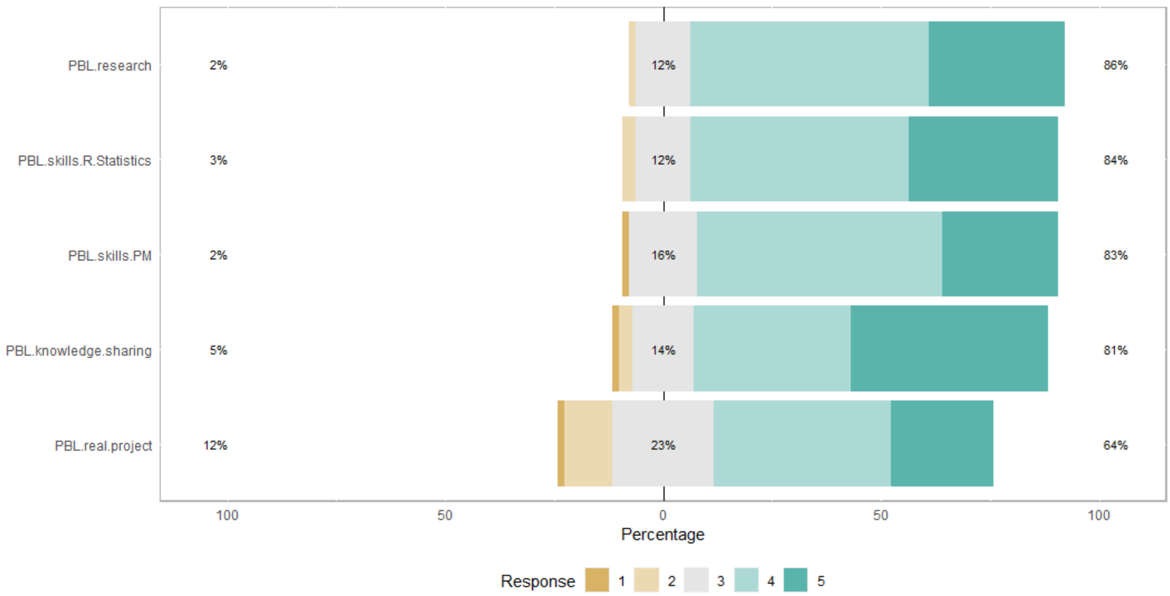

Figure 4. The divergent bar chart of the answers for the third set of questions related to the effectiveness of the project-based learning approach.

Set 4: Answers related to the students' perceptions about teamwork

The students' answers to the fourth set of questions (Figure 5) revealed that working in a team was a pleasant experience for 75% of the students; 73% answered that, in moments of difficulties, the students helped each other and 73% acknowledged that during the project the teams worked in harmony. Moreover, 70% stated that all team members contributed to the accomplishment of the Challenges of the Week. Finally, 55% of the students declared that the workload was fairly divided among the team members.

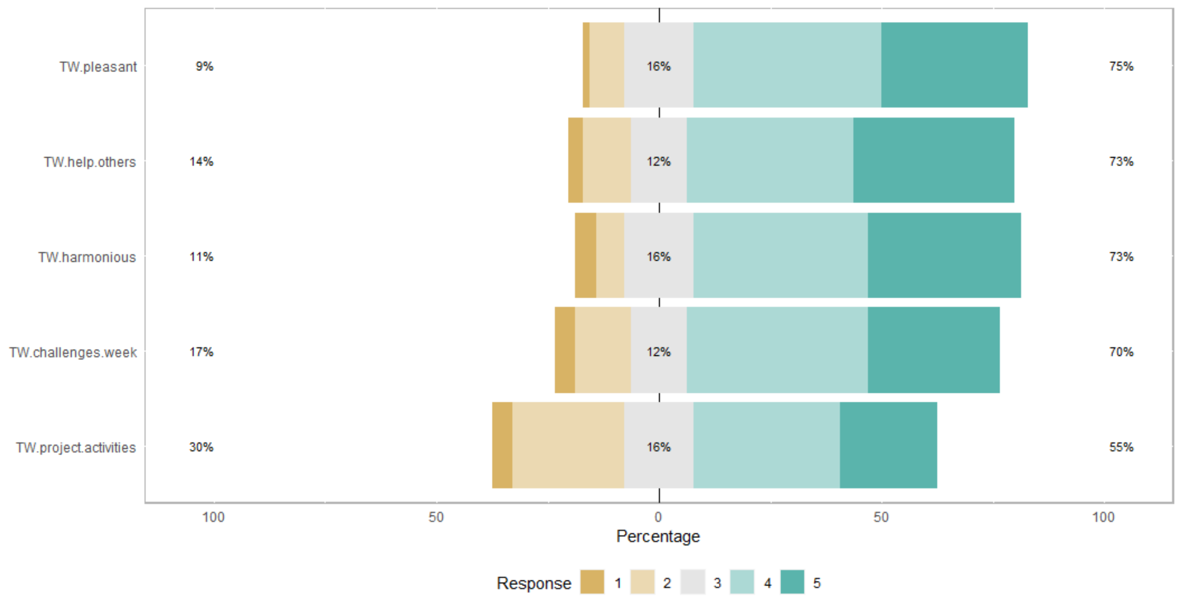

Figure 5. The divergent bar chart of the answers for the fourth set of questions related to the students' perceptions about teamwork.

Set 5: Answers related to the students' perception of the importance of what they have learned

The students' answers to the fifth set of questions (Figure 6) revealed that almost all students (92%) recognized the importance of their learning about teamwork; 84% acknowledged that what they learned in this course helped to understand other courses, 81% declared that what they learned would increase their employability, and 80% acknowledged the importance of what they had learned about Statistics, R and Project Management for their future professional life.

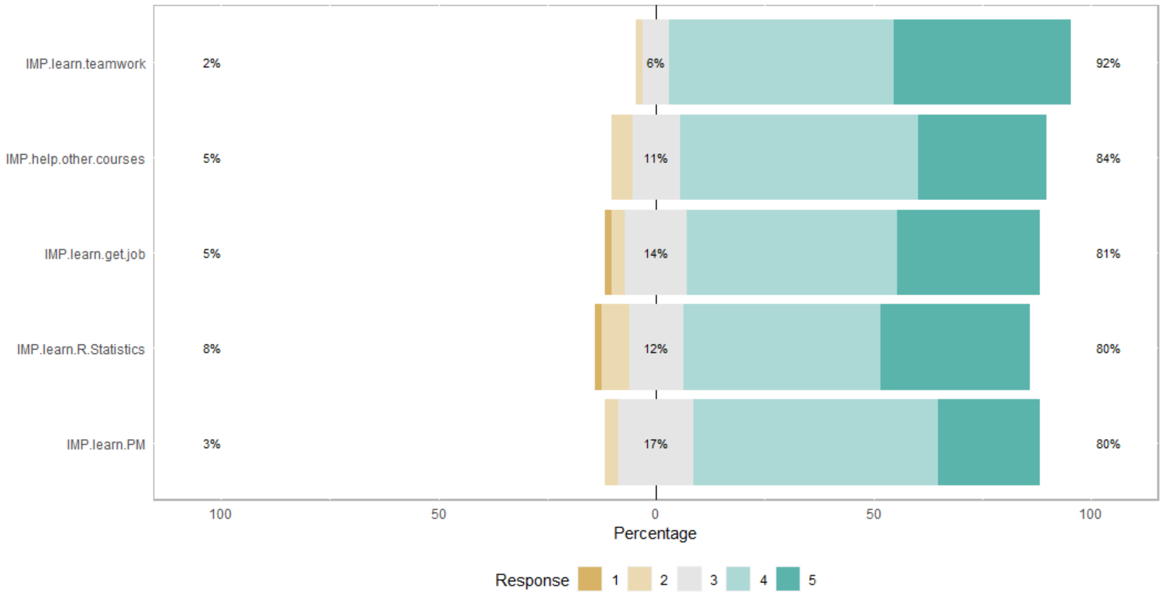

Figure 6. The divergent bar chart of the answers for the fifth set of questions related to the importance of what they had learned.

Set 6: Answers related to the learning effort

The students' answers to the sixth set of questions (Figure 7) revealed the 89% of the students made efforts to participate in project activities, 88% worked on the Challenges of the week (86%), 88% took actions to address the professor's recommendation, 84% dedicated themselves to study the courses' resources and 48% put efforts in following the other teams' projects.

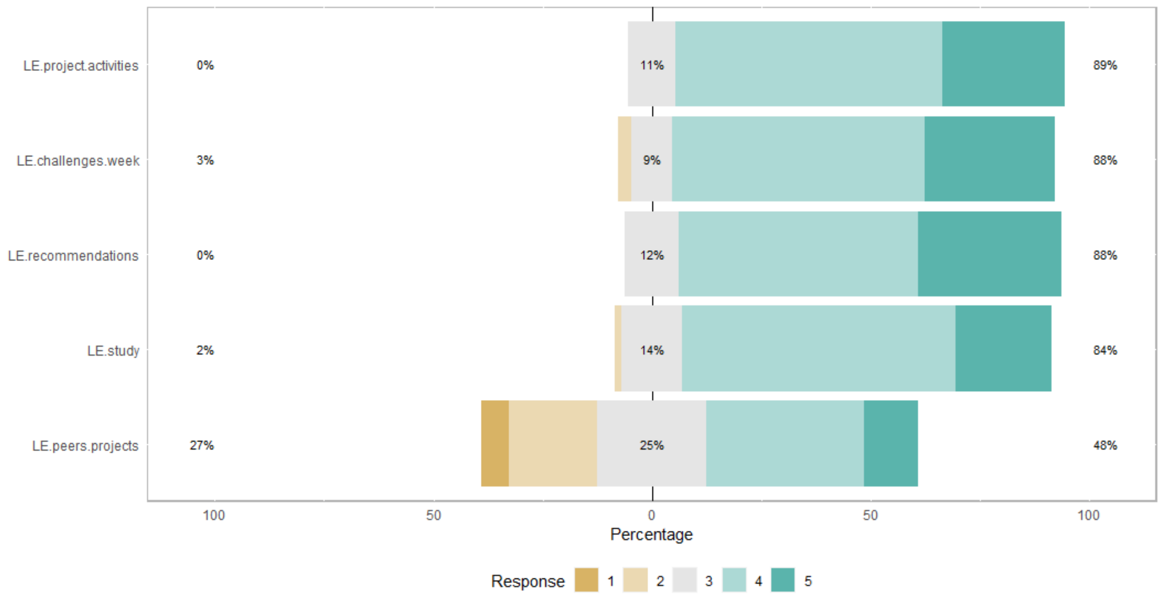

Figure 7. The divergent bar chart of the answers for the sixth set of questions related to the learning effort.

Set 7: Answers related to the ways that the students learned

The students' answers to the seventh set of questions (Figure 8) revealed that students learned while following the professor's recommendations (88%) and sharing ideas with their peers (88%). In addition, they also learned while using project management IT tools (75%) and 64% acknowledged they learned by metacognition activities (writing in their websites, what they have learned week by week). Not many students (45%) admitted learning by following the other teams' projects.

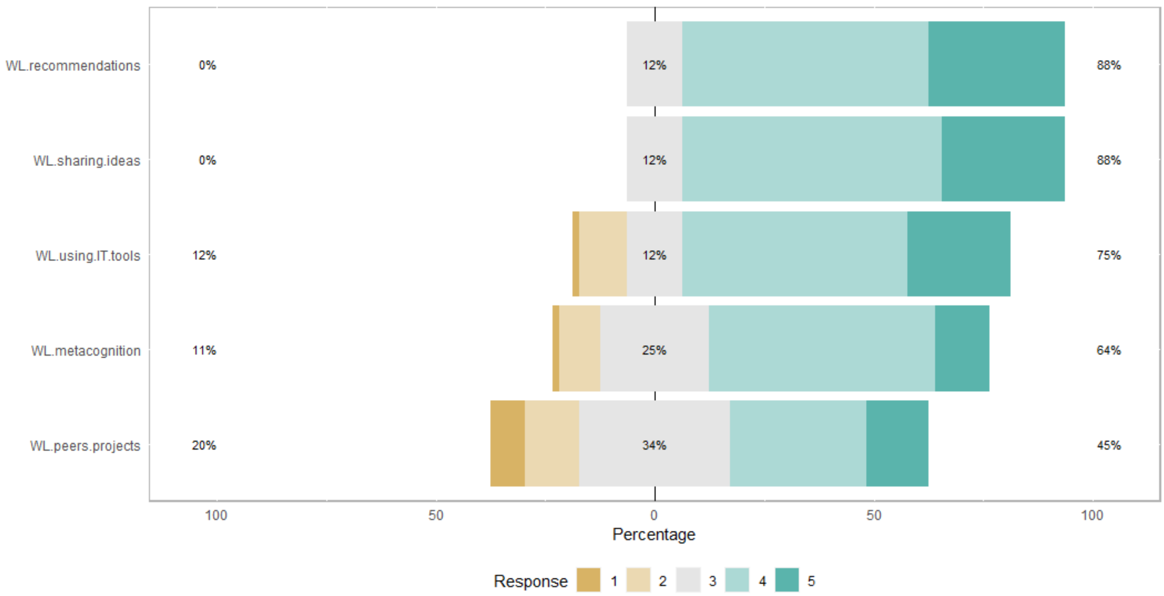

Figure 8. The divergent bar chart of the answers for the seventh set of questions related to the ways in which the students learned.

Set 8: Answers related to the students' perceptions about their learning

The students' answers to the eighth set of questions (Figure 9) revealed that, for the majority of the students (92%) that the overall learning experience was effective, 89% acknowledged learning about project management and about R coding (84%). In addition to that, the majority of the students answered that their learning about Statistics (80%) and IT tools (77%) was relevant.

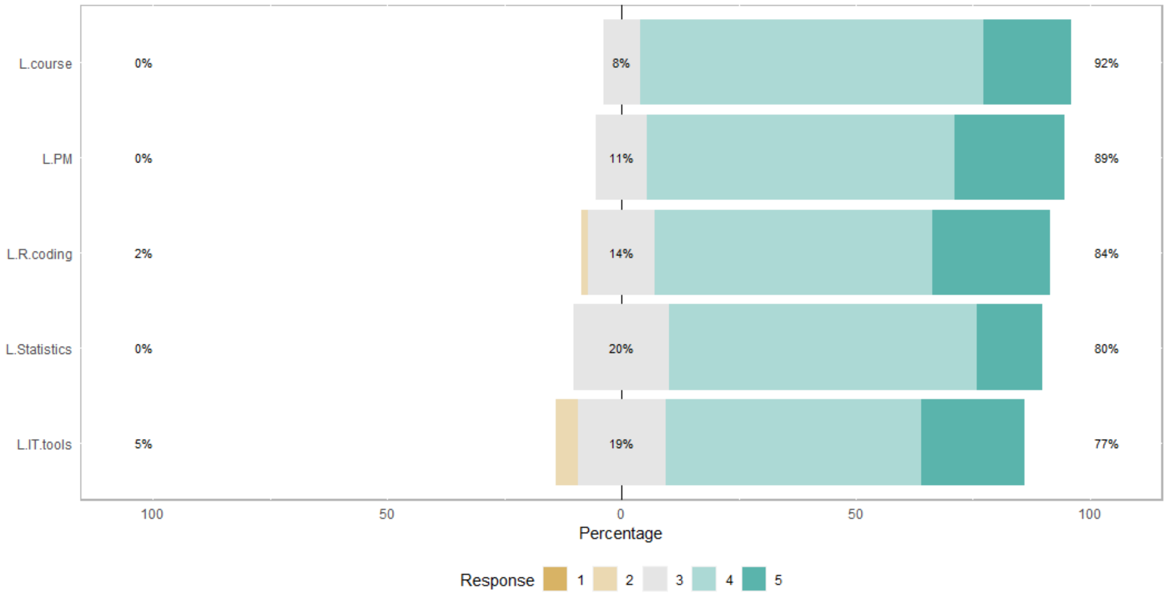

Figure 9. The divergent bar chart of the answers for the seventh set of questions related to the students' perceptions about their learning.

Results from qualitative data

Analyzing the data from the teams' website, we found the following recurrent themes (thereafter, RT):

RT1: The teams acknowledged that the course helped to learn Data Science, knowledge that would bring future career benefits

Through an analysis of the project's website, it became evident that all groups expressed a strong appreciation for the course, highlighting its significance in enabling them to acquire data science skills through the completion of the proposed challenges. Furthermore, they conveyed the belief that this acquired knowledge would be highly advantageous for their future careers and employment prospects.

One team's leader pointed out:

> The project was extremely important to us; we developed management skills, learned R software and Statistics. We think that these skills and knowledge will be crucial to our professional career development.

Another team's leader wrote:

> All team members agreed that the course experience was very enriching. Everything we learned (Statistics, R coding, team management) will give us a competitive advantage in finding a job.

RT2: The teams acknowledged that the course resources and the course management helped their learning

The students duly recognized the valuable contribution of the course resources, affirming their effectiveness in facilitating their learning experience. Furthermore, they expressed a strong affinity towards the comprehensive video lectures specifically addressing topics pertaining to Statistics. Notably, they emphasized the significance of the teacher's feedback, underscoring its instrumental role in addressing their queries and enhancing their conceptual understanding.

One team leader's explained:

> The resources that we got from the course's website were more than enough to improve our learning on Descriptive Statistics, Inferential Statistics and Regression. The teacher's weekly feedback helped us to learn from our mistakes, which helped us not fall into the same errors in the following activities.

RT3: The teams acknowledged the importance of their learning

The students conveyed that the course held significant value for them, as it not only fostered their comprehension of project management principles but also facilitated the enhancement of their data science skills. Moreover, they acknowledged the acquisition of valuable teamwork abilities, including the capacity to deal with diverse opinions and perspectives.

One team member explained:

> The key learning, beyond learning Data Science, occurred when we faced problems; we developed skills in teamwork, communication, organization and collaboration. We learned to analyze different points of view and to reach consensus. We learned how to plan and replan, to analyze the project's constraints and to use project management tools.

RT4: The teams faced problems (such as dropouts, communication problems, and lack of commitment) to different degrees along the project

The students communicated that the project presented various challenges, encompassing issues such as participant dropouts, inadequate commitment from team members, and diverse communication difficulties. These challenges exerted varying impacts on their respective projects. One team's leader explained the problems with the dropouts and the lack of commitment:

> We had dropouts at the beginning of the course and one team member put little effort into the project's activities, increasing the burden for the other members.

Another team's leader explained the problems of communication:

> During the project we faced some communication problems (a few team members failed to participate in online meetings). Despite these problems, the project unfolded well, and we were able to accomplish the project's activities.

DISCUSSION

Based on the data related to the students' perceptions about teamwork (Figure 5) we may affirm that the more the students worked on the project activities, the more they developed their team working skills (Figure 10, feedback loop "Developing teamwork skills").

The data related to the students perceptions about their learning (Figure 9) revealed that they also developed their IT skills, since they made use of project management IT tools (such as the GanttProject software to plan and control the project) and website creator tools (such as Google sites, used to register the activities they have accomplished during the project. Therefore we may consider that there was also a feedback loop that led to the enhancement of their IT skills (Figure 10, feedback loop "Developing IT skills"). It is reasonable to conjecture that the development of teamwork skills -- added to the development of IT skills -- contributed to the development of their project management skills (Figure 10, feedback loop "Developing PM skills").

In addition, the students let us know (Figure 9) that they also learned R coding and Statistics. The qualitative RT1 (*the teams acknowledged that the course helped to learn Data Science, knowledge that would bring future career benefits*) reinforced the finding from the quantitative data. Therefore we conjecture that there was a feedback loop that led to the development of Data Science skills (figure 10, "Developing Data Science Skills).

Based on the evidence presented here, we may speculate that the four feedback loops described previously were driven by the addition of the competition component to a project-based learning centered course. The more motivated the students were to compete, the more they put effort into the project activities and in learning activities. In addition to that, the quantitative data (Figure 8) also revealed that the project-based learning approach created opportunities for the students to reflect about their learning and share their knowledge. Therefore we may speculate that there was another feedback loop related to the metacognition and knowledge sharing (Figure 10, feedback loop "Reflecting and sharing knowledge"). Reflecting on all the intertwined dynamics described previously, we came to our first finding:

> *The use of competition in a project-based learning centered course helped the students to develop project management skills (teamwork and IT skills), data science skills (Statistics and R coding) and provided activities that fostered metacognition and knowledge-sharing opportunities.*

This finding is aligned with the findings of other researchers (Issa et al., 2014; Willard & Duffrin, 2003) who pointed out that the combination of PBL and competition foster the development of 21st-century skills.

The data related to students' perception about the importance of what they learned (Figure 6) suggested that the students saw purpose in what they learned. Sense of purpose is one of the key components of intrinsic motivation (Fregni, 2019). Moreover, the motivation made them learn in different ways, such as by sharing knowledge with their peers, following professor's recommendations, and using IT PM tools. In addition, the qualitative data RT3 (*The teams acknowledged the importance of what they learned*) reinforces this insight. This led us to our second finding:

> *The Data Science Olympics increased the students' intrinsic motivation to learn.*

This finding is in accordance with the findings of other scholars (Lam et al.; Ocak & Uluyol, 2010) who pointed out the relationship between intrinsic motivation and learning effort in PBL-centered courses.

The data related to the course management (Figure 3) and the data related to the effectiveness of project-based learning approach (Figure 4) revealed that the professor's feedback, the course resources, and the professor's demands impacted positively on learning (we represented these positive impacts in Figure 10, by the exogenous variables "Effectiveness of PBL approach", "Learning resources" and "Following teacher´s demands"). This insight is reinforced by RT2 *(The teams acknowledged that the course resources and the course management helped their learning*). This led us to our third finding:

> *The project-based teaching practices (scaffolding the students learn, giving meaningful feedback to the students, and managing the activities) facilitated the students' learning.*

This finding is aligned with the findings of other scholars (Cable & Cheung, 2017; Larmer & Boss, 2018) who pointed out the importance of scaffolding the learning environment and giving prompt feedback to the students (Moallem & Webb, 2016).

On the other hand, RT4 (*The teams faced problems (such as dropouts, communication problems, lack of commitment, difficulties to schedule online team meetings) to different degrees along the project*) helped us to understand that the students also had problems that impacted negatively on their motivation (these negative impacts are represented in Figure 10, by the exogenous variables "Dropouts", "Lack of commitment," "Communication problems" and "Planning problems"). This led us to our fourth finding:

> *The problems the students faced throughout the Project (dropouts, communication problems, lack of commitment, difficulty to schedule online team meetings) impacted negatively on the students' motivation.*

This finding is aligned with the findings of other scholars who also pointed out problems caused by dropouts in online courses (Nistor & Neubauer, 2010). It is also aligned with the findings of researchers (Aksela & Haatainen, 2019; Arantes do Amaral, 2020) who pointed out problems that students face in PBL-centered courses (such as lack of commitment of team members, conflicts, and problems of communication between team members). We conjecture that this problem could have been mitigated if students had had a better participation in the synchronous online meetings and had been more committed to following the projects of the other teams.

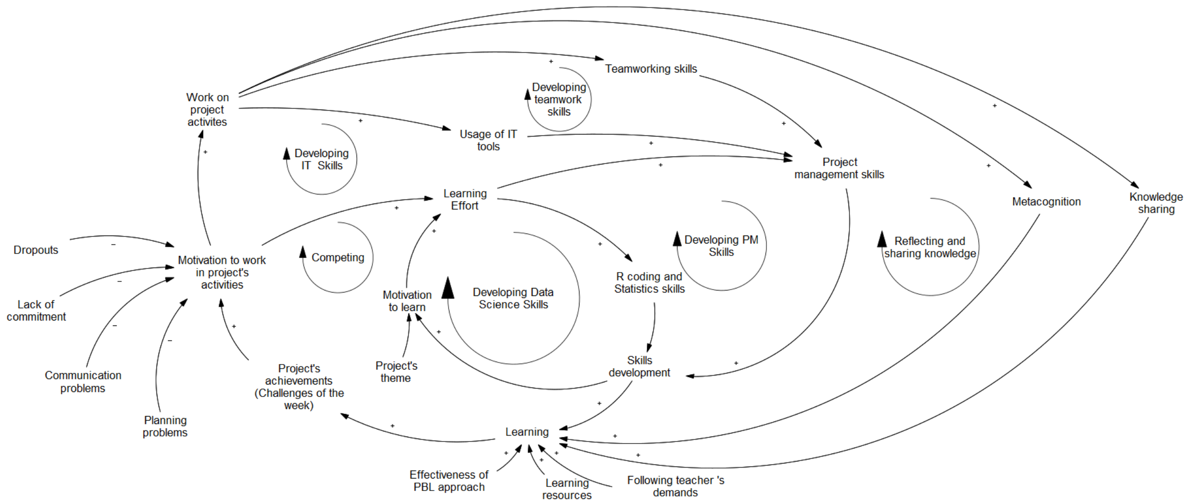

Figure 10. The course driven dynamics.

CONCLUSION

So, what did we learn from this experience?
Coming back to our research question (*What are the systemic impacts of using competition to improve the students' learning in a project-based learning-centered*

course?) we identified that the competition triggered five dynamics: the development of Project Management skills, the development of Data Science skills, the development of Teamwork skills, the development of IT skills and the improvement of the knowledge sharing and reflection.

The project theme, Data Science Olympics, was indeed a good choice. It increased the students' motivation to learn and the project was a playful experience for the students. Moreover, the course helped the students to retrieve information from the previous course (Statistics), which fostered long-lasting learning. In addition, the course increased the students' intrinsic motivation, since they perceived that the learning that they experienced would be helpful for their future careers. We can affirm that the university's rule of making the participation in synchronous activities optional impacted negatively on the course since only four of the sixty-four students participated in our synchronous activities. We recognize that the University rule was necessary since it aimed to protect the students who, for problems related to the pandemic or problems related to technology, could not attend the meetings. However, we speculate if they had participated, the learning would be even better.

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APPENDIX-1

Group One: Questions about the lack of participation in synchronous activities	
Closed-ended Questions	Identifier
1. I didn´t schedule meetings because I felt there was no need for it.	P.no.need
2. I didn´t schedule meetings because I was too busy with other courses.	P.too.busy
3. I didn´t schedule meetings because I had no doubts.	P.no.doubts
4. I didn´t schedule meetings because the professor's feedback clarified my doubts.	P.prof.feedback
5. I didn´t schedule meetings because I am tired of synchronous meetings.	P.tired.meetings
Group Two: Questions about the course management	
Closed-ended Questions	Identifier
1. I think the course´s workload was fair.	CM.workload
2. I think the amount of topics covered was adequate.	CM.topics
3. I think the professor's demandingness was adequate.	CM.demandingness
4. I think the resources available (video-lectures, books) were adequate.	CM.resources
5. I think the professor´s feedback was adequate.	CM.prof.feedback
Group three: Questions about the effectiveness of the project-based learning approach	
Closed-ended Questions	Identifier
1. The knowledge sharing between team members improved my learning experience.	PBL.knowledge.sharing
2. The research I did to solve the weekly challenges improved my learning experience.	PBL.research
3. Working in this project helped me to learn/remember Statistics and R programming.	PBL.skills.R.Statistics
4. Working in this helped me to improve my project-management skills.	PBL.skills.PM

5. Working in this project improved my skills to work in future real-life projects.	PBL.real.project
Group four: Questions about the teamwork	
Closed-ended Questions	Identifier
1. Teamworking was a pleasant experience.	TW.pleasant
2. The team members worked in harmony.	TW.harmonious
3. All the team members put effort on the project activities.	TW.project.activities
4. All team members contributed equally to the accomplishment of the Challenges of the week.	TW.challenges.week
5. All team members helped each other in moments of difficulties.	TW.help.others
Group five: Questions about the importance of what they have learned	
Closed-ended Questions	Identifier
1. What I have learned about project-management will be important to my professional life.	IMP.learn.PM
2. Learning Statistics and R will be important to my professional life.	IMP.learn.R.Statistic s
3. What I have learned about team working will be important to my professional life.	IMP.learn.teamwork
4. What I have learned in this course will help me in other courses.	IMP.help.other.cours es
5. What I have learned in this course will help me to get a job.	IMP.learn.get.job
Group six: Questions about the learning effort	
Closed-ended Questions	Identifier
1. I put effort into studying all course materials (readings, video-lectures, etc.)	LE.study
2. I put effort into following the professor´s recommendations.	LE.recommendations
3. I put effort into accomplishing the project’s activities.	LE.project.activities

4. I put effort into following the other teams' websites.	LE.peers.projects
5. I put effort to accomplish the Challenges of the week	LE.challenges.week
Group seven: Questions about the ways that the students learned	
Closed-ended Questions	Identifier
1. I learned more when I wrote about my learning	WL.metacognition
2. I learned more when I discussed the project's activities with my team members.	WL.sharing.ideas
3. I learned more when I attended the professor´s demands	WL.recommendation s
4. I learned more when I followed the other teams' website	WL.peers.projects
5. I learned more when I made use of IT tools (such as project management software)	WL.using.IT.tools
Group eight: Questions about what the students perceptions about their learning	
Closed-ended Questions	Identifier
1. I think my learning about Project Management was adequate.	L.PM
2. I think my learning about Statistics was adequate.	L.Statistics
3. I think my learning about the use of IT tools was adequate.	L.IT.tools
4. I think my learning about R coding was adequate.	L.R.coding
5. I think my learning in this course was adequate.	L.course

*The possible answers for each-closed ended questions were:

1. Strongly disagree 2. Disagree 3. Neither agree nor disagree 4. Agree 5. Strongly agree