

AN EXPERIENCE OF IMPLEMENTING ICONIX, A SOFTWARE DEVELOPMENT METHODOLOGY, IN A SOFTWARE DEVELOPMENT CLASS DICTATED IN A PRIVATELY MANAGED UNIVERSITY FROM ARGENTINA, VIRTUALLY, DUE TO THE QUARANTINE

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ABSTRACT

Due to the mandatory quarantine implemented in most countries, and especially where this investigation is taking place, Argentina, most Academic organizations, either public or privately managed, needed to reinvent themselves in order to be able to teach courses in a completely remote environment. In this context, one class, which has the objective of develop a specific software and where this research took place, will use ICONIX, a software development methodology that is one of the latest technology standards used in the software industry, and flipped classroom, where instead of professors teaching students, they provide them with all the necessary information so they can study them before the class takes place. Given that this class has been always taught face-to-face and under other software development methodologies, the purpose of this paper is to evaluate the experience and take relevant data, measurable, about the degree of acceptance of both students and professors, in order to conclude if this virtual experience can be replicated after the quarantine period ends, replacing, if possible, the classroom teaching for a more up-to-date approach, taking advantage of the latest tools that have been developed for communicating, creating, distributing, grading assignments and sharing files and knowledge between teachers and students.

Introduction

As cited in [1], “during history nothing has caused more human deaths than infectious diseases”. COVID-19, as of today, has shown us how vulnerable we still are to these invisible and unknown threats. Also known as “Coronavirus”, COVID-19 is an infectious disease caused by the SARS-CoV-2 virus strain (Severe acute respiratory syndrome Coronavirus 2) and it was identified at the end of 2019, by December, in Wuhan, capital of Hubei, a province in China. Since that moment, its spread has not stopped, resulting in the COVID Pandemic we stand now. As of today, more than 32 million cases have been reported in more than 210 countries, with over 990000 deaths around the globe. On the other hand, luckily, more than 22 million people have recovered from it. COVID-19 was declared a pandemic by the World Health Organization (OMS) on March 11th because of its alarming rates of propagation and severity. The term “Pandemic” is used when a new disease is spread worldwide, where most of the persons do not have immunity for it [2]. The first case in Argentina was detected in a 43 year old man that had been in Italy recently, this also made this the first imported case of COVID-19. By March 4th, the number of suspected cases due to suspicious symptoms was around 10. On March 5th, the second case was officialized in Argentina, a 23 year old young man that also had been abroad. On March 6th, Argentina officialized 8 COVID-19 cases. Unfortunately, by March 7th, Argentina had the first disease due to the infection. Days passed by and the number of infected and diseased people increased. Therefore, the Argentinian President, through the decree 297/2020 in March 18th officialized the quarantine, which was called “Preventive and mandatory social isolation”, in order to protect public health and prepare hospitals to be able to handle severe cases. During its validity, people must remain in their residences, abstaining themselves from attending their workplaces, without being able to drive in public ways, lanes and public places, with the final purpose of reducing the circulation of

people and the possibilities of getting infected with COVID-19. Because of this disposition, educational entities and institutes, in all educational levels, were forced to close their physical buildings and started the process of “digital transformation”. This means that courses had to be migrated to a virtual format.

High education institutes and universities, like for example UTN BA (National Technological University from Buenos Aires), through one of its internal organism “EAD” (Distance Education Directorate), had been working, taking several orientational actions, support and training, in order to be able to dictate courses, virtually, across all careers [3]. Virtual classrooms were implemented using their internal software, already in place, which is also used to manage classes, classrooms, information, communication and several more functionalities, for both students and professors. The main challenge for the University was reaching all classes and careers in a short period of time and measuring the teaching learning process exclusively using their internal tools. The UNR (National University from Rosario, Santa Fe, Argentina) has implemented virtual classrooms to assure the academic year. In the case of the UBA (University from Buenos Aires) has decided to reschedule their academic calendar. This was decided to guarantee that students take classes in person without exposing them to a possible contagion. Given the size of the UBA (over 300000 students), is that some of their Faculties made exceptions, like the Faculty of Exact Sciences where some of their careers are using virtual methods to assure courses and classes are given [5, 6]. The Austral University (Privately managed University) has made available to students and professors the “Plan de continuidad de actividades académicas COVID-19” (COVID-19 Academic Activities Continuity Plan) [7], with the intention of assuring that all academic activities take place. This, basically, establishes guidelines of how classes will take place, which tools are going to use, general rules and code of conduct.

Institutional Situation

The privately managed educational institution from Rosario, Argentina, where this work took place, was ready, partially, to face the challenges of virtual education. From one side, they had already started with blended education, four assignments are dictated using that methodology, with a remote percentage of classes, up to 50%. This proposal finds its foundations, first, in the article “Educación Superior y Tecnología: la propuesta de Educación A Distancia en Argentina y su marco legal” from Ana Carolina Ezeiza-Pohl [8], that describes the remote education proposal and its legal framework; and the legal resolution 1717/2004 from the Science, Technology and Education Ministry [9]. This resolution describes the general dispositions of remote education. Also, the University already had a contingency protocol in cases where, due to extreme circumstances, this needs to remain closed and virtual classes are implemented. That is why, with the spread of COVID-19 in Argentina and the strict quarantine that was decreed in March the 20th, the University was forced to close their physical doors of all its dependencies and execute their contingency protocol.

The University had to reorganize itself like other institutes have done. All professors had to be trained to be able to adapt their classes to the new virtual methodology. Also, all study materials along with plans and all the information that is relevant for courses and classes had to be digitized to be shared with students. To simplify some of the processes of adapting to the new tools, several professors have recorded videos and uploaded them, and thus made them available when both students and professors need it. It should be noted that several professors already have the necessary experience to carry out virtual classes, and that much of the documents were already digitized, facilitating some of the adaptation processes to this new situation. Students accustomed to studying and attending to presential classes within the University, are also in an exceptional adaptation process, which is happening not only in Argentina, but worldwide.

In this research work, quantitative information was collected, which serves to evaluate the adoption level of a group of students facing this new virtual education system, in one class, and finally, to conclude if it is possible and potentially fruitful the implementation, in the long term, of the virtual education system, even after the COVID-19 pandemic ends. Also, through surveys, professors presented their conclusions after the beginning of the first semester, concluding with an assessment of the viability for the implementation of a virtual educational system once the quarantine has been lifted and the face-to-face courses are reinstated in the University.

Iconix

Iconix [10] is a minimalistic process of practical software development. It’s a simplified and more traditional methodology that unifies a set of object oriented methods in order to have strict control over the entire development life cycle of the product that’s been made, and has a sequence of steps that must be followed that clearly determines the activities to be carried out at each stage of the life cycle of the project that uses it. Iconix derives directly from RUP (Rational Unified Process, standard object-oriented software development methodology, with its analysis and documentation) and its foundation is the fact that 80% of cases can be solved with only 20% use of UML (Unified Modeling Language, standard for the visual representation of objects, states and processes within the system that’s being developed) which greatly simplifies the process without losing documentation by leaving only

what is necessary. This implies a dynamic use of UML in such a way that other diagrams can be used in addition to the ones already stipulated if it is convenient. Iconix is guided using “Use Cases” and follows an incremental and iterative life cycle. The end goal is that the final version of the software that is being developed is obtained from the Use Cases. The Iconix process is divided into dynamic and static workflows, which are highly interactive. It may happen that you have to go from one iteration of the entire development process to a small number of Use Cases. The Iconix process is suitable for Agile projects where quick reaction is necessary when it comes to factors such as requirements, design, and estimates.

Iconix has the following key features:

- Rationalized use of UML
 - Minimalist approach.
 - Small amounts of steps to succeed.
- Traceability
 - In any stage a line can be traced to the system requirements.
 - Objects follow up as they evolve.
- Iterative and incremental
 - Between domain modeling and Use case analysis.
 - Iterations over the dynamic model that refine the static model.

To simplify, Iconix process consists of the following stages:

- *Requirements*: where functional requirements definition happens, the development domain is modeled, the behavior requirements are defined and as a closure for this stage, use cases need to fit the client’s expectations.
- *Analysis and preliminary design*: robustness diagrams design (this are graphical representation of the steps of one use case), while use cases are rewritten, if necessary; updating the domain model, determining the controllers needed to run use cases and rewriting use case sketches.
- *Preliminary design revision*
- *Detailed design*: sequence diagrams design, domain model update as the sequence diagrams are developed and static model cleanse.
- *Critical design revision*
- *Implementation*: unity testing, integration testing, revised code execution and an update model to be ready for the next stage of work development.

In **Table 1**, we are comparing the process models in terms of the characteristics of the project, and analyzing the size of the process, equipment, and problem complexity for each model. We can highlight that with a small development team, large, highly complex projects can be carried out; in the case of XP and SCRUM [12].

Process model	Process size	Team size	Problem complexity
RUP	Medium/Extensive	Medium/Extensive	Medium/High
ICONIX	Small/Medium	Small/Medium	Small/Medium
XP	Small/Medium	Small	Medium/High
SCRUM	Small/Medium	Small	Medium/High

Table 1: Process models comparison.

In **Table 2** we can observe, with respect to learning curves, that Agile models offer greater advantage, but with certain limitations, since they have not yet been exploited on a large scale as, for instance, RUP, that is has high support and comprehensive tools that guides through it, facilitating the application of this methodology more effectively, allowing to make the most of it [12].

Process model	Learning curve	Integration tools	Extern support
RUP	Slow	High support	High support
ICONIX	Fast	Some support	Some support
XP	Fast	Not specified	Some support
SCRUM	Fast	Not specified	Some support

Table 2: Process models comparison, learning curve perspective.

Among the advantages of Iconix we can name that it's a process that has certain similarities to Agile methodologies to carry out software development, and that it's focused on the construction of management systems of small and medium complexity with the participation of end users. Among its disadvantages, we can mention that this methodology needs fast and precise information on the requirements, of the design and the estimates; also, this methodology should not be used in long term projects given its characteristics. From a work force point of view, in Rosario (Santa Fe state, Argentina) most development and sourcing companies that are focused in developing custom software mostly use Agile alternatives like Scrum, Kanban or hybrids, none of them use Iconix.

Description Of The Course Selected To Carry Out This Research Work

The course selected to carry out this work has the final purpose of developing custom-made software, in this case, a "Security module", this is a set of functionalities whose main objective is to regulate and organize, though groups and permissions over forms, the users who may or may not interact with a software and its functionalities. Students are requested to develop (source code and working application) and documentation, following certain guidelines. This course is from the third year from the Systems Engineering degree career and is based basically on all the knowledge that has been gathered in previous years, where all the necessary concepts to design and develop were addressed. Among those important materials that students need to have in order to go through the course with no inconvenience we can name: system analysis, programming, object-oriented programming, development methodologies, domain modeling, design, and database management. Historically, this subject was carried out using the Unified Process methodology alternating with more agile models such as Iconix.

During 2019, the course used a complete "Agile" approach, implementing Scrum as software development and work methodology with all its ceremonies, artefacts, roles, and requirements. The experience was positive, for both students and professor, and the results were favorable. A more Agile approach and mindset and expertise lay the foundations for a more in-depth approach and given that, during 2020, the course is using Iconix, it serves as a contrast with what was done in previous years. 2019 course with a more "Agile" approach was done using and following steps:

- 1 All the work was done by the entire class as one group, the professor played as "Product Owner" and a group of students served as "Scrum masters".
- 2 Stages where aligned with Scrum:
 - a) All ceremonies were performed, planning daily stand ups, retrospective meetings, and project progress review meeting at the end of the Sprint (mostly called "Demo meeting")
 - b) User stories were used as a tool for documenting requirements.
 - c) An agile Management tool was used to properly manage sprints, backlogs, and tasks.
- 3 The development served the same characteristics as it was described previously (a Security module essentially).
- 4 Even though all the work was executed as a whole team, each student needed to defend the work that the whole team did, individually. This was a way to ensure that the students learned, and they can approve the course.

Applying Iconix in the Selected Course

The course selected for the purpose of this work, which was detailed previously, has as final goal, the development of a "Security module". This course is mainly enriched by the classroom experience, the contact with the professor and the teamwork, but given the current social context, it has been forced to implement the necessary tools so that this experience is not lost, classes can be carried out and students can finally learn. The professor has the necessary experience to be able to carry out the virtual teaching of his course, and most of the study material is digitized, simplifying the adaptation to the virtual learning model.

For the development of the "Security module", "Iconix" was used as a development methodology. This "Security module" must meet certain functional and non-functional requirements. Among the functional requirements we can name: login, logout, password change and reset, profiles and groups management, and an audit module to be able to view data traceability. It was also necessary for the student, during the design and analysis stages, to document requirements and, using UML, to develop all diagrams (all required by Iconix).

The software tools chosen for this course were: Zoom (at the beginning), Blackboard and Google Classroom. For Documentation and programming, students were able to choose the tool with which he felt more comfortable, although with certain restrictions, for instance, the programming language must be object oriented, Databases must be relational and Iconix guidelines must be followed at all times.

Course schedule and classes:

Date	Unit	Lesson
7/4/2019	Unit 1	The process of creating software
14/4/2019	Unit 1	The process of creating software
21/4/2019	Unit 2	Security module analysis and design
28/4/2019	Unit 2	Security module analysis and design
5/5/2019	Unit 3	Metrics
12/5/2019	Unit 3	Metrics
19/5/2019	Unit 4	Risk and quality management
26/5/2019	Unit 4	Risk and quality management
2/6/2019	Unit 5	Design patterns
9/6/2019	Unit 5	Design patterns
16/6/2019	Unit 5	Design patterns
23/6/2019	Unit 5	Design patterns
30/6/2019	Unit 5	Design patterns
7/7/2019	Unit 6	Software testing
14/7/2019	Unit 6	Software testing
21/7/2019	Unit 6	Software testing

Table 3: Detailed schedule of the course.

The course was dictated once a week, on Tuesdays, in two separate blocks, both of 80 minutes each, with a 20 minutes break between them. The course is programmed as follows, the first block, will review lessons detailed in Table 3 and using the “flipped classroom” methodology, which is a semi-face-to-face or virtual learning methodology, a different way of learning and teaching. Using this methodology, prior to the beginning of the course, all the information needed on the topics to be discussed, along with a short evaluation, which serves as a review of the topics discussed, will be shared by the professor. This evaluation will be relevant also at the moment of identifying the acceptance by the students of this learning methodology. The professor and the group of students review the concepts in search of queries or doubts in this regard. Once this first block was finished, it was considered that the concepts were assimilated correctly by the students.

The second part of the course is of a purely practical approach, where the practical implementation of the theoretical concepts (revised during the first block) about the work that the students must carry out, the “Security module”.

The articulation between the course and Iconix occurs in the following way: given that this process has defined phases, the subject was presented following the corresponding model. These are:

- 1 Requirement analysis: during the first classes, an exhaustive study of functional and non-functional requirements of the Security module was carried out, concluding this first stage with the following deliverables: Use case model, Domain model, preliminary design and Detailed use cases.
- 2 Preliminary design analysis: focused on discovering the objects and got deeper in the domain model, finishing with a preliminary technical architecture and has as deliverable the Robustness diagram, which will be used in the next phase as the skeleton of the Sequence diagrams.
- 3 Once the preliminary design phase concludes, the detailed design phase is immediately continued, which focus on a deep review of the preliminary design and has the Sequence diagrams and the Class diagrams as deliverables.
- 4 After the detailed design stage, the implementation phase is started, which consists of testing and subsequent programming.

All information necessary to carry out all previously mentioned phases proposed by Iconix could be found within a collaborative tool, Google Classroom. To carry out the courses and dictation, at the beginning Zoom was used, and then, Blackboard Collaborate was used. Beyond the work needed to approve the course, students must comply with two partial examinations, which consisted of partial deliveries of their work with its defense, and also, a research request, which consisted of the application of Design patterns in their project, responding to functional and non-functional requirements. Unlike other years, as we mentioned earlier, the work was carried out individually, and since the courses will be in a virtual mode, the students were responsible for the partial and final deliveries to be made in a fixed schedule. Requirement changes will be introduced throughout the semester to force students to carry out research tasks, and to review the best approach to implement those changes to their solutions.

During the second semester, the same experience will be carried out, but instead of using Iconix, Scrum will be used, this will be evaluated in a separate investigation work.

Proposal Acceptance Indicators

In order to be able to qualify the acceptance degree (or not) of both, the students and professors, of the proposed methodology used during the time the course took place, the following indicators have been taken into account.

- *Attendance*: student attendance was relieved in all classes. As the course is done in two parts, the assistance will be taken in both parts, and thus, evaluate desertion degree and interest.
- *Students participation*: we measured the number of questions and querying students asked during classed. With this indicator, the higher the number, the higher the interest students had of topics and subjects that are covered in the classes.

Adherence to Iconix practices and progress in student work

- *Progress in student’s work*: the progress of the work each student needed to do was evaluated in each partial delivery that the professor requested. This way, we were able to obtain a global progress metric in terms of the development of the work and the adherence to Iconix, as development methodology.
- *Adherence and acceptance of Iconix as a development methodology*, through the analysis of self-assessments included in each class.
- *Previous knowledge of Software methodologies*: the starting point of the students in terms of software methodologies was surveyed, to understand their previous experience, both in working environments and in educational matters in relation to Agile methodologies, requirements engineering and domain modeling, among others.
- *At the end of the semester*, the knowledge acquired about Software Process Methodologies will be relieved to have an overview of the learning curve in this matter.
- *Periodical interviews with the professor* to understand his point of view regarding the use the students are giving to the virtual work methodology and the learning context.

Proposal Acceptance Evaluation

We emphasize that at the time this work was presented, the percentage of student attendance is vastly higher than when classes took place in premises, as can be seen in Figure 1. Attendance was never below 88,88%. Also, given the characteristics of this course, consisting in two modules, we can see that the attendance percentage is still high, and with few dropouts, with an average attendance of 90,74%.

Regarding class duration, please note that this is adjusted to the needs of the professor and the students. We can see in Figure 2 that, except for the first class, on April 7th where Zoom was used (with it’s 40 minutes limitation), the rest of the classes remained above 60 minutes, which corresponds to 75% of the estimated course duration. The second part of the course, which is also 80 minutes long, has a good record also, in average, the total was about 75% of respected duration.

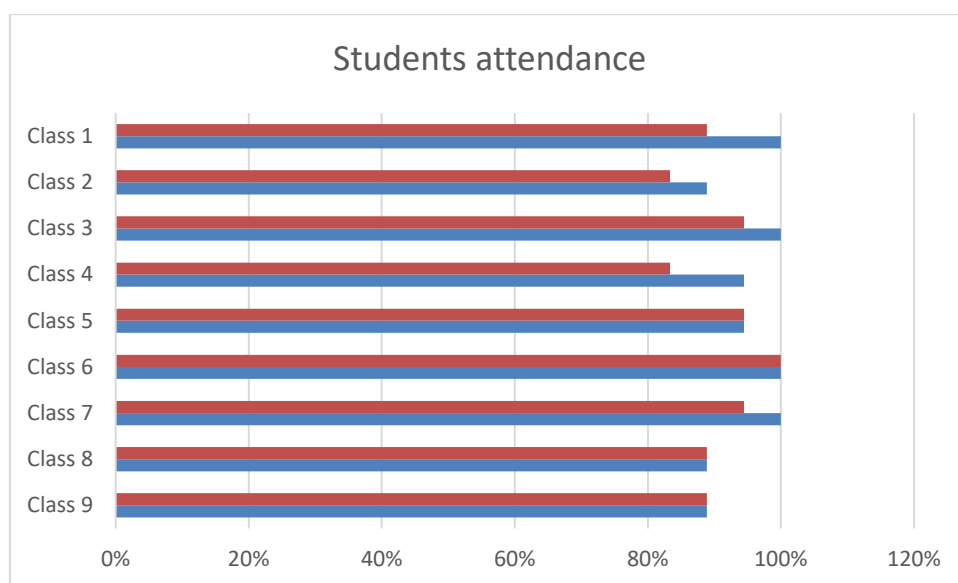


Figure 1: Students attendance during class, first part of the class represented in blue, the second part, in red.

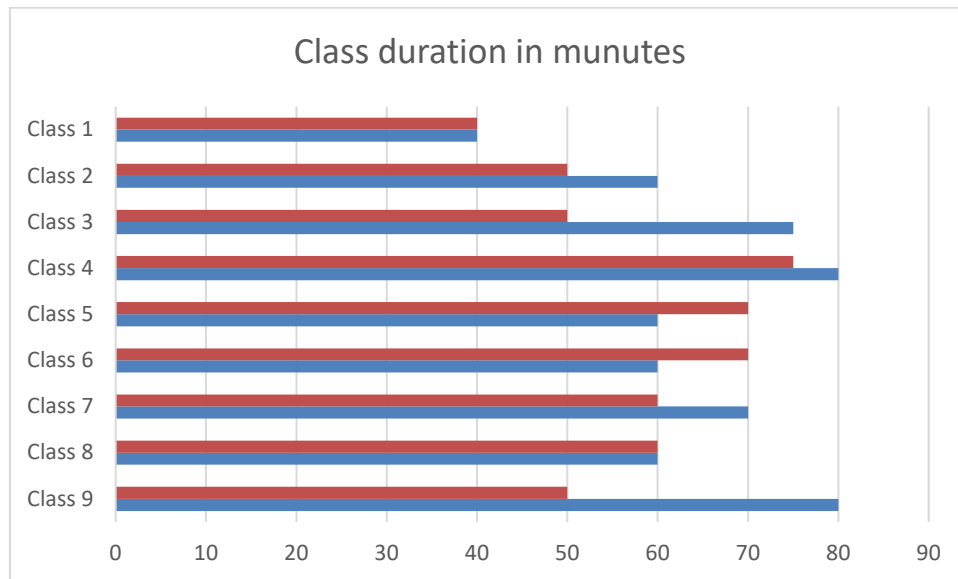


Figure 2: Class duration record, expressed in minutes. In Blue, the first part of the course is represented, in red, the second part.

Of the indicators selected to evaluate the student’s experience, the most relevant that we used to measure was the participation in classes. After talking with the professor, we noticed that the participation is normal due to the course characteristics and past years, and, on average, the questioning and querying from the students surround doubts regarding functional requirements, characteristics of the practical work to be carried out and technical specifications over some diagrams requested by Iconix (like, for example, Robustness and Sequence diagrams).

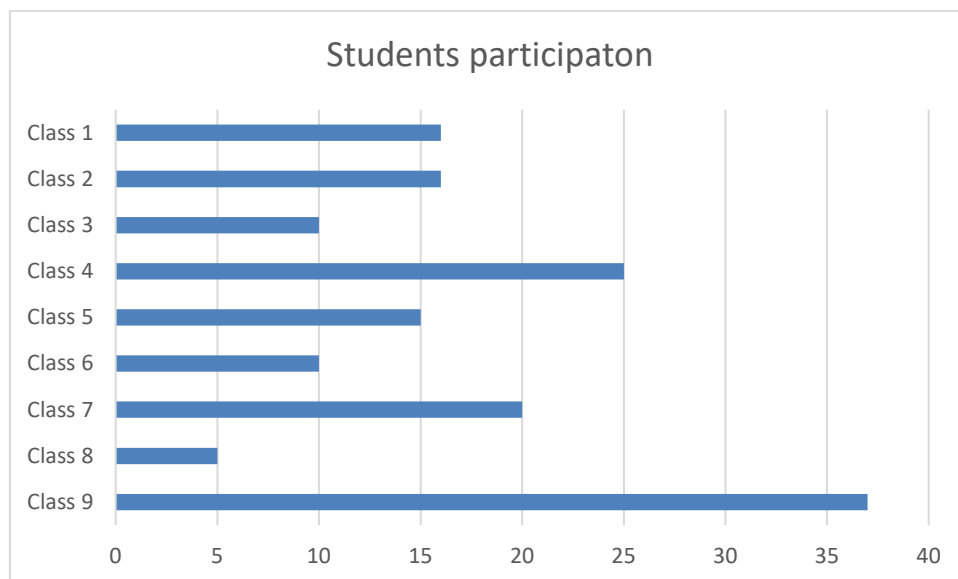


Figure 3: Number of questions and querying made by students in the classes. A note must be made, in class 8 there was an examination instance and that is the reason behind the considerable drop in participation.

Adherence to Iconix practices and progress in student work

By the time this work took place, we can define that, based on what was reported by the professor, from 17 students that formed the students group, only two students did not pass the first partial examination that took place in class 8 and only 1 student was absent. Consequently, 82% of all students passed the first partial instance, which is an excellent indicator of their progress. Using as a reference the weekly evaluations sent by the professor within the context of “flipped learning” applied during the course, in the 9 classes that have been surveyed at the moment this work took place, there were approximately 65% deliveries, with good results. From the information obtained at the beginning of the semester through the knowledge of software process model evaluation that was sent, most of the students had academic knowledge of Agile methodologies (Figure 4) and requirement engineering (Figure 5), they consider themselves able to conceptualize requirements.

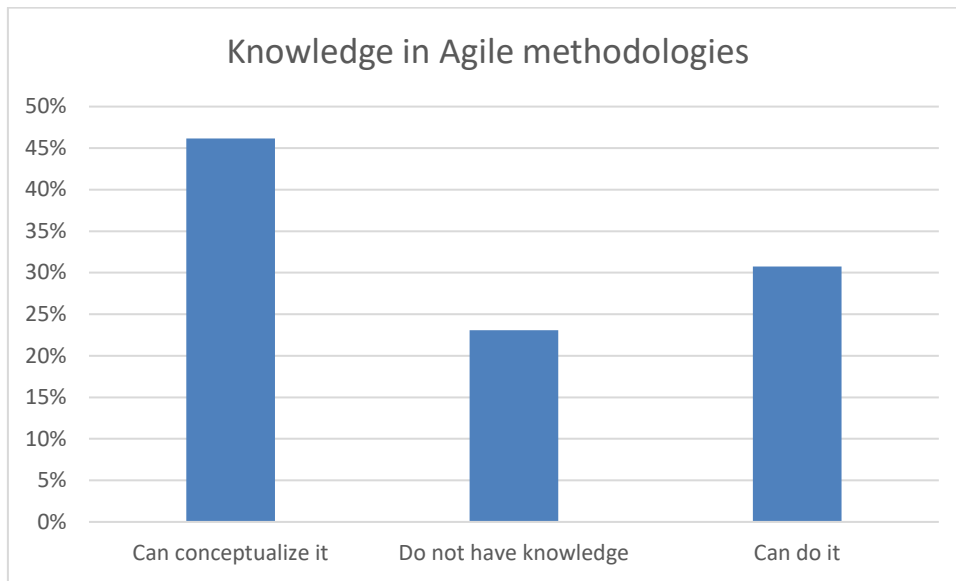


Figure 4: Students that had responded to the Development process knowledge survey regarding Agile methodologies knowledge.

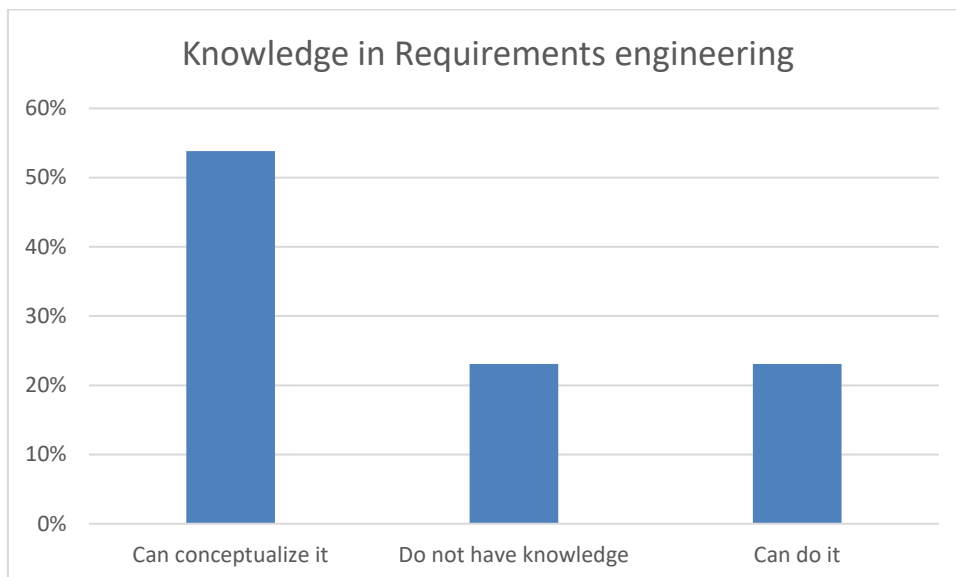


Figure 4: Students that had responded to the Development process knowledge survey regarding requirements engineering knowledge.

Finally, and based on the interviews that took place with the professor, we conclude that, although Iconix is an excellent development methodology for the pedagogical field, it is not within the standards of the labor market, distancing students from it. On the other hand, the virtual methodology used during course with an inverted learning methodology like “flipped classroom”, although favorable for the empowerment of the students, finds its weakness first in the absence of face-to-face contact and secondly, the large amount of time it take professors to prepare every class, class by class, in advance.

Conclusions

Being able to generate the proper environment for that the teaching-education process happened in a timely manner in times of isolation was not an easy task. The main challenge was to find the intersection between students, professors, communication tools, pedagogical tools, and the technology to generate synergy and thus, being able to go through the first semester in harmony.

The course that was selected to carry out this work has special characteristics compared to others, for example, applies Agile-type work methodologies, it is focused on analysis, design and development of special software and

all the work needed to be carried out individually. To face and overcome this challenge, several factors needed to happen. In the first instance, the University had provided the course with all necessary tools so that the virtual dictation of courses was as similar as a face-to-face interaction, and in order for this to happen, Blackboard and Classroom were implemented as communication and collaboration tools, between professors and students. Human factor in this experience is crucial. Over its history, the University has a more traditional approach for courses and classes, on premises. In recent years, only a few subjects implemented semi-presence, up to 50% but these are only a few examples. As a result of the quarantine, students and professors were forced to migrate to the virtual modality, altering the status quo.

In the course selected for this work to happen, the attendance and punctuality of students improve considerable, participation during classes has not been affected due to the need of first interacting with the tool and then being able to do the querying, finally, in the course selected for this work to happen, in comparison with previous years, no desertion or drop out was registered. Regarding the methodology used to carry out the development of the Security module, the information collected through the surveys and interviews informs us that, unlike previous years, a great deal of the students had a great percentage of progress in the work they are carrying out most of them, with their partial examinations approved; always taking in consideration that, from our initial survey, most of them did not had great experience working with development methodologies. Flipped learning also served its purpose, students took the time and the necessary work to study the material provided by the professor and then complete the self-assessments. In this regard, on average, 60% of students completed the self-assessments class by class. Finally, based on the interviews carried out with the course professor, although he considered that the students have adopted the Iconix practices, he also expressed that the completely virtual methodology is not the most appropriate one for courses like this one, referencing the need for semi-presence due to the lack of contact with and between students, and, on the other hand, although Iconix is a very good pedagogical methodology, currently, on the labor market, is not used as a developing framework in the software industry. Considering the partial results obtained in the course, during this semester, from the professor and students point of view, we can conclude as follows: Iconix, a development methodology, although with great academic application, but not used in the software industry, accomplished its objective moderately during the first semester. The group of students made good use of the tools available for teaching and complied in a timely manner with their deliveries with a moderate to normal participation during classes. Finally, and given the special characteristics of this course, although the completely virtual model is fulfilling its objective, at the same time, it is very demanding for the professor in the absence of presence to be able to interact directly with students.

Using 2019 as reference, we consider that, based on the possibilities of extended isolation in Argentina with the continuity of the virtual model, it is necessary to apply a different work methodology, which is adjusted to the current software industry situation, that trains students in the latest technological standards and simplifies teaching work. The proposal is focused on the use of Scrum as a working framework with the use of project management tools and the support of students and professors for this to be successful.

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