USE OF A JUST IN TIME TEACHING / FLIPPED CLASSROOM QUESTIONNAIRE FOR THE DETECTION OF IMPROVEMENTS IN UNIVERSITY EDUCATIONAL MATERIALS

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Abstract: With this experimental research, we try to detect the possibility of improving the educational materials used in university teaching. The creation and improvement of educational materials go through several stages such as: defining contents to be taught, selecting sources of information, process materials, make the information available to the students, be studied by them, check the assimilation, to detect defects of assimilation, improvement of materials and, to verify that the improvement made generates the appropriate effects on students. This article demonstrates the realization of an experiment of detection, improvement and verification of that improvement of some university educational materials. To carry out the task, we use questionnaires like Just in Time Teaching / Flipped Classroom to obtain information from the students, and the use of mixed methodologies for the detection of materials to improvement and verification of the effects that has had the improvement in the application of the same.

Keywords: Just In Time Teaching / Flipped Classroom; University Education; Mixed Analysis; Software Engineering; Educational Materials.

1. Introduction

In some cases, the educational material used to teach in the university does not usually pass through adequate filters that allow us to verify and decide if with their use it is possible to achieve the goals for which they are meant to be. Sometimes, these materials are collected from the bibliographies most commonly used in the subjects in which they intend to train, and even in other less common cases, they are created "ad hoc" to achieve the objectives sought. Therefore, in this research we aim to carry out an experimental study about the monitoring of some of the materials used in university teaching to verify if they accomplish the educational function that had been foreseen and, in case it is detected that it is not like that, to improve them so that they fulfill their function. Specifically, we will use the topic of study related to the subject Software Engineering that is taught in the Degree of Engineering in Computer Science at the University of Extremadura.

A mixed research methodology will be used (Hernández Sampieri, R., Fernández Collado, C. and Baptista Lucio, P., 2014), in which students are the ones who think about which part of the subject to deal with is the least understood.

In the following sections of this article, the procedures carried out will be explained in more depth. The article has been divided in the following sections: an introduction about the question of our competence, a section of context where the fundamental elements of the research will be contextualized, a methodology section that will explain concretely the process that has been followed, a section to obtain and analyze the results, for both qualitative and quantitative data, and a final section of conclusions.

2. Context

The research was carried out in the University Center of Mérida of the University of Extremadura in Spain. Specifically, it has been carried out in one of the Grades that are taught in the same called Degree in Computer Engineering in Information Technology. The

Degree is composed of four courses, in the first two the basic subjects and common to the different engineers are mainly studied, in the third and fourth course the obligatory concrete subjects of information technologies are studied and additional optional subjects that allow students to improve their knowledge about different specialization itineraries. For the current concrete case, the research uses one of the subjects of the third course named Software Engineering, being the coordinating professor the main author of this article.

Although the University Center of Merida is a small center where there are no classrooms with large numbers of students, we chose this subject because it is a compulsory subject where the number of students remains constant over the time. In addition, another reason why it was chosen, besides the authors have the sufficient knowledge in the matter, was the possibility of accessing the information provided by the students in a simple way; since there was an interaction with them in the subject and it was possible to obtain the data that was searched experimentally.

The basic bibliography of some authors (Pressman, Roger S., 2002), (Rumbaugh, J., Jacobson, I. and Booch, G., 2000) and (Humphrey, WS, 2001), among others was used. Brief descriptions of the theoretical and practical contents that are addressed in the subject of Software Engineering are the following: "to know the basis of software engineering, and the concepts of computer system and life cycle; to know the different development models, techniques and associated tools, also the activities that must be performed by the software engineer during a software development (specification, design and construction of software systems); to know the standards in order to ensure the software quality; to plan and manage the development of computer projects; to analyze the risks that can affect the development of a project. "

Precisely, the description of these contents is materialized in the division of the theoretical syllabus of the subject in seven themes, besides the practices. Of all of them, the research will

focus on topic 1, where the subject is contextualized. Topic 1 is entitled: "Contextualization of the subject of Software Engineering". In this topic, there is a development of concepts related to: the definition of systems, definition of methodology, classification of different software development methodologies, concepts about the different life cycles of software development (cascade, spiral, object oriented, etc.). The basic notions of different tools and modeling languages are discussed together with some models and diagrams of the language; the language is reviewed with examples, etc. The rest of the topics will not be taken into consideration in this research.

These materials will be improved according to the opinion of the students; only the improvement will be made on some of the detected materials. Then, with the change introduced in the materials we will reassess if the increase of students' understanding is achieved.

3. Methodology

The research methodology that has been used is a mixed research, it is a qualitative methodology used along with other quantitative methodology, and in this order. The first methodology is used to find out the areas of improvement in the subject of study with the students' estimation; with this we can know the parts of the subject that are more difficult of assimilation. Subsequently, one of the parts of the topic that the student understands less will be chosen, and then some of the elements that compose it will be improved. With the new materials generated, it will be explained again the part misunderstood and it will be checked if the new materials used fulfill the expected function. The second methodology is used to verify statistically the fulfillment of a hypothesis, which we will formulate later, on the achievement of the improvement of new materials that have been created or modified. We will take advantage of the data obtained from conducting a questionnaire to students after explaining the new materials created. This type of mixed research has already been used

successfully in other previous researches such as (Contreras, JA, Luengo, R., Arias, J. and Casas, LM, 2014a) and (Contreras, JA; Luengo, R.; Arias, J. and Casas, LM, 2014b), so we believe that it is possible to reuse it in this new research. The complete process to be carried out in the research can be visualized in the Figure 1.

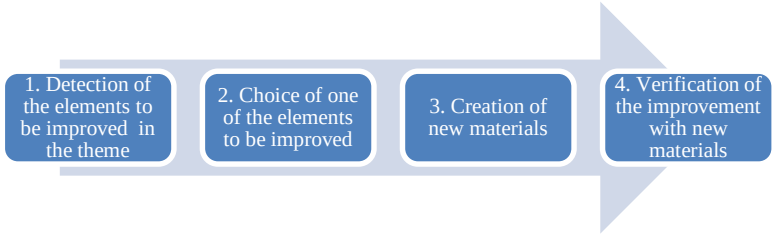


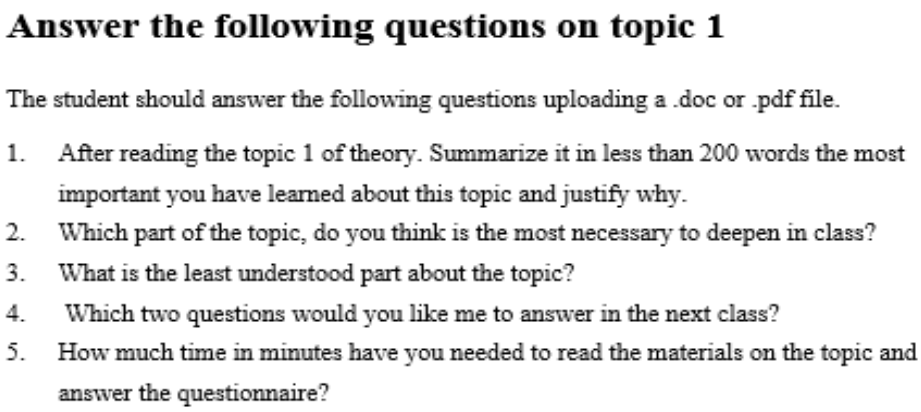
Figure 1. *Process to be performed in the research.*

Following the scheme of the previous figure, each of the parts will be specified separately, indicating how they have been carried out and highlighting the different tools used.

3.1. Detection of the elements to be improved in the theme

To carry out this process, the methodology of qualitative research is used as a fundamental element. This methodology will be applied to certain textual information that we need to collect from the students.

At the beginning of the topic, before explaining and performing the practical exercises in class, students are asked for information. For this, students must study the subject and, before the first class, must respond to an online questionnaire which is in the virtual space of the subject. The questionnaire is a Just In Time Teaching / Flipped Classroom (JITT / FC) similar to that created by Alfredo Prieto and others (Prieto Martin, A., Díaz Martin, D. Monserrat Sanz, J. and Reyes Martin, E., 2014), following the recommendations of teachers such as McKeachie (Mckeachie, WJ & Svinicki, M., 2006), Felder (Felder, R. & Brent, R., 2006) and others. Applications and case studies examples of how to do the Flipped Classroom we find in (Tucker, B., 2012) and (Herreid, C.F. & Schiller, N.A., 2013).The specific questionnaire we send to our students can be seen in the Figure 2.



Answer the following questions on topic 1

The student should answer the following questions uploading a .doc or .pdf file.

1. After reading the topic 1 of theory. Summarize it in less than 200 words the most important you have learned about this topic and justify why.
2. Which part of the topic, do you think is the most necessary to deepen in class?
3. What is the least understood part about the topic?
4. Which two questions would you like me to answer in the next class?
5. How much time in minutes have you needed to read the materials on the topic and answer the questionnaire?

Figure 2. *Questionnaire used to have students' answers before the first class of the topic.*

The questionnaire consists of five questions numbered from one to five. The first one is designed so that the students synthesize, in their point of view, the most important matters of the subject. With this it can be detected: gaps of knowledge about the subject of study, if they give more importance to certain issues that really are not meant to be, the way they perform syntheses and summaries, etc. The second question is related to their belief about what should be deepened in class, either because, in their opinion, it is not sufficiently explained in the text, or because it somehow catches their attention, and indeed for the subject of study, it does not have importance; which entails a deeper explanation. They should give an explanation of why we should go deeper and not just say the part that they believe. The third question is the key to the investigation, since it indicates that part of the subject has been less clear or not sufficiently understood. The information that appears in this question is the one that is going to be used to carry out the qualitative analysis and to detect which parts of the subject, the students consider that need to be improved. The fourth question is used with the purpose that the students ask questions themselves on the subject studied and can be answered among them; if it is not possible, they formulate at least two questions and publish them so that they can interact in class. This action can serve the teacher to make the students interact among them or between the teacher and the students. However, most of these questions are satisfied while the topic is developed in class. Despite it, if at the end of the

development of the topic there are any of these questions that remain unanswered, the appropriate response would be given either to the student or to the group if it is found to be of everyone's interest. With the fifth and last question, it is intended to verify the temporary assessment of work involved in the study of the issue in question, this allows to check the time devoted to the study by each student and compare it with the average or the value established by the teacher, and also to detect those students who do not spend enough time or those who need to devote more time than necessary.

With the information that has generated each student in the third question, it will be extracted and formed a corpus of answers to be examined through the qualitative analysis. This analysis will be done by using WebQDA software (Souza, F.N.; Costa, A.P. & Moreira, A., 2011). All the answers will be analyzed to detect the parts of the subject that have not been clear for the majority of the students, or at least for a great part of them. It is possible that during the analysis it can be deduced that there is more than one part of the subject that is not clear enough. Regarding this experimental research, only one of them will be selected, in the teacher's point of view, which will be the most relevant one. In the remaining, it is possible to apply the same methodology as for this one.

3.2. Choice of one of the elements to be improved

Once the information has been analyzed, the categorization of the information of the source texts has been done and the parts of the subject that are susceptible of improvement have been detected, the teacher must establish some criterion that allows for deciding to start working, which one to choose from all possible improvements. In the particular case of this experiment, the criterion that has been followed to choose an area of improvement is not the number of references of each one of the categories that the analysis contains; rather the teacher, taking into account a quantitative value of the number of students, who have been less clear about that part of the topic, chooses the part of the topic that seems most important

to him and his experience. However, in the case of different areas of improvement with similar number of references by the students, each one can be sequentially addressed, without being the order of choice an important issue if all the issues are interesting for students.

3.3. Creation of new materials

Once the main improvement area has been set up, according to the criteria established by the teacher, the new materials should be generated. This with the purpose to explain the part of the topic that the students find harder to understand, or that is not really well explained in the writing of the information in the issue in question.

The way to carry out this contribution will be at the teacher's discretion or teaching team. That is, they must establish, in the case of maintaining that part of the topic, how to improve the existing explanation. This can be done in several ways such as: using a new bibliography, where the previous explanation is described with better resources, creating new information elements that allow clarifying the parts of the explanation that can be elucidated, expanding the documentation with new elements of information created "ad hoc", etc.

3.4. Verification of the improvement with new materials

In order to verify the improvement of the materials, a survey was carried out in two periods. The questionnaire used was created in the virtual classroom that uses the subject of Software Engineering, and was done by the students twice. The first time was after the first study of the original materials. The students scored from 0 (nothing) to 10 (a lot), of what they thought about the explanation of the original materials. The second time, after preparing the new teaching materials, they were shown again the new materials prepared to be studied again, and re-rated from 0 (nothing) to 10 (a lot), depending on their appreciation of the understanding of the new materials studied.

We can observe the questionnaire, both before and after the explanation of the new materials, in the following Figure 3 and Figure 4. It should be noted that explanation A corresponds to the original materials and explanation B corresponds to the improved materials.

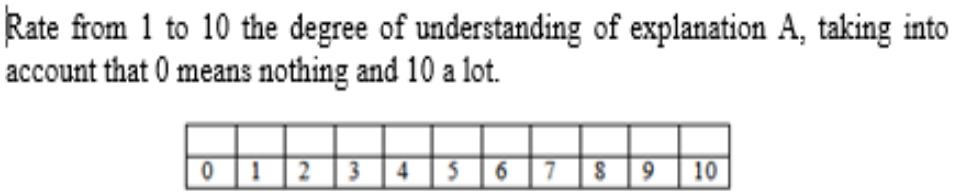


Figure 3. *Question to collect the students' score on the original materials (A).*

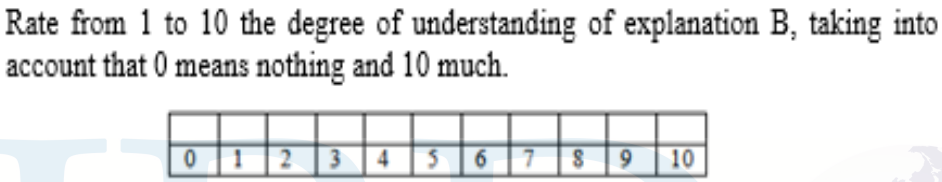


Figure 4. Question to collect the students' score on the improved materials (B).

The hypothesis initially addressed in the research (H1) was as follows: "The new materials improve the understanding and the explanation for students in the part of the chosen topic". This hypothesis must be validated by some statistical inference test. For this, we used the statistical analysis software SPSS[1], IBM, version 19.

Being a small sample of students, the type of statistical inferential tests to be used are nonparametric tests. In this particular case, the null hypothesis (H0) will be checked and in the case of non-compliance, with an error of less than 5%, the initial hypothesis (H1) can be stablished as valid. Specifically, it will be performed the Wilcoxon Signed-Rank Test. Being related samples, the difference between the values obtained from the students' previous questionnaire in the two question periods (A and B) will be observed.

[1] IBM SPSS Statistics Base is a family of products that addresses the entire analytical process, from planning and data collection to analysis, reporting and deployment of reports. It can be found at: http://www-03.ibm.com/software/products/es/spss-stats-base

4. Results and Discussion

The results obtained and the discussion about them is organized according to the methodology explained above. Firstly, the data of the tests performed on the students will be shown; in this case, it will be exposed only one example of the answers given by the students to the test, and it will be commented. Subsequently, the results of the qualitative analysis carried out with the answers to question three will be shown, and the pertinent comments will be made. Secondly, the element to be improved will be decided from among all possibilities. Thirdly, new materials will be updated or created on the chosen enhancement element. And, finally, the results of checking which of the materials seems best to the students and the statistical analysis performed on them will be shown.

4.1. Results of the detection of the elements to improve the subject

In the following example of Figure 5, the qualitative analysis used to perform over the information source can be observed. The rest of the tests done by the students are similar to this example.

1. After reading the topic 1 of theory. Summarize it in less than 200 words the most important you have learned about this topic and justify why.

In the first topic it is put into context the subject, it explains the need for a methodology to solve the software crisis of the 60's and the different life cycles with their characteristics and structures. The second part explains and develops the different types of UML diagrams, models and their uses.

The most important of the subject, from my point of view, is to know the different life cycles and different knowledge, to know when it is more convenient to use one or the other, depending on the type of software that will be developed to maximize the development, reducing costs and shorten delivery times.

With this section, knowledge of the UML modeling diagrams is indispensable to study the evolution of the system and the interaction between the elements that compose it; therefore, it is necessary for a correct modeling of the system to be developed, to know the different possible diagrams, the purpose of each one and the way in which the elements are related. The main thing is to learn how to optimize software development in all aspects.

2. Which part of the topic, do you think is the most necessary to deepen in class? Why?

Personally, the different UML diagrams and different behavior models have not been completely clear. There are diagrams of sequences in images that I find difficult to understand. The spiral life cycle is also complex to understand and it would be advisable to go deeper.

On the other hand, I think it is important to learn how to differentiate between life cycles and which is more optimal to use depending on the software development project, so it would be good to go deeper in this part.

3. What is the least understood part about the topic?

UML diagram models, especially the behavior model has not been clear to me, as well as the spiral life cycle.

4. Which two questions would you like to answer in the next class?

When is it most appropriate to carry out a spiral life cycle and when a cascade one with risk reduction? How does the sequence diagram of recursive invocation and object destruction work?

Figure 5. *Example of responses to the JITT / FC test.*

All the answers given by the students were obtained in the question 3: "What is the least understood about the topic?", and with this information, a textual corpus was generated in order to perform a qualitative analysis by using the WebQDA software. The categories obtained from the analysis, including the groupings of each of them, were the following: (1) UML, (1.1) UML diagrams, (1.2) UML models, (1.3) UML in general; (2) Life cycle, (2.1) Cascade life cycle, (2.2) Spiral life cycle, (2.3) Life cycles in general and (3) Methodology.

In Table 1, the final result of the qualitative analysis can be observed, referring to the number of references obtained by each of the simple or group categories.

Table 1. *Result of the qualitative analysis.*

Group Category	Simple Category	Number of References
UML	UML diagrams	7
	UML models	7
	UML in general	3
Life cycle	Cascade life cycle	0
	Spiral life cycle	5
	Life cycles in general	1
Methodology	Methodology	2

It is possible to observe in the table above, among all the contents of topic 1, the questions that are less clear to the students, and in this order, are the following:

1) UML (Unified Modeling Language) information: UML diagrams, UML models, as well as other general language issues are included in this group. However, this part of the subject will be seen more in depth during its development in class, even making examples and practices, which will allow a better understanding of this part of the subject at the end of it.
2) Information on software life cycles: in this group are mainly the cascade life cycle, the spiral life cycle and other life cycle issues. These elements are theoretical concepts supported by graphical elements for their explanation, and there will not be exercises or practices later on them. The information that exists should be enough for their

understanding. It caught our attention the difficulty of understanding in the spiral life cycle, so this can be an optimal candidate for the improvement of the materials.

3) Information about methodologies: although there is a minimum difficulty of understanding in this group, these doubts can be solved in class with some additional explanation. It could also be said that the different methodologies defined here will be worked out in the classroom, throughout the course, so their understanding at the end of the course should be sufficiently resolved.

If students have difficulty in understanding an explanatory graph, it should be improved, so that these difficulties disappear or are minimized as much as possible.

4.2. Choice of one of the elements to be improved in the theme

After completing the qualitative study, we can see that the three categories in which students emphasize the possible improvement are UML diagrams and models with equal value (7 references) and spiral life cycle (5 references). In the rest of the categories there is less affectation.

Therefore, taking into account that UML will perform additional practices, which are not included in the theoretical part; this will contribute to improve the understanding of language. This is why it is decided that the most immediate area of improvement should be the spiral life cycle. This last one is the area of improvement in which this second part of the research is going to be focused on.

4.3. Creation or improvement of teaching materials

The original materials used to explain the spiral life cycle consist of a graphic and explanatory text. The graph is similar to Figure 6.

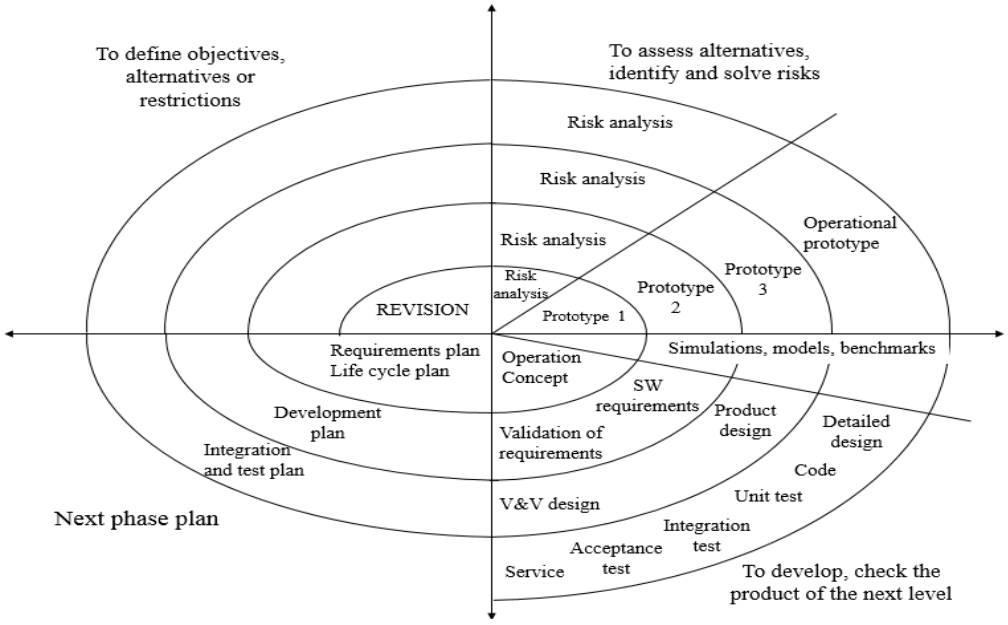


Figure 6. *Spiral chart.*

The explanatory text that accompanies the previous figure is the following one: "*Initially proposed by Boehm in 1988. It consists of a series of cycles that are repeated. Each has the same phases and when it ends gives an extended product with respect to the previous cycle. In this sense it is similar to the incremental model; the important difference is that it takes into account the concept of risk. A risk can be many things: requirements not understood, bad design, errors in implementation, etc. A typical representation of this structure is shown in the figure*. "

Further information on the Boehm spiral can be found in (Boehm, 1988) and (Boehm, B., 2000). However, considering the difficulties that students have in their understanding, we decided to improve it by incorporating elements that may not be clearly implicit in looking at the figure and the original explanation above. We even turn to color to improve the display of it. The result of this improvement, not including the previous explanatory text which is maintained in the new explanation, can be observed in an orderly way and in several new figures in the following Figure 7. It shows the different phases in which the spiral is divided, the global tasks to be performed in each of the quadrants of the spiral, numbered in order in

which they are made, the different cycles of the spiral, each with a different color (red, blue, green and brown) and the sense of reading of each cycle.

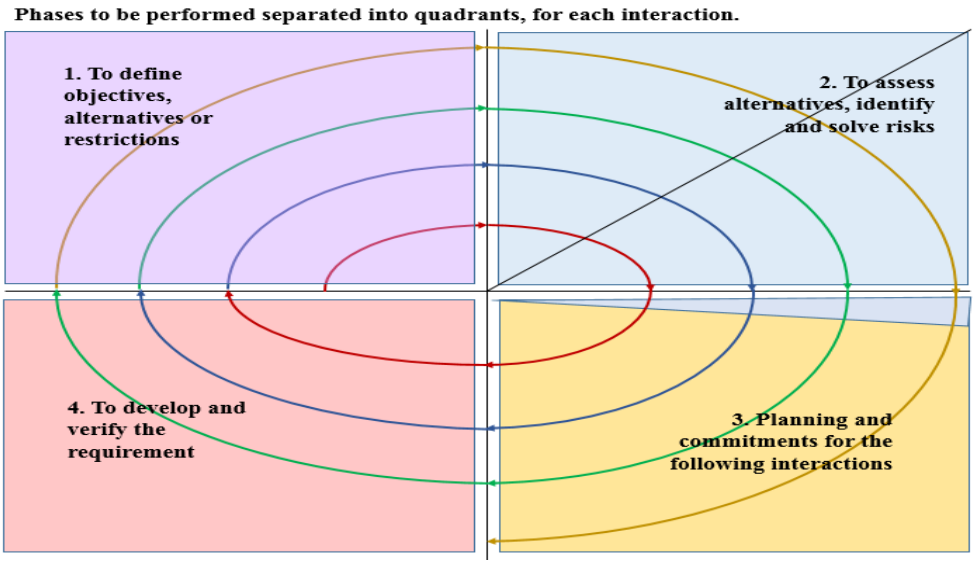


Figure 7. *General explanation of how to perform the reading of the spiral*

In each quadrant, only the actions indicated for each cycle will be performed. For example, in quadrant 1, objectives, alternatives and restrictions will be determined for cycle 1 (red), as well as for cycle 2 (blue), 3 (green) and 4 (brown). The spiral is read starting with cycle 1 in the direction indicated by the arrows until reaching cycle 4.

The reading of the spiral by cycles, with the tasks that are performed in each cycle, can be observed in the following: Figure 8, Figure 9, Figure 10 and Figure 11.

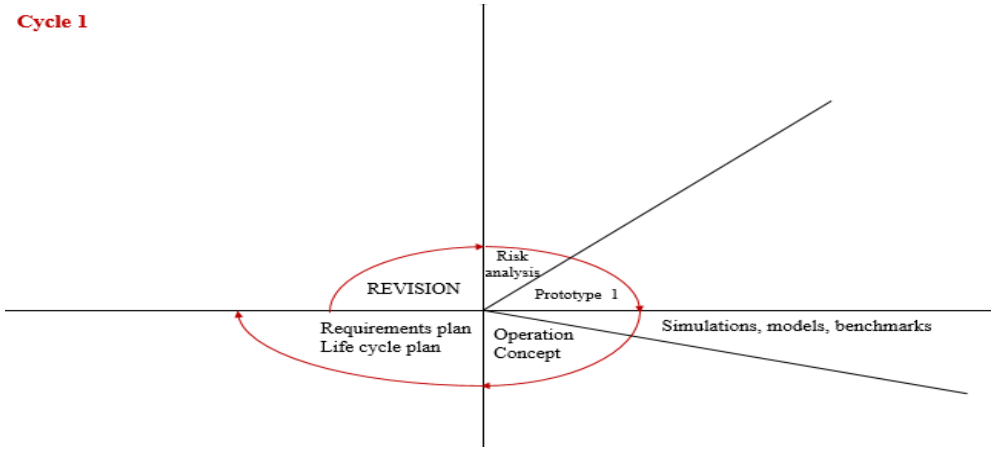


Figure 8*. Reading of the cycle 1 of the spiral together with the tasks to be performed in it.*

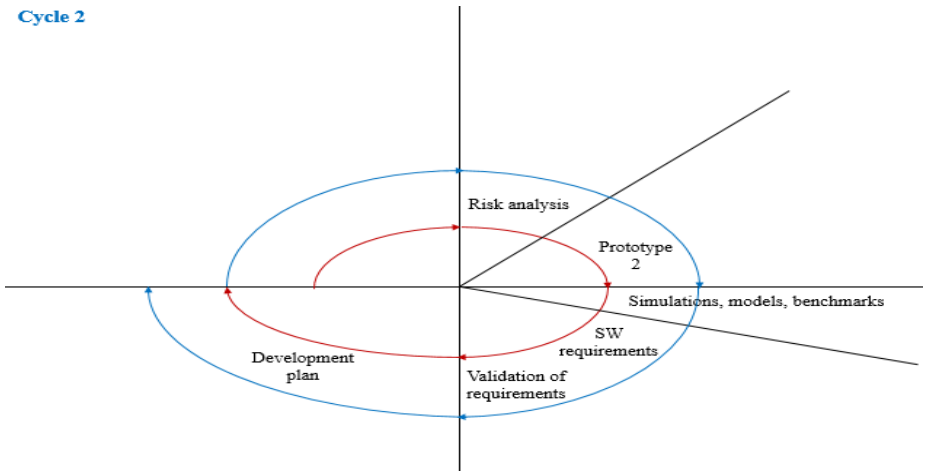


***Figure 9**. Reading of the cycle 2 of the spiral together with the tasks to be performed in it.*

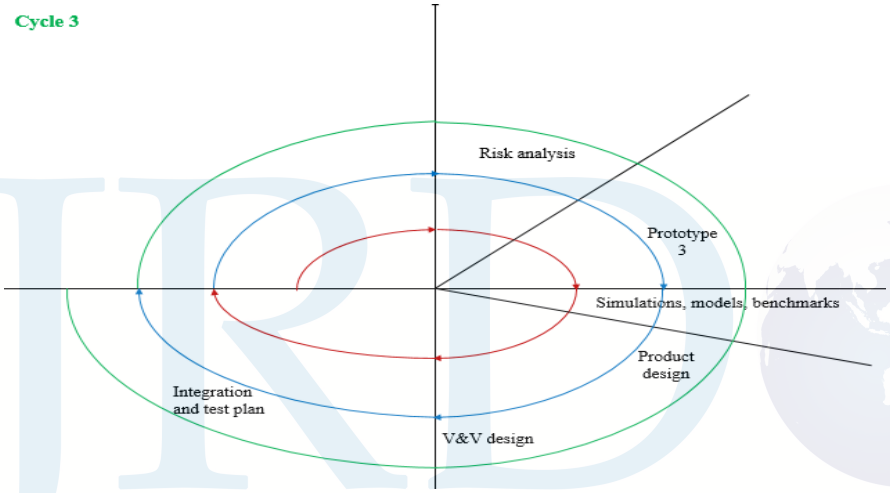


***Figure 10**. Reading of the cycle 3 of the spiral together with the tasks to be performed in it.*

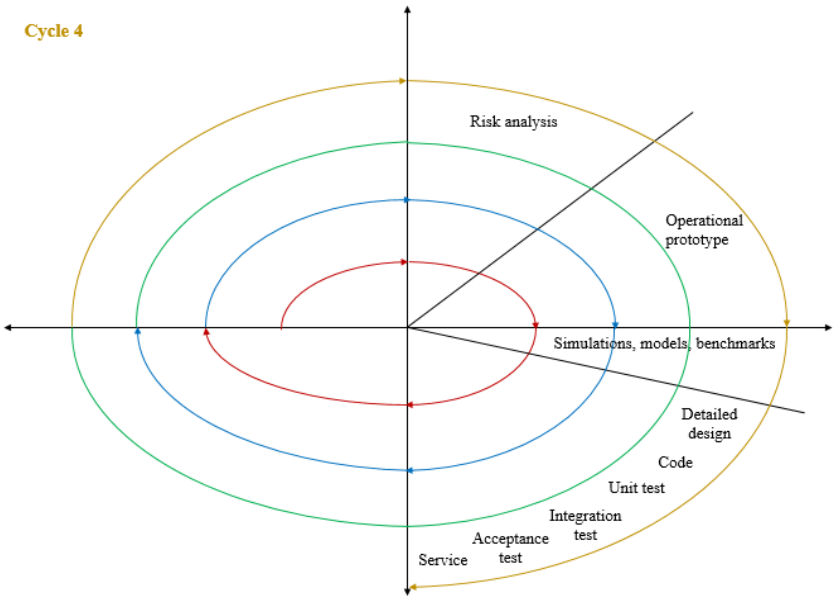


***Figure 11.** Reading of cycle 4 of the spiral together with the tasks to be performed in it.*

Finally, the improved original explanation should only be stated again as follows:

- Phases:

1. To determine objectives, alternatives and restrictions:

   - Objectives: Clients are interviewed and they have to fulfill questionnaires, etc.
   - Alternatives: These are the different possible ways of achieving the objectives. They are considered from two points of view:
     - Product characteristics.
     - Ways to manage the project.
   - Restrictions:
     - From the point of view of the product: Interfaces in some way, performance, etc.
     - From the organizational point of view: Cost, time, personnel, etc.

2. To evaluate alternatives and identify and solve risks:

   - Risks: List of identified risks.
   - Resolution of the risks: the most used technique is the construction of prototypes.

3. To develop and verify the requirement:

   - Results: It is the product that remains after the resolution of the risks.

4. Planning and commitments for the following iterations:

   - Plans: The things that will be done in the next phase.
   - Commitment: Management decisions on how to continue.

4.4. Verification of the improvement of materials

After completing the process of explaining the new materials, the students re-evaluate the new explanation B. With the obtained score, together explanation A obtained initially, it will be possible to determine the fulfillment or not of the hypothesis. The data obtained can be seen in Table 2.

Table 2. *Results of students' assessments in each explanation.*

Students	Explanation A	Explanation B
LCG	6	9
AMCS	5	10
JGB	5	9
FGP	4	9
PGF	6	9
RMF	3	9
RJMD	4	8
JJNM	5	9
PPF	8	10
ARR	7	10
CRP	4	9
LVR	7	10
JVG	6	9

It will be verified if the alternative hypothesis (H0) is fulfilled: "The new materials do not improve the students' explanation and understanding on the part of the chosen theme", so that if the value of the significance in Wilcoxon Signed-Rank Test is less than 0.05, we will change our opinion and accept the initial hypothesis (H1). Table 3 shows information from the Wilcoxon Signed-Rank Test and in the Table 4 the statistical values of this same test.

Table 3. *Wilcoxon Signed-Rank Test information*

Ranks				
		N	**Average rank**	**Sum of ranks**
Explanation B – Explanation A	Negative ranks	0a	,00	,00
	Positive ranks	13b	7,00	91,00
	Draws	0c		
	Total	13		

a. Explanation B < Explanation A b. Explanation B > Explanation A c. Explanation B = Explanation A

Table 4. *Statistical Values of the Wilcoxon Signed-Rank Test*

Contrast Statistics	
	Explanation B - Explanation A
Z	-3,207a
Sig. asymptote. (bilateral)	,001

a. Based on negative ranks. b. Wilcoxon Signed-Rank Test

Being as much as careful that it is necessary to be in these cases, being a small sample of students, and depending on the value of the variable Sig. asymptote. (Bilateral) of 0.001, there is significant evidence that the hypothesis H0 is not fulfilled; therefore, students understand better the new explanation made with the new materials, so the hypothesis initially proposed (H1) is validated with the data obtained.

5. Conclusions

In conclusion, in this research we have fundamentally influenced several important issues. The first point refers to the methodology used in the experiment; it is the mixture of tools and research methodologies used: JITT / FC for information gathering, qualitative analysis to discover new knowledge, creation or improvement of materials, application of a questionnaire to retrieve information about the improvement, and, finally, verification of the improvement through quantitative analysis.

The second point is the service that provides the qualitative analysis of the texts (answers of the students to question 3). This has made it possible to detect concrete elements of improvement in the materials studied by students, who are in a sea of textual information, and without this type of analysis had not come to light. Therefore, it is important initially to get the students' opinions on what they feel it is needed an improvement in materials, using techniques of this type.

The third issue, besides the improvements provided by this type of mixed research, it is the appreciation obtained from students when they are the focus of interaction to produce new and better teaching materials. Their interaction is positive and sincere and I think that this type of interaction should be more habitual. It provides an interesting feedback of information that allows improving the teaching.

The last and not least important issue is the improvement that occurs in the materials of the subject, in which this type of research is carried out. Since there is an improvement of the

elements that compose the subject, students' understanding is better; either by restructuring the existing elements or by creating new elements.

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