

Creation of a Digital Learning Ecosystem Using Research-Based Learning for Future Programming Teachers

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ABSTRACT

Training future programming teachers requires an innovative approach. Students need to handle the most current trends in technologies and teaching-learning methodologies, and they must develop the capacity and criteria to search and select the most adequate to their context. This work analyzes the application of a collaborative research-based learning methodology in the programming subject of a Master's degree in teacher training. The objective was to create a digital learning ecosystem and analyze the impact on the development of programming teaching skills. The results show that students perceive positive effects on the development of teaching skills, generating useful resources. However, teamwork has conditioned the quality of such resources. The digital ecosystem has allowed students to share knowledge with their peers and forthcoming students. Students who already had the generated ecosystem available valued it very positively. Future programming teachers require lifelong learning which can be supported by this living ecosystem.

KEYWORDS

Active Learning Methodologies, Collaborative Learning, Knowledge Creation, Teacher Training, Teaching Programming, Teaching Skills, Virtual Communities

INTRODUCTION

Teacher training has been evolving together with society (Maquilón, 2011). Professional, digital and interpersonal skills, together with resilience and lifelong learning are key features that future teachers will need to adapt to new generations of students. Hence, numerous studies have been remarking for decades the need to change the teaching methodologies to give the students –in all fields and levels, but especially future teachers- an active and central role in the learning process, as this will enhance their competence development (Sein Echaluze et al., 2017). For this reason, current higher education curricula have changed from a training-centered and professional development model to a competence development model, from a work orientation to a lifelong learning orientation, from a

DOI: 10.4018/JITR.298324

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teaching paradigm to a learning paradigm. The logical consequence of this change is that innovation is required, not only in the form of instruments and digitization of learning, but also in the learning process and in the students' learning experiences (Nurul Ratnawati, 2020).

There are countless learning methodologies that can be used for teacher training, such as challenge-based learning (CBL), project /problem-based learning (PBL), teamwork, etc., that can help to improve future teachers' learning and, especially, to satisfy nowadays demands. Teachers must be trained to transit through their own learning paths and to analyze and evaluate the different didactical strategies that have been designed and applied to create knowledge (Sánchez Puentes, 2014).

All active methodologies have common goals and processes. Their mission is to ensure that students in general actively participate in the learning process, cooperating with other students, reflecting, making decisions, and producing knowledge (Fidalgo et al., 2019a). It has been proven that the increase of active participation (typical of methodologies such as PBL, Gamification, Research-based Learning- RBL, etc.) benefits the aspects related to collaboration and, therefore, the development of necessary transversal competencies in the professional future. Specifically, the RBL methodology allows students to create new knowledge through research and integrate it into their skills and professional practice (Afdal & Spernes, 2018). It can develop the critical thinking skills, problem solving, creativity, and communication skills, which are key in 21st century learning processes (Susiani et al., 2018). As these authors mention, this methodology proposes to follow the scientific method in class. This includes starting from a general question, looking for existing literature on the topic, defining questions and hypothesis, designing the activities and data collection, analyzing data and interpreting it, and presenting the results.

In the case of future teachers, developing the aforementioned competences is fundamental because they will be applied in their classrooms with school students. Hence, the use of RBL in their learning programs seems to be crucial. In this context, Afdal & Spernes point out that there is a growing body of research in Europe and North America around the incorporation of Research-Based Learning in teacher education programs, policies, and educational research (Afdal & Spernes, 2018). These authors explain that RBL enables teachers to make autonomous, rational, and theory-based decisions and to integrate research and practice in a profound way. And this is important because future teachers need to be able to continuously renew their curricula and teaching methodologies according to students' changing needs, and to create knowledge instead of just receiving it. Therefore, using RBL with future teachers implies educating them in a specific style of thinking and acting that is based on the scientific method (Griffiths, 2004).

The future use of RBL by teachers in their classrooms will contribute to changing the present models, which are currently still excessively focused on the teacher's role. This is intended to break the individual and passive focus of the learning process, typical of the current educational model and which negatively affects the learning process itself. As Fidalgo et al. (2019b) remark, student passivity directly affects several factors in the cooperative dynamics, such as low participation in collective work and difficulty in creating knowledge. Consequently, a stark importance has been given to the enhancement of the collaborative work in the educational sphere (Fidalgo et al., 2015a). The teamwork among the students endorses the communicative interactions between team members. These communications can be conducted both presence-based or virtually and can lead to collective knowledge creation.

Virtual collaboration takes on special relevance due to its daily use in the informal university environment. According to the 2015 Barometer of Employability and Employment of University Students in Spain, virtual collaboration is also a necessary competence for the professional future of students (Michavila et al., 2016), and particularly in scientific-technological fields (Orta-Castañón et al., 2018), taking into account the transformation of many aspects in the way of learning and working that the knowledge society has meant. Indeed, the incorporation of Information and Communication Technology (ICT) in the teaching-learning process achieves new functionalities, processes and methods

that must be applied to traditional procedures. This has become especially relevant since March 2020, due to the COVID pandemic, when the virtual tools have been daily used.

Online social networking used for virtual collaboration is supported by digital ecosystems, as they foster complex, self-organizing interactions among people, and between people and internet technology (Gómez et al., 2013). The use of the concepts of digital ecosystems in higher education has been already studied and considered a helpful analogy (Reyna, 2011) and many studies have addressed the use of popular social networking sites in higher education as well (Anderson, 2019; Novak et al., 2012). The digital learning ecosystems include faculty, students, the physical devices used to access content, the internet connection, the e-learning interface, structure and content, and the interactions among all components (García Holgado & García Peñalvo, 2018). They allow collaboration through sharing and creating knowledge in web communities (synchronous knowledge creation). And provided that content is not removed, the legacy of materials created in the digital ecosystem ensures that future students can view and learn from previous cohorts (asynchronous knowledge creation) (Gómez et al., 2013). Both kinds of knowledge creation will be considered depending on the target audience to which the knowledge is destined. If it is shared among the current course, analyzed and even validated, the knowledge is built within the existing group. However, if it remains solely as evidence, the future students will be the ones working on that knowledge.

As in natural ecosystems, learning ecosystems evolve over time to cover the changing needs of students and teachers or faculty (García Holgado & García Peñalvo, 2018). Traditional conceptions of learning give way to the notion of learning ecosystems where intra-action is at the core of learning, showing that future teachers' learning takes place everywhere, in every space, at every moment of their lives, with different people and the surrounding resources (Sancho-Gil & Domingo-Coscollola, 2020). One of the advantages of using digital learning ecosystems to create and manage knowledge is that they gather useful and filtered information for students' use. Given the current development of ICT, organizations and users deal with great amount of information coming from many systems. Hence, identifying a resource of relevant information to a specific context becomes a real challenge. And therefore, it is interesting to develop a model to analyze the pedagogical value of the resources within a learning ecosystem (Ben Ameur et al., 2017). Digital learning ecosystems also promote collaborative learning and allow exchange and share of knowledge and/or skills for succeeding in a common project. They offer different options for knowledge management and organization. In traditional Learning Management Systems, used by many teaching staff as simple repositories, the teacher is the only agent managing and organizing knowledge. But, in some cases, it might be interesting that the students themselves are the ones who do the classification of the created knowledge according to the criteria they have considered, related to their own experience in the classroom (Fidalgo et al., 2020). In short, learning ecosystems have changed the way of learning because students are part of their own learning, and they are the ones who contribute to the ecosystem based on their interests (Mediani & Abel, 2016).

Finally, to achieve the introduction of successful presence-based and virtual collaborative actions in the classroom, these must be previously planned and evaluated by the teacher. Mechanisms to collect evidence should be developed to evaluate the teamwork skills and compromise of individual team members (ABET, 2017). Analyzing the interaction of the team members, through a learning analysis system, permits a formative evaluation that indicates the progress of each member and allows for corrective measures in case of inadequate progress (Sein-Echaluze et al., 2018). The evidence for assessing the acquisition of teamwork competences is classified into three dimensions: (i) the individual dimension, acquired by each team member; (ii) the group dimension, composed by the results of the teamwork; and (iii) the final outcome dimension (Fidalgo et al., 2020).

The present paper shows an experience of teacher training in the scientific-technological field. It is based on the educational trends that seek a more active involvement of students (future teachers) in their learning process. The aim is to analyze the strategies of collaboration that have been applied to

increase the student participation, both virtual and presence-based, to promote a set of characteristics -already described decades ago-, which increase the learning process quality: interaction (Vygotsky, 1978), active and continuous participation (Kolb, 1984), creation of knowledge (Bloom et al., 1956) and recombination of knowledge (Piaget, 1964). The last two characteristics can be approached by the creation of useful knowledge communities among the student body and the faculty, using a digital learning ecosystem.

METHODOLOGY

This study has been performed in the Master's degree in Teacher Training in the subject of Programming (compulsory in the specialization of Technology and elective in the specializations of Mathematics, Physics and Chemistry and Graphic Expression), at the Universidad Politécnica de Madrid. Teaching programming is a challenge for teachers because it is constantly changing. New programming languages are emerging every day that require constant adaptation. However, this subject, framed in the teacher training, does not try to teach programming, but rather to teach how to teach programming. Added to this complex challenge is the very varied profile of students, which increases the difficulty. Graduate students in computer science, or telecommunications engineers with a high background in programming can be found in the same classroom as architects or chemical or physical engineers with no or very little training in programming. Therefore, the creation of a digital learning ecosystem has been proposed; in which students contribute to the creation of knowledge through RBL.

The study collected data during two consecutive years: 2019-20 (cohort one) and 2020-21 (cohort two). The 2019-20 academic year included 27 students who were grouped into 8 teams. The 2020-21 year the class was composed of 44 students who were grouped into 14 teams. The teams were formed according to the preferences of the students. They indicated their choice for one of the available topics and the groups were formed. Despite the fact that the second year has been developed under pandemic conditions, the RBL methodology has been developed without alterations (with presence-based classes and a virtual environment). No contagions were detected and there were only some cases of isolation in which students were able to participate in distance classes through BB Collaborate conference software (Blackboard Inc, 2021).

The goals of the study are:

1. To analyze the effectiveness of Research Based Learning and the digital learning ecosystem as a methodology for the development of programming teaching skills.
2. To evaluate the degree of collaboration within the Research Based Learning teams and its connection with the quality of produced resources and individual performance of the teams' members.
3. To analyze the students' perception of the usefulness of the digital learning ecosystem as a resource for programming teachers.

The subject required students to complete three different assignments. The first of them was done individually. It consisted of a basic programming task using block programming with Scratch (MIT Media Lab, 2020). This task involves a first contact with programming in which students must design a video game that is used to teach a subject. With this task, programming concepts are worked on in a general way, as for some of the students they are well known but are novel for others.

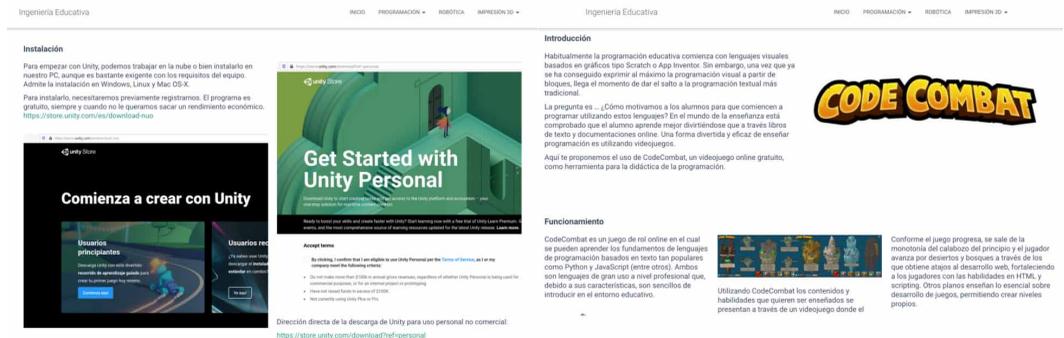
In the second activity students had to develop a code using Processing (Processing Foundation, 2020). In this programming environment, students program using code and the complexity rises. For this reason, this task is carried out in pairs with the aim of carrying out a program that supports the teaching of any subject.

The third one is a collaborative knowledge production activity through the RBL methodology. The aim of this task is to introduce students to the broad spectrum of applications used to teach programming and the diversity of languages. The collaborative model followed is based on teamwork. Teams of 3 to 4 students were formed, according to their topic preferences. The Comprehensive Training Model of the Teamwork Competence (CTMTC) that allows monitoring the development of the teamwork guided the teamwork (Fidalgo et al., 2015b). There was an initial explanation of the CTMTC teamwork method, and the evidence of an internal organization that each group had to upload to Moodle (Moodle, 2020). In the first cohort, the teams chose a topic from a wide list prepared by the professor. In the second cohort, the teams had the same list available to choose a topic, but increased with new applications and the elaborated resources by the previous cohort published in an institutional blog (Wordpress, 2020) (Figure 1). Each team had to prepare three outputs, all of them intended to be useful for other teachers: a video, a didactic guide, and class notes. In the last two sessions, all the teams presented their work to the rest of the class and received feedback and an evaluation. Later, the resources were formatted and uploaded to the blog. Hence, the created knowledge is shared with the students of the present course in class and, later with next cohorts, as it is uploaded to an institutional blog, and it can be used by future students.

The tools used to analyze the study goals are the following:

1. To analyze the effectiveness of RBL and the digital learning ecosystem as a methodology for the development of programming teaching skills, the grades obtained by the students in the three different activities have been analyzed: basic programming, advanced programming and RBL. Mann-Whitney non parametric tests were carried out to assess possible differences. Also, the related items from the official university end-of-subject survey in which students value the degree of achievement of the objectives were taken into account.
2. The degree of collaboration within the teams was evaluated with the evidence of internal organization that each team produced. Throughout the development of the RBL activity, students were working on common spaces such as forums and wikis, accessible on the course's Moodle platform, to ensure the internal organization of the team and the publication of intermediate progress. These evidences have been analyzed to evaluate the actual degree of collaboration within the group, quantifying if all the students have participated in the teamwork and if they have followed a structure of labour division. Four levels have been established for the analysis of the different participations in forums and/or wiki entries. The professor graded such participation depending on a qualitative analysis of the duration and intensity of the students' contributions. In addition, the grades obtained

Figure 1. The blog with the published created knowledge



by the students in the collaborative project and also in other individual activities during the subjects, are both analyzed and compared. In order to establish the connection between the degree of collaboration and the grades, non-parametric correlations were calculated through the Spearman correlation coefficient, r_s .

3. The student’s perceptions were assessed considering the related items of the official university end-of-subject survey and a Focus Group carried out at the end of the subject. The survey analyzes the subject within the master and follows the structure defined by the university. The items are valued on a 1 to 6 Likert scale. As regards the Focus group, the questions were: (1) Which of the tasks performed did you like the most?; (2) What are the most important learning of this subject for you as a future programming teacher?; (3) Do you think your ability to teach programming has progressed?

RESULTS

The results are organized according to three objectives established in the methodology.

Analysis of the Effectiveness of Research-Based Learning and the Digital Learning Ecosystem as a Methodology for the Development of Programming Teaching Skills

The grades of the different tasks are valued on a 0 to 10 scale (Table 1). In general, the grades are good and it can be seen that the lowest grades are those of the first evaluation carried out individually. Regarding team tasks, they have a slightly higher mean score, with the RBL activity of cohort two being the highest and with the least dispersion. However, the medians are equal and Mann-Whitney U-test showed no significant differences between RBL results for both cohorts (p-value=0.072, alpha level=0.05).

Items from the end-of-subject surveys related to the methodology, the perceived workload, the usefulness of the evaluations, the learning of expected competences and the usefulness of the available resources have been selected and analyzed (Table 2). Students perceive a high relationship between the assessments and the objectives of the subject in both cohorts, with scores very close to the maximum (5.72 and 5.58). In the case of perceived workload, the score of cohort two is significantly smaller than that of cohort one (p=0.014). With respect to the usefulness of the assessment and competences development, in cohort one the students have a slightly higher perception than in cohort two, although the dispersion is very high and there are no significant differences. However, in the case of the usefulness of the available resources, students in cohort two value it better than those in cohort one, but there are no significant differences.

Degree of Collaboration Within the Teams and Its Connection to the Grades

In cohort one, there is no significant correlation between the grades of the groups and the degree of participation of the team ($r_s = .500$, Table 3, columns 3 and 4). There is no relationship either between individual student grades in other activities and group grades in the Research-Based Learning collaborative projects (Table 3, columns 4 and 5). In general, the group grades were similar to the

Table 1. Assignments grades

Academic year	Basic programming (Individual)				Advanced programming (Pairs)				Research-based Learning (Groups of 3-4 students)			
	Mean	SD	Med	IQR	Mean	SD	Med	IQR	Mean	SD	Med	IQR
2019-20	8.30	0.98	8.00	1.50	8.77	0.65	9.00	1.13	8.60	0.94	9.00	0.13
2020-21	8.31	0.65	8.50	1.00	8.48	1.25	9.00	0.50	8.97	0.49	9.00	0.88

*IQR= Interquartile range

Table 2. Students' perception of the degree of achievement of the objectives Mean and standard deviation.

	2019-20 N=25 (92.59% of total no. of students)	2020-21 N=38 (86.36% of total no. of students)
1. Relation between assignments and the subject objectives	5.72 (0.54)	5.58 (0.50)
2. Perceived workload according to ECTS	5.60 (0.71)	5.29 (0.52)*
3. Assessment Utility	5.64 (0.57)	5.47 (0.56)
4. Learning of the expected competences	5.76 (0.72)	5.63 (0.49)
5. Usefulness of the available resources	5.54 (1.10)	5.92 (0.27)

* p-value<0.05

average of the individual marks, although the correlation was non-significant ($r_s = .286$). It can also be appreciated that the group grades reduce their dispersion with respect to the individual ones, with more homogeneous works. There is a significant correlation between the degree of participation within the team in follow-up activities and the individual marks ($r_s = .928$). Finally, it should be outlined that there are extreme cases, such as students with very good results in teamwork and quite low marks in individual work.

Interestingly, regarding cohort two, all the Spearman correlations are significant. First of all, the grades of the RBL collaborative projects and the degree of participation of the team show a significant correlation: $r_s = .815$ (Table 3, columns 3 and 4) showing that students who worked better in a team obtained higher grades. There is also a significant correlation between individual student grades in other activities and group grades in the RBL collaborative projects: $r_s = .865$ (Table 3, columns 4 and 5). This is partly expected, because students with better individual records are supposed to be more involved. And finally, there is a significant correlation between the degree of participation within the team in follow-up activities and the individual marks $r_s = .805$ (Table 3, columns 3 and 5). This situation could be explained in part, because the main problems detected were not related to coordination or misunderstanding within the teams, but rather the involvement or lack of time of some students, which relates the student's performance to their work in the team.

Student's Perceptions About Utility of the Digital Learning Ecosystem

The students' perceptions about the usefulness of the digital learning ecosystem were collected through an end of subject 1 to 6- Likert scale survey and a focus group. The results of the survey are shown in Table 4. Four categories of items related to the students' perception of the subject, the professor's performance, motivation towards the subject and overall satisfaction have been included in the analysis. A slightly higher value and a lower dispersion is observed in all the items in cohort two, however, no significant differences are found.

In the focus group that was carried out as a classroom activity, the students discussed three questions and their relationship to the subject. Figure 2 shows a map of the main topics that were addressed. First of all, they discussed the different tasks proposed. Assignments were analyzed as one of the main issues that concern them the most. The task developed in RBL is the one that they perceive to be the most complex and with a greater workload, despite them being the ones who choose the topic and being carried out in teams. This was even more notable in cohort two, since students commented that being able to access the assignments from other courses creates pressure for them to generate resources of a similar or higher level. Interestingly, the fact of being able to access the resources of previous years since the beginning of the course in the reference blog has been very well perceived by the students, especially by those who had a lower level of programming. This has also

Table 3. Collaboration results and grades (collaborative project and other individual activities)

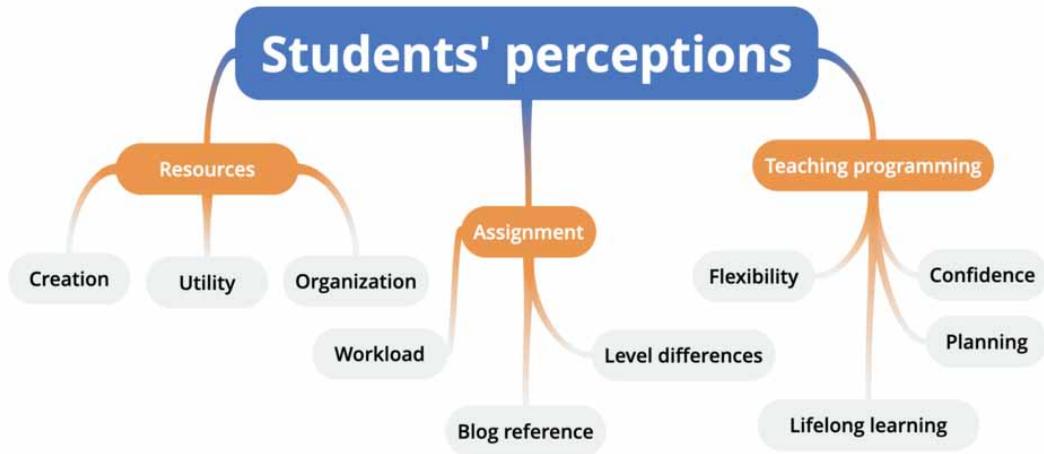
Team	Academic year	Degree of collaboration within the team (1 - 4)	Collaborative project grade (1 -10)	Other Individual grades, averaged by team (St. Dev.)
1	2019-20	1	9.0	7.00 (0.00)
2		4	9.0	8.50 (0.57)
3		1	7.0	7.50 (3.04)
4		3	8.0	8.00 (0.41)
5		4	9.0	8.38 (0.48)
6		3	9.0	7.75 (0.35)
7		4	8.5	9.34 (0.28)
8		4	9.0	9.66 (0.58)
1	2020-21	4	9.5	9.00 (0.94)
2		4	9.0	8.75 (0.79)
3		4	9.0	9.16 (0.75)
4		3	9.0	8.8 (0.74)
5		1	8.0	7.69 (1.54)
6		4	8.5	8.48 (1.17)
7		3	8.5	8.75 (1.5)
8		4	9.5	9.08 (0.8)
9		4	9.5	9.42 (0.92)
10		1	7.0	7.21 (0.78)
11		4	9	9.08 (0.75)
12		3	8.5	8.16 (0.55)
13		3	8	7.9 (0.98)
14		4	9	9.14 (0.52)

Table 4. Students' perception of the subject, the professor's performance, motivation towards the subject and overall Mean and standard deviation.

	2019-20 N=25 (92.59%)	2020-21 N=38 (86.36%)
1. Suitability of the subject	5.72 (0.54)	5.76 (0.46)
2. Professor performance	5.64 (0.70)	5.76 (0.43)
3. Incentive of the subject	5.70 (0.65)	5.88 (0.33)
4. Global Satisfaction	5.75 (0.53)	5.82 (0.39)

had an impact on the number of instructions requested by both cohorts, to develop the tasks. While students from the first cohort perceived more complexity in the RBL task, as they could not see any example, in the second cohort, students developed their videos, manuals and posts with very little instructions from the professor.

Figure 2. Map of the categories regarding students' perceptions collected in the focus group



The collaboration design was also discussed. The students in both cohorts highlighted the importance of being able to collaborate in multilevel groups, since despite having an objective of developing teaching materials, they considered it important to have a good programming base in order to offer a format and structure best suited to the subject. Finally, their future as programming teachers and the contribution of the subject in this regard were analyzed. Students with programming experience valued the availability of resources to teach programming classes very positively, since their previous training had been purely technical. On the other hand, students with less experience in programming perceived the wide range of possibilities of teaching programming and found in the ecosystem a place of consultation to update themselves and learn about new teaching options, which gave them greater confidence. In general, all students agreed that lifelong learning is an essential requirement for a programming teacher and having a shared knowledge space in which tools can be quickly reviewed, and which are accompanied by teaching resources will facilitate their future work. With respect to the topics that were selected by the second cohort, they concluded that the availability of previous tasks did not reduce or condition their topic choice, but rather prompted them to update the ecosystem with new novelty topics like machine learning or simulations. Hence, only two topics from the second cohort were related to the previous cohort, and the rest of the resources were completely new.

DISCUSSION

The experience in the development of a digital learning ecosystem has been developed in two academic courses. In the first year, the students developed the resources within a Research-Based Learning methodology to be published in a blog. In the second, the students did the same work, but the main difference is that they had the reference of the blog already published in which the resources of the first year were available, hence obtaining active and self-regulated learning (Gómez et al., 2013). Most of the work done under RBL methodology generated valid materials for future teachers, to know and deepen the tools to teach programming. The topics analyzed are part of the curriculum of the Programming subject in Secondary School, although they are not covered during the Master course due to lack of time or the diversity of levels among the students. The results show that the students have obtained high grades, being slightly higher in collaborative tasks. The RBL methodology has given answers to an underlying problem in the subject. As it is a technical course, there may be

students with computer engineering training (experts in programming) or with other backgrounds, such as architects, agronomists, physicists, chemists, economists (who have received little training on the topic). With such a gap in their background, the possibility of guiding students towards a research process, permits them to focus on the objective of the subject “to know how to teach programming”, regardless of their technical level. This has facilitated that each group of students researched about topics in relation to their technological base, elaborating teaching materials that could be used by others. Students were satisfied to be able to choose a research topic according to their level of programming knowledge. This allowed them to research in a practical way and adjusted to their abilities. In addition, RBL allowed them to be participants throughout the knowledge creation process (Sánchez Puentes, 2014) and perceive an improvement in their self-perception about the competencies to be future programming teachers. The availability of the ecosystem has been a differential factor, because the students in cohort two perceived a lower workload than those in cohort one. However, in the focus group, they highlighted the expectations established by the previous works. This can be explained due to the fact that students who have examples of resources already prepared better adjusted the focus of the resources to be developed and the time necessary for their development.

The degree of collaboration inside teams has presented significant differences in the quality of the resources generated. Collaboration through teamwork is a complex activity in which there are many students' personal factors that influence and condition the proper development of it. Generally, the faculty is not used to collect evidence on group work, apart from the regular classwork itself, therefore it is difficult to assess the degree of involvement of each student. The CTMTC methodology has been satisfactory to collect proof to evaluate how internal teamwork has progressed (Fidalgo et al., 2015b). Regarding the students' perceptions, those from the second cohort, who had access to the digital learning ecosystem, in general, valued the subject better and had fewer doubts in carrying out the tasks. However, the availability of resources already prepared, in addition to establishing a work reference, set expectations that generated pressure to generate resources of equal or better quality than the previous ones. Despite this, the students of the second cohort did not seem to be conditioned by the digital ecosystem in the topic choice, as they showed interest in other more current fields such as machine learning, choosing to work on some resources that did not exist or were incipient in the previous year (Mediani & Abel, 2016). These factors contribute to generating a flexible ecosystem that supports future teachers' lifelong learning adapted to their needs (Sancho-Gil & Domingo-Coscollola, 2020) and evolves together with students and new trends, adapting to the needs of the programming teacher (García Holgado & García Peñalvo, 2018).

The digital learning ecosystem has been developed over two academic years, but with the next cohorts, it will continue to grow. Future lines of action to enhance the ecosystem will include a greater role given to students as the volume of resources becomes difficult to handle. It is proposed to establish a voting model to validate resources and prioritize those that are considered most useful by students (Ben Ameur et al., 2017). In addition, if students participate in the classification of resources, this favors better access to the knowledge created (Sein-Echaluze et al., 2019) and therefore the ecosystem will be more effective.

CONCLUSION

The active methodologies are shown in this study case as solutions for very common problems in university courses. RBL methodology implies an active process of analyzing, synthesizing and evaluating information that improves learning and the development of critical thinking and research competences. The mastery of this methodology by future teachers will enhance such competences when applied in their future classes.

The RBL combined with collaborative learning helps the involvement of future teachers and makes them participants of their own learning. Moreover, the resources generated in the first cohort analyzed were published on a blog that was made available to forthcoming students, which generated

a digital learning ecosystem that the future teachers of the second edition have used for their study and have expanded with their new contributions.

Programming teaching is a complex task that requires lifelong learning on the part of the teacher. Programming, and in particular the computational thinking, is key to future Science, Technology, Engineering and Mathematics (STEM) professions and requires continuous learning to be able to offer students the latest technologies and the criteria for selecting them. Students who have contributed to this digital learning ecosystem will find, as future programming teachers, a place to learn and acquire useful resources for teaching programming.

ACKNOWLEDGMENT

This research was partially supported by the MECOVA Educational Innovation Project at Universidad Politécnica de Madrid [grant number IE1920.0601].

FUNDING AGENCY

Publisher has waived the Open Access publishing fee.

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