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Assessment of the virtualised self-regulated learning ecology for the Didactics of Natural Sciences during the COVID-19 crisis

Valoración de la Ecología de Aprendizaje Autorregulado Virtualizada para la Didáctica de las Ciencias de la Naturaleza durante la crisis COVID-19

在新冠疫情危机期间对自然科学教学法的虚拟化自我调节学习生态进行评估

Оценка виртуализированной экологии саморегулируемого обучения для дидактики естественных наук во время кризиса COVID-19

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Abstract

University teaching-learning models are being affected by the crisis caused by COVID-19. To address this unleashed crisis, a virtualized self-regulated learning ecology proposal was urgently designed in the subject of Natural Sciences and its Didactics I, of the Degree in Primary Education Teacher, during the confinement of 2020. In this article it is described this learning ecology: the materials produced, the designed environments and the use of teaching-learning strategies based on self-regulated learning, both in virtual teaching and in student tutoring. The objective of this study is to analyze the ecology of self-regulated learning through the students' appreciation regarding their motivation towards the subject, their opinion on the quality of the materials and on the evaluation, the students' perception of the teacher's motivation towards the subject and with respect to the workload of the subject, as well as the general satisfaction of the teaching work. The information was collected using the Student Opinion Questionnaire on the quality of teaching carried out by the University of Burgos. All the items were well valued, so the experience can lay the foundations for the implementation of learning ecologies that can be extrapolated to other university degrees and contexts other than the one implemented here.

Keywords: self-regulated learning, learning ecology, physics didactics, COVID-19, Primary Education Teacher.

Resumen

Los modelos de enseñanza-aprendizaje universitarios están siendo afectados por la crisis originada por la COVID-19. Para atender a esta crisis desencadenada se diseñó de urgencia una propuesta de ecología de aprendizaje autorregulado virtualizada durante el confinamiento de 2020 en la asignatura de Ciencias de la Naturaleza y su Didáctica I del Grado en Maestro de Educación Primaria. En este artículo se describe esta ecología de aprendizaje: los materiales elaborados, los contextos diseñados y la utilización de estrategias de enseñanza-aprendizaje basadas en el aprendizaje autorregulado, tanto durante la docencia virtual como durante la tutorización del alumnado. El objetivo de este estudio es analizar la ecología de aprendizaje autorregulado a través de la apreciación del alumnado con respecto a su motivación hacia la asignatura, su opinión sobre la calidad de los materiales y sobre la evaluación, la percepción del alumnado de la motivación del profesorado hacia la asignatura y respecto a la carga de trabajo de la asignatura, así como la satisfacción general de la labor docente. La información se recabó utilizando el Cuestionario de opinión del alumnado sobre la calidad de la docencia realizado por la Universidad de Burgos. Todos los ítems fueron bien valorados, por lo que la experiencia puede sentar las bases para la implementación de ecologías de aprendizaje que puedan extrapolarse a otras titulaciones universitarias y contextos diferentes al aquí implementado.

Palabras clave: aprendizaje autorregulado, ecología de aprendizaje, didáctica de la física, COVID-19, Maestro de Educación Primaria.

概要

大学教学模式正在遭受新冠疫情危机的影响。为了解决这一危机，在 2020 年的隔离期间，我们紧急设计了一项虚拟化的自我调节学习生态提案，其针对对象为小学师范本科学位关于自然科学教学法 I的课程。本文描述了该学习生态：在进行虚拟教学和对学生辅导期间所制作的材料、设计的环境以及对基于自我调节学习的教学策略的使用。本研究的目的是通过学生对学习动机的评价、对教材质量和评估的看法以及学生对老师教学动机的看法和其在该科目上的工作量和总体满意度来分析自主学习的生态。这些信息是通过对布

尔戈斯大学教学质量的学生意见问卷收集的。所有项目都得到了很好的评价，因此该经验可以为学习生态的实施奠定基础，并将其推行至其他大学学位和不同环境中。

关键词: 自我调节学习、学习生态学、物理教学、新冠疫情、小学教师

Аннотация

Университетские модели преподавания-обучения испытывают влияние кризиса, вызванного COVID-19. Для преодоления этого кризиса, предложение по виртуализированной саморегулируемой экологии обучения было срочно разработано во время заключения 2020 года по предмету «Естественные науки и их дидактика I степени в начальном образовании». В данной статье описывается эта экология обучения: разработанные материалы, созданные контексты и использование стратегий преподавания-обучения, основанных на саморегулируемом обучении, как во время виртуального обучения, так и во время репетиторства студентов. Цель данного исследования - проанализировать экологию саморегулируемого обучения через оценку студентами своей мотивации к предмету, их мнение о качестве материалов и об оценке, восприятие студентами мотивации преподавателей к предмету и в отношении нагрузки по предмету, а также общую удовлетворенность преподавательской работой. Информация была собрана с помощью Анкеты мнения студентов о качестве преподавания в Университете Бургоса. Все предметы получили хорошие оценки, поэтому данный опыт может заложить основы для внедрения экологий обучения, которые можно экстраполировать на другие университетские степени и контексты, отличные от реализованного здесь.

Ключевые слова: саморегулируемое обучение, экология обучения, дидактика физики, COVID-19, учитель начальной школы.

Introduction

The COVID-19 pandemic has forced an urgent transformation of teaching methods in our universities, from models typically strongly focused on the concept of information transmission and face-to-face teaching to scenarios in which learning takes place solely through technological means. This technology is usually oriented towards the content rather than the students themselves, without duly exploiting its capacity for interaction and feedback (Cabero-Almenara & Llorente-Cejudo, 2020). The resulting situation was very complex, both for the teachers and their students. The latter, despite being 'digital natives', mainly use ICT tools more for leisure than for learning (Lai & Hong, 2015; Vázquez-Cano et al., 2020), so they cannot necessarily be deemed digitally competent (Šorgo et al., 2016; Teo et al., 2019). Accordingly, in addition to the specific difficulties of each subject, students also had the added difficulties of acquiring the digital competences necessary to follow their studies and their limited experience self-regulating their learning (Cabero-Almenara & Llorente-Cejudo, 2020). This situation posed an opportunity to implement certain proposals that had already been introduced in other non-digital teacher training environments (Vázquez-Dorrío, 2016; Vázquez-Dorrío & Vázquez-Dorrío, 2018). A particularly relevant example is the creation and use of adaptive online virtual learning spaces to meet the different needs of users. These spaces allow teachers to duly focus their educational interventions in a manner that caters to the diversity of the students and anticipates their possible conceptual, methodological or technological difficulties. Siemens (2007) defined these spaces as a learning ecology. Although a polysemous concept, research into learning ecologies is widely approached from the theoretical standpoint of social constructivism (Sangrá et al., 2019). Jackson suggests that an individual's learning ecology is "the process and set of contexts and interactions that provides them with opportunities and resources for learning, development and achievement" (p. 14).

This article describes the urgent adaptation of the Didactics of Natural Sciences I course of the Bachelor's Degree in Primary Education at the University of Burgos to allow teaching during the lockdown due to the COVID-19 crisis by defining a completely virtualised teaching-learning ecosystem created specifically for this purpose. Although the learning ecology described in this article was designed to address a specific situation, it may also serve as the basis for future designs to improve teaching methods using virtual environments as an additional tool. This paper also describes the self-regulated training processes for students, including the materials developed and the tutoring carried out in different ways and at different times. The opinions and assessments of the students with regard to the subject (and the different components of the learning ecology) and its adaptation to the change from face-to-face to non-face-to-face are also analysed. The main contributions of this study refer to the students' description and assessment of the virtualised self-regulated learning ecology put into practice. This learning ecology is adaptable to other situations and can also be used to complement and reinforce face-to-face methods, presumably resulting in improved academic performance on the part of the students and greater interest in and appreciation of the subjects. It is increasingly common for teaching in higher education to take place in learning contexts that combine virtual learning environments with direct instruction. As a minimum, this allows teachers to monitor students and provide individualised attention and personalised curriculum adaptation (Muñoz-Carril & González-Sanmamed, 2009). In these combined contexts that promoted self-regulated learning, students showed a significant increase in self-regulated learning processes and perceived they had greater support from teachers (Martínez-Sarmiento & González, 2019). Similarly, the student monitoring and personalised attention in the self-regulated learning experiences conducted during the lockdown resulted in low drop-out rates and high student satisfaction with the teaching-learning process (Sáiz-Manzanares et al., 2021).

The aim of this article is to describe the learning ecology model used in virtualised self-regulated learning and analyse the students' assessment of the course, the teacher's role and the methodology used as a means of adaptation to the lockdown situation.

Self-regulated learning ecology

In the 1970s, Flavell coined the term 'metacognition', describing it as "knowledge and cognition about cognitive phenomena" (p. 906) and drawing a distinction between declarative knowledge (metacognitive knowledge) and procedural knowledge (metacognitive skills). Meanwhile, Brown and DeLoache (1978) included the role of self-regulation as a component of metacognition and its direct relationship with deep learning as opposed to surface learning (Boekaerts & Corno, 2005). Despite this, the scientific community has not settled on a general conceptual definition of the term 'self-regulation', although there is agreement that both metacognition and self-regulation refer to higher-order processes that take place in the frontal and prefrontal lobes (Veenman et al., 2006).

It is also relevant to mention the vision offered by Zimmerman (2008) and Zimmerman and Schunk (2008) regarding the importance of social and emotional aspects in the development of self-regulation and metacognitive skills within procedural knowledge. These aspects include skills such as self-planning, self-observation and self-evaluation, which are essential for learning and solving tasks or problems. These skills require a hierarchisation of the cognitive strategies used in execution processes (Carlson et al., 2004). However, adequate development of self-regulation skills is required in order to effectively increase these strategies (Brown, 1987).

This interrelation between metacognitive skills and self-regulation strategies guided by the learner's motivation is of key importance in learning processes, especially those that require a high degree of abstract thinking as in the case of learning of scientific content. It is also the cause behind a high percentage of learning difficulties (Otero, 1990).

Therefore, the use in instructional processes of a teaching methodology based on training in self-regulation that encourages the use of the metacognitive skills of self-planning, self-observation and self-evaluation can be very effective in fostering students' planning and evaluative thinking based on learning from mistakes (Mateos, 2001). This leads to better results in these disciplines and thus improves motivation towards learning these subjects, an interactive circle that facilitates the development of effective learning. The use of self-regulated learning (SRL), understood as a process of self-planning and self-monitoring of one's own learning process (Pintrich, 2004; Sáiz-Manzanares et al., 2019a), facilitates the development of feedback concerned with the processes and not just the learning outcomes (Brooks et al., 2019; Coertjens, 2018; Hattie & Clarke, 2018). Therefore, the use of SRL as a teaching strategy improves learners' understanding and provides them with tools for self-learning as it is directly related to procedural knowledge (Norman & Furnes, 2016; Veenman, 2011a). Having the ability to self-regulate one's own learning has a positive impact on the learner's academic performance (Gómez & Romero, 2019; Sáiz-Manzanares & Valdivieso-León). The development of these self-regulation competences is therefore fundamental for students to self-manage their own process of appropriation of the resources necessary to achieve their learning objectives. However, the degree of personal development will be dependent upon the richness of the ecological environment in which the learner develops (Bronfenbrenner, 1994) and the feedback they receive on the effects of their actions. Thus, the design of learning ecologies must take into account learning strategies to equip the learner's environment with the necessary resources and enrich their contexts, relationships and interactions (Jackson, 2013; González-Sanmamed et al., 2019).

The learning framework of the didactics of experimental science requires students to resolve problems posed in inquiry questions. In this learning context, the implementation of self-regulation and self-assessment processes is especially significant, given that it incorporates the development of planning and evaluative thinking skills and means-ends thinking in the training for future teachers. This is an essential aspect for acquisition of scientific thinking skills and ultimately for the construction of deep learning (Akben, 2020; Campanario, 2000).

Teachers are an essential part of the acquisition of SRL strategies, as they are responsible for modelling and shaping the use of metacognitive and self-regulation strategies during problem solving. Teacher feedback also plays an important role in this process. However, it should be noted that not all feedback has the same effect. Hattie and Gan (2014) describe three levels of feedback: a) the first engages learners at the task level, such as providing information about the correct answer; b) at the second level the feedback is oriented towards processes, such as providing processing strategies and hints for resolution (resolution algorithms); and c) the third and highest level of feedback focuses on self-regulation. This latter level offers guidance for task resolution, providing learners with information about their weaknesses as well as appropriate resolution strategies and knowledge about how to continue, increasing levels of motivation towards learning.

On the other hand, it must also be taken into account that the learning context has changed over the last decade. Nowadays, learning increasingly takes place in virtual environments within what have been dubbed *Learning Management Systems* (LMS), among which special mention should be made of the *Modular Object-Oriented Dynamic Learning Environment* (Moodle) due to its popularity (Cerezo et al., 2016). The use of LMS offers an important opportunity for teachers to implement SRL procedures and process-oriented feedback as opposed to solely outcome-oriented feedback. This facilitates creation of the structures necessary for the development of the learning ecology. Given that knowledge is a distributed process, learning takes place through networks which connect the different content or systems that facilitate this learning process. Ecologies provide the space in which these connections occur.

In an ideal learning ecology, the learner's access to information is not hindered by constraints or scarcity of resources. Trial and error is permitted as part of the innovation process and knowledge is shared and transparent, allowing for co-creation and re-creation (Siemens, 2007). LMS can therefore be used to design and implement learning ecologies that guide student learning by enabling the processes necessary for learning to take place. These learning platforms give rise to adaptive, dynamic, chaotic and diverse structures which allow generation of collective knowledge and are self-organised through the interactions between the different elements. These interactions are a characteristic feature of learning ecologies (González-Sanmamed et al., 2018; Siemens, 2007).

LMS have proven very effective to achieve SRL in learning processes as long as they are well designed. To achieve this goal they should include, among others: a) an analysis of the learner's prior concepts in order to design different levels of difficulty; b) learning tasks that include a discovery-learning design; and c) process-oriented feedback so that learners can learn from their mistakes. All these functionalities enhance personalised learning adapted to the learning pace of each student (Sáiz-Manzanares et al., 2021, Sáiz-Manzanares et al., 2019b; Vázquez-Dorrío, 2016; Vázquez-Dorrío & Vázquez-Dorrío, 2018).

According to the model developed by Garrison, Anderson, and Archer (2000), this quality learning in virtual environments occurs when Communities of Inquiry comprising students and teachers are formed, with interaction between three key elements that define the role of the teacher (Hernández-Sellés et al., 2015): a) social presence, referring to the teacher's ability to manage the interpersonal relationships generated between students and teachers, encouraging participation and addressing the affective needs of the students; b) teaching presence, referring to the teacher's role as a guide in learning experiences; and c) cognitive presence to ensure that the interactions produce high-level knowledge.

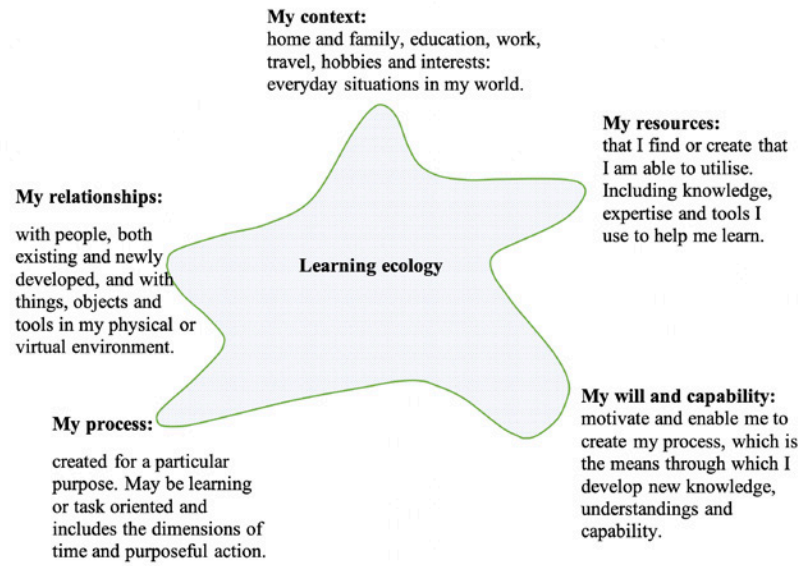
In addition, it should be borne in mind that metacognitive strategies can be trained. In this sense, Veenman (2011b) suggests the following sequence: a) the synthesis position, in which the teacher relates the metacognitive strategies to specific task demands; b) informed instruction, whereby students are informed of the benefits of applying metacognitive strategies; and c) prolonged instruction, given that metacognitive intervention is not meaningful in short periods of time.

On the other hand, the appropriate use of metacognitive strategies is related to the 'learning to learn' construct (Salmerón-Pérez & Gutiérrez-Braojos, 2012) and is necessary for its development. Development of this competence is in turn necessary for students, given that they will have to function in contexts in which they will have to make decisions about what and how to learn (Gargallo et al., 2016). These metacognitive strategies are especially important in science learning because of the students' prior ideas, raising the need for an adequate range of comprehension strategies to enable them to detect errors in their degree of understanding of scientific content. If students do not detect these deficiencies, it will be difficult for them to implement measures to correct them (Mateos, 2001).

In light of the above, a virtual learning ecology was designed based on the individual learning ecology proposed by Jackson (p. 14), the key components of which are shown in Figure 1.

Figure 1

Individual learning ecology



Note. Adapted from "The concept of learning ecologies", por N. J. Jackson, *Lifewide learning, education & personal development* (p. 14), 2013.

Teaching of the Didactics of Science in the Bachelor's Degree in Primary Education

The Didactics of Science is an interdisciplinary subject embracing content and skills from the area of science as well as pedagogy and psychology. This means that the teachers who teach these subjects require scientific-technological training as well as skills and strategies relating to teaching-learning processes (Álvarez-Herrero & Valls-Bautista, 2019).

Students' lack of interest in science, and particularly physics, has long been known, along with the fact this lack of interest increases as students progress through the education system (Sáiz-Manzanares et al., 2020; Vázquez-Alonso & Manassero-Mas, 2008). The students of the Bachelor's Degree in Primary Education share these same negative attitudes towards these disciplines (Pipitone & García-Lladó, 2020; Pipitone et al., 2019). However, meaningful science learning is essential during the training of primary school teachers, especially if we consider that a large proportion of students have not studied science since Compulsory Secondary Education (Vázquez-Dorrío & Vázquez-Dorrío, 2018). Otherwise, teachers' lack of training in science content will make them more insecure when teaching science and will therefore limit the incorporation of scientific content in the classroom (Mellado, 2003). This in turn will result in future pupils further perpetuating this dislike of science (Costillo et al., 2013), since the primary education stages are fundamental for generating motivation and interest in science among younger pupils (Sáiz-Manzanares et al., 2020).

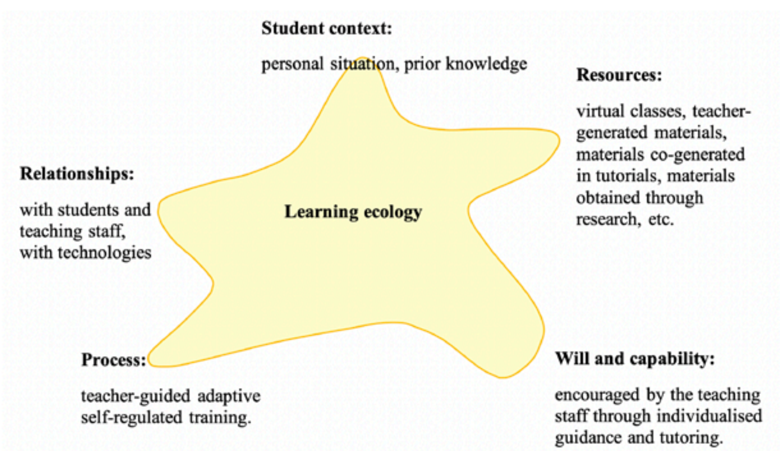
Methodology

Context

The context for this study is the Didactics of Natural Sciences I course, which is taught in the second year of the Bachelor's Degree in Primary Education under the syllabus of the University of Burgos. A half-year subject worth six ECTS credits, its content is divided into two parts, Didactics of Chemistry and Didactics of Physics, both with a similar structure. Given that the lockdown began shortly before the start of the course, in response to this educational crisis the decision was made to maintain the structure of the course and adapt it to the new virtual context. A virtualised SRL ecology (Figure 2) was designed with the assistance of two faculty members and the Head of the Department based on the individual learning ecology proposed by Jackson (2013).

Figure 2

Key components of the learning ecology developed



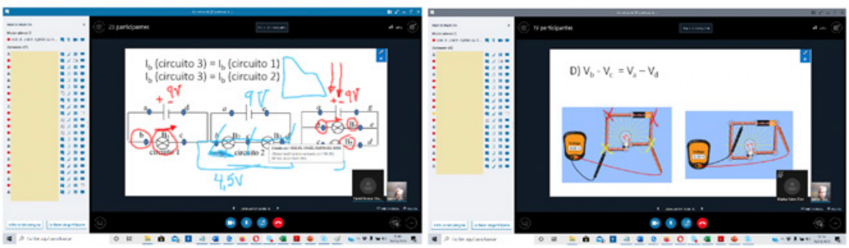
Note. Adapted from "The concept of learning ecologies", por N. J. Jackson, *Lifewide learning, education & personal development* (p. 14), 2013.

The following is a summary of the course design and the changes made to the construction of the learning ecology during the lockdown:

- Lectures in which the teaching staff teach the pedagogical and scientific content of the subject. During the lockdown period, classes were taught via videoconference using Teams or Skype (Figure 3), maintaining the timetables for the course. Two weekly sessions were held with a duration of approximately two hours, depending on the queries and conversations that arose with the students. The same content was worked on in the two sessions. The content was developed in the first session, while in the second session after the revision and student work the focus was placed on aspects or difficulties that had arisen, while at the same time resolving any doubts or problems. The aim was to guide students' cognitive and metacognitive activity in order to help them achieve an increasing level of competence and autonomy (Mateos, 2001).

Figure 3

Screenshots of two sessions via Skype. The problems are solved through dialogue with students using different resources: illustrations, screenshots of virtual laboratory simulations, etc.



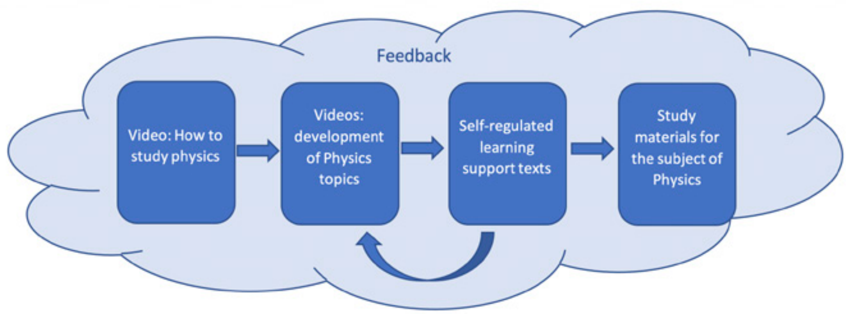
In addition, certain materials were generated for the students. The teaching staff recorded a video on "how to study the subject", along with explanatory videos for the content starting from a basic level. These videos were interspersed with questions and activities in the form of problems to serve as SRL materials for the students. Texts developed for self-regulated learning of physics content were also made available to the students (Queiruga-Dios, 2016). Figure 4 shows a suggested approach to the learning materials for the subject.

- Practical seminars, in which students carry out activities to explore the content taught in teams of four students. For each of these activities, the teams must submit a report on the work carried out. In addition, open-ended questions are included to relate the scientific content to technological applications and social or environmental impact, requiring students to search for information and use external sources. The aim of these practical classes is to encourage students to learn the content of the subject in a meaningful way and promote the development of scientific skills through investigative processes. The practical seminars were adapted to the students' possibilities, carrying out the investigative procedures using both materials commonly found at home and virtual physics laboratories (PHET, 2020). Each team uploaded the reports corresponding to the activities carried out on the platform. Once they had been reviewed by the teaching staff, they were shared during the virtual classes, carrying out peer co-assessment.

- Design of a Teaching Unit, also in teams, for its application in the Primary Education classroom. This Teaching Unit involves implementation of Physics and Chemistry content in the classroom through investigative activities or problem solving. The students must design their own practical activities based on information found in different sources (books, specialised journals, events, projects, associations, conferences, websites, audiovisual media, companies, teaching material, interactive museums, etc.). The design of this Teaching Unit is carried out in parallel to the development of the course in teams of four students. The experimental part of the Teaching Unit was also adapted to the lockdown situation so that students could use everyday materials and objects as their basis, along with virtual laboratories, thereby enabling them to carry out the experiments at home. Meetings between group members had to be held virtually.

Figure 4

The students have at their disposal a variety of online resources specific to the subject in order to train their SRL through feedback with the teaching staff.



Due to the lack of face-to-face contact, the students were asked to record evidence of their experiments and trials via screenshots, photographs and videos (Figure 5), which were shared with the rest of the teams.

Figure 5

Screenshots of videos made by the students, showing their experiments and trials as part of the investigative activities.

The tutorials were reinforced to address the diversity of the students. These tutorials were mainly conducted in group or individual videoconferences and via email, although other means of communication such as WhatsApp were also used. The aim of this flexibility in the teacher-student communication channels was to be able to respond to possible technological difficulties or personal situations of the students. During some of these tutorials, based on a dialogue with the students the teacher created a simple explanatory video on the spot using a smartphone and then shared it with the rest of the students. During the virtual classes, situations arose that gave rise to the generation of this type of material. In both the tutorials and the virtual teaching interventions, feedback was given to students according to the levels described (Hattie & Gan, 2014).

In regular teaching, students have the possibility of personalised attention in tutorials with the teaching staff, during which they can resolve any doubts or difficulties they may have. Although the planned teaching was entirely face-to-face, the Moodle platform for the course provided materials to expand on the content (in the form of hypermedia), teaching guides, guides for the preparation of Teaching Units and sample written tests. Students were also provided with additional materials of progressive difficulty during the lockdown, which were designed to facilitate their SRL. These materials were in hypermedia and video format.

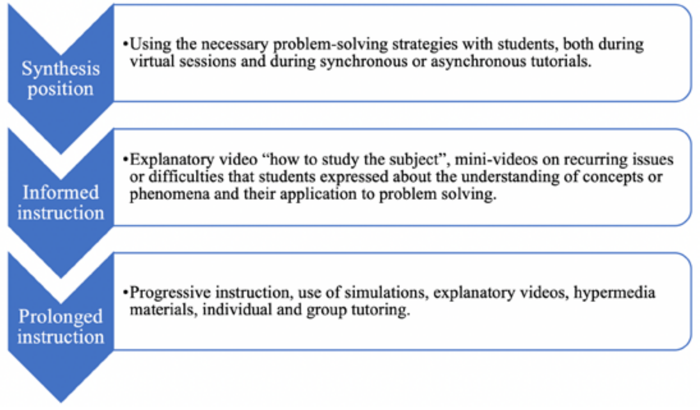
For the evaluation, students had to hand in the reports of the practical seminars (in teams) and the report of the Teaching Unit, as well as presenting and defending it. Finally, they also sat a written test on the content. The same evaluation tests were maintained with adaptations to the lockdown situation as described above. The written test was carried out by means of questionnaires developed on the Moodle platform. The weighting of the evaluation of the different aspects was maintained, which was as follows:

- Written test: 40%
- Report on the Teaching Unit designed, presentation and defence: 50%
- Participation and attendance at practical seminars: 10%

The students' self-regulated training was carried out according to the sequence indicated by Veenman (2011b) as shown in Figure 6. This training began with the teaching of the subject and was developed in each educational intervention until the end of the academic year.

Figure 6

Self-regulated training sequence carried out



This allows us to trace the structure of the learning ecology designed in the context of the subject during the lockdown from the perspective of the learner, taking into account the key components of individual learning ecologies (Jackson, 2013, p. 14), the outline of which can be seen in Figure 2. It should be stressed that these key components are interconnected. For example, many of them were addressed or reinforced at the same time through tutoring: the particular context of the students, through individualised telematic tutoring and the creation of different communication channels (email, Teams, WhatsApp, etc.); will and capability, encouraged through tutoring and individualised tutoring; student-teacher relationships; the self-regulated training process; and also in the resources, given that through this individualised tutoring resources were exchanged and co-generated.

Sample

The study sample consisted of 60 students, 38 females (M_{age}=21.97; SD age=3.45) and 22 males (M_{age}=22.57; SD age=2.78) of the Bachelor's Degree in Primary Education at the University of Burgos, comprising one of the three Seminar groups to which this subject is taught. 22 students completed the questionnaire. The opinion survey was voluntary and was carried out on the basis of a written commitment in the questionnaire itself.

Instruments

A descriptive design was used with application of an analysis of descriptive statistics (mean and standard deviation).

Information-gathering instruments

For the assessment of the learning ecology, the questionnaire on student opinions of the quality of teaching at the University of Burgos was used. Due to the urgency of the situation, no other type of questionnaire specifically designed for this research was used. However, the questionnaire used is adapted from the *Student Evaluation of Educational Quality (SEEQ)- Short version* (Marsh, 1987) and a sample of 5,551 students was used for its validation (Bol et al., 2013). The questionnaire was completed by students on a voluntary and completely anonymous basis (for the protection of personal data) at the end of each course. The aim of the assessment of the teaching activity through this questionnaire is to improve the quality of teaching, increase student satisfaction and foster successful learning outcomes.

The questionnaire consists of 11 questions using a Likert-type scale, with values ranging from 1: *strongly disagree* to 5: *strongly agree*. These questions measure student motivation towards the subject (1), their opinion on the quality of the course materials (2, 5, 8) and the continuous evaluation (6, 7), student perceptions of the teachers' motivation towards the subject (3, 4, 9) and the course workload (10) and their overall satisfaction with the teaching (11). In addition, for the teaching during the lockdown due to COVID-19, an open question regarding the adaptation of teaching to virtual contexts was introduced in the questionnaire: *How do you rate the way face-to-face teaching and evaluation has been adapted to non-face-to-face teaching and evaluation during the special situation due to the COVID-19 pandemic?*

Information analysis tools

For the analysis of the open question of the questionnaire, after reading the information gathered the students' answers were categorised. This categorisation is shown in Table 1. The positive responses related to: (A1) the facilities provided to students to access knowledge on the subject content through the materials generated by the teaching staff and made available to them; (A2) positive assessment of the tutoring process carried out by the teaching staff; (A3) positive assessment of the virtual teaching and the approach to educational interventions; and, finally, positive assessment without further explanation (A4); or negative assessment without further explanation (B). These subcategories may be related to the key components of the learning ecology developed: Student context (A2), Resources (A1, A2 and A3), Will and capability (A2), Processes (A1, A2, A3) and Relationships (A2).

Table 1

Categorisation of students' responses regarding the adaptation of the teaching

Category	Subcategory
A. Positive responses	A1. Accessibility to knowledge through the course resources
	A2. Tutoring and monitoring of students
	A3. Quality of virtual teaching
	A4. Positive (unspecified)
B. Negative responses	B. Negative (unspecified)

Results

Table 2 shows the results of the responses to the questionnaire on the opinion and assessment of the quality of teaching. As indicated, a Likert-type scale was used with values ranging between 1: *strongly disagree* and 5: *strongly agree*.

It can be seen from the results that the scores for most of the items are higher than 4. The following are exceptions: *5. The teaching materials for the subject were useful*, although it is very close to 4 (3.90); *6. The tests and assignments set were useful for my learning* (3.64); and *7. The evaluation procedures were fair and appropriate* (3.52). However, these scores are higher than 3, which represents neutrality, and they may be influenced by the exceptional situation in which the teaching took place.

Meanwhile, the items that received the highest scores were: *3. The teacher shows interest in the students* (4.64); *4. The teacher was accessible during tutoring and after class* (4.62); *8. The teaching materials were well prepared and carefully explained* (4.45); and *9. The teacher encouraged students to participate in class* (4.43).

The results obtained with respect to the open question *'How do you rate the way face-to-face teaching and evaluation has been adapted to non-face-to-face teaching and evaluation during the special situation due to the COVID-19 pandemic?'* after categorising the answers are shown in Table 3. It should be noted that in some of the students' answers their opinion refers to several of the categories defined. For example, one of the answers given was: *Good; he has always explained the topics through online calls and has* *provided us with virtual laboratories so that the investigative methodology contemplated for this subject could be followed normally*.

Table 2

Responses to the questionnaire on assessment of teaching

Question	M	SD
1. The course was interesting	4.00	.76
2. I have used the course teaching materials	4.23	1.02
3. The teacher shows interest in the students	4.64	.58
4. The teacher was accessible during tutoring hours and after class	4.62	.67
5. The teaching materials for the subject were useful	3.90	1.18
6. The tests and assignments set were useful for my learning	3.64	1.00
7. The evaluation procedures were fair and appropriate	3.52	1.03
8. The teaching materials were well prepared and carefully explained	4.45	.80
9. The teacher encouraged students to participate in class	4.43	.81
10. The amount of work required in this subject compared to other subjects with the same number of credits was…	4.27	.88
11. In general, I am satisfied with the teaching	4.32	.72

Note. N=22 participants, M=mean, SD=standard deviation.

Table 3

Results of the responses according to the categorisation made

Subcategory	Result
A1. Accessibility to knowledge through the course resources	9.5%
A2. Tutoring and monitoring of students	47.6%
A3. Quality of virtual teaching	66.7%
A4. Positive (unspecified)	23.8%
B. Negative (unspecified)	9.5%

As can be seen from the results, the most positively valued aspects in the survey refer to the students' satisfaction with the virtual teaching (66.7%) (*…we had online video-conference classes that lasted until absolutely all the students understood everything, and remedial classes to clarify doubts*. *Fantastic experience with this teacher*…) and regarding tutoring (47.6%) *(He has adapted very well, he has always been interested in our learning and very accessible for what we needed*…). It should be mentioned that the negative responses received refer to the students' belief that adaptation of the course is synonymous with a reduction of the workload *(It hasn't been adapted very much*. *It still has the same or an even bigger workload than before*…).

Publicaciones 51(3), 399-420. https://doi.org/10.30827/publicaciones.v51i3.18046
Queiruga, M. A. et al. (2021). Assessment of the virtualised self-regulated…

Discussion and conclusions

In view of the results of all the items, it may be concluded that the SRL methodology, as part of the learning ecology created during the virtual teaching introduced as a result of the lockdown due to the COVID-19 pandemic, has been positively assessed by students who in the future will be Primary Education teachers. In the authors' opinion, this positive assessment should encourage teacher trainers and future teachers to implement similar teaching proposals in their teaching practice.

As indicated above, all the elements of the ecology are interrelated, even though the results obtained have been discussed separately: the educational interventions, the materials created, the networks established, the self-regulated learning methodologies employed, the collaborative activities to be carried out by the students, etc., all form part of the learning ecology designed. To give an example, the positive assessment of the teaching materials is related to how they were used and the tutoring provided, as well as the interest shown by the students in the subject.

Having said this, the students stated that they found the subject interesting, despite the growing disinterest in scientific disciplines throughout students' education as indicated previously, and which increases as the student progresses through the education system (Sáiz-Manzanares et al., 2020; Vázquez-Alonso et al., 2005; Vázquez-Alonso & Manassero, 2008). Although this study does not measure initial interest in the subject, studies of primary school teacher trainees show that they have limited interest in science subjects, particularly physics (Pipitone & García-Lladó, 2020; Pipitone et al., 2019, Vázquez-Dorrío, 2016).

With regard to the students' assessment of the materials used during the course (questions 2, 5, 8), although all the questions had a positive evaluation, the score obtained for question 8 stands out. *The teaching materials were well prepared and carefully explained* (4.45). Considering the nature of the materials developed and their use, this indicates a positive assessment by students of both the different levels of feedback used and the self-regulated training (Veenman, 2011b). The students are accordingly learning physics content and methodologies that they will be able to apply in the future.

The score relating to the students' perception of the workload is high (4.27). This may be due to the added difficulties deriving from the lockdown. Regardless, this result is consistent with other research conducted with university students in face-to-face conditions (Bol et al., 2013; Rodrigo-Alsina & Almiron, 2013). However, it should be noted that the workload is unrelated to the positive or negative assessment of the teacher and the subject. The results of this assessment are related to the students' perception of their learning (Dee, 2007; Remedios & Lieberman, 2008) and the interest in the subject that the teacher has managed to instil in them (Bol et al., 2013). The high score for the perceived workload is, in turn, related to the overall evaluation results (Bol et al., 2013). The questions concerning evaluation (6, 7), although positive, had the lowest scores, but are nevertheless higher than the students' perception of the evaluation in other studies of students of the Bachelor's Degree in Primary Education (Gutiérrez-García et al., 2011). The high scores relating to the perceived workload are presumably related, in this case, to the students' loss of interest in scientific disciplines, which occurs from the early stages of their education and which results in early abandonment of these disciplines (Vázquez-Alonso & Manassero-Mas, 2008). A major effort is required on the part of the students to acquire the level required by the subject.

The students' perception of the teachers' motivation towards the subject (3, 4, 9) was one of the highest scores for the different items, indicating that the monitoring and guidance carried out by the teaching staff was perceived positively by the students. This is in turn related to the different levels of feedback put into practice during the educational interventions in the virtual classes and the telematic tutorials. These results are in line with the answers to the open question on the adaptation of the subject to virtual teaching, for which the students rated the teaching (66.7%) and the tutoring (47.6%) positively.

As can be seen, the teaching methodology used in the subject, within the framework of the self-regulated learning ecology defined, was assessed positively by the students in the different aspects of the questionnaire and they found the subject interesting. Moreover, the students showed a high degree of interest in the subject, a result that is presumably directly linked to the learning ecology developed in view of the general lack of interest in science among students (Sáiz-Manzanares et al., 2020; Pipitone & García-Lladó, 2020; Pipitone et al., 2019; Vázquez-Alonso & Manassero-Mas, 2008).

These concepts should be incorporated in the educational world to ensure that these students, the future trainers of new students, experiment with them and assume responsibility for their own learning processes. This will allow them to expand their repertoire of learning strategies and help them apply these strategies to tasks in a self-regulated manner (Queiruga-Dios, 2016) as part of a learning ecology. It will also enable students to adapt to the changing corpus of knowledge due to the increase in information, communication and connectivity (Siemens, 2007).

Furthermore and as is demonstrated by this study, these learning strategies can and should be taught jointly in each discipline without the need to add extra time (Monereo et al., 2001) as it is a relevant aspect of training, especially so in the context of primary teacher training.

It is increasingly common to offer instruction at university and pre-university level, or at least part of it, through virtual learning environments. This aspect assumes even greater importance in crisis situations such as the current context due to the COVID-19 pandemic. These environments facilitate process-oriented feedback and enhance self-regulated learning, thereby helping to develop metacognitive strategies. Moreover, these techniques, models and methods allow teachers to improve the pedagogical design of courses and reinforce the role of tutorials, resulting in greater personalisation of student learning (Sáiz-Manzanares et al., 2017). In this sense, it is likely that these systems will continue to evolve towards environments with technological enhancements such as voice assistants integrated in learning platforms, as a means of improving teacher-student feedback and promoting self-regulated learning (Ochoa-Orihuel et al., 2020; Sáiz-Manzanares et al., 2020).

As this article has shown, the components of learning ecologies can be oriented to promote more valuable, authentic and satisfying learning by taking advantage of the conditions of available environments and resources and selecting those which are the most favourable for learning (González-Sanmamed et al., 2019).

Implications and limitations

This article describes and assesses the creation of a learning ecology in the Didactics of Natural Sciences I course of the Bachelor's Degree in Primary Education, comprising multiple elements that allow future teachers to draw from a diversity of resources adapted to their situation and context. The tutoring and monitoring of students has also been adapted to take into account the diversity, needs and possibilities of each student. As a result, the role of the teacher has been adapted in accordance with the model proposed by Garrison, Anderson and Archer (2000), with integration of the attributes of social, teaching and cognitive presence in order to provide quality learning (Hernández-Sellés et al., 2015).

The results suggest that the creation of learning ecologies centred on the SRL of the students (with all that this implies in terms of tutoring and attention to individual needs) will enhance their interest in the disciplines, and so their analysis and incorporation in future university education models would be positive. A possible starting point would be the incorporation of these aspects, together with other methodologies, in the training plans of subjects in the Bachelor's Degree in Primary Education and in the continuing education of university teaching staff (González-Sanmamed et al., 2020). This would help future teachers to avoid falling into a vicious circle of reproducing traditional transmission models that are disconnected from reality due to a lack of mastery of the content and its didactics (Pipitone et al., 2019; Vázquez-Dorrío, 2016).

The generalisability of the results should be viewed with caution due to the size of the sample and the absence of a specific questionnaire to obtain information on the assessment of each of the key components. However, the positive response by the students to implementation of the learning ecology is clearly evident. On the other hand, it should be noted that the learning ecology described above was an emergency response to the COVID-19 crisis. Future studies should seek to improve the design of the learning ecology, complementing it with face-to-face teaching, increasing the sample size and increasing the number of subjects and degree courses studied.

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