European Public & Social Innovation Review

ISSN 2529-9824

Research article

Sustainable meaningful learning through the tree of knowledge: a teaching project for Nepal

Aprendizaje significativo sostenible a través del árbol del conocimiento: un proyecto didáctico para Nepal

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Date of Reception: (29-05-2024)

Acceptance Date: (21-08-2024)

Publication Date: (26-08-2024)

How to cite the article (APA 7th):

Pérez de Villarreal, M. (2024). Sustainable meaningful learning through the tree of knowledge: a teaching project for Nepal [Aprendizaje significativo sostenible a través del árbol del conocimiento: un proyecto didáctico para Nepal]. *European Public & Social Innovation Review*, 9, 01-14. https://doi.org/10.31637/epsir-2024-574

Abstract:
Introduction: The climate crisis and social justice are at the focus of UNESCO's 2030 Agenda, which presents 17 SDGs (Sustainable Development Goals) as a roadmap for the preservation of the planet. From the educational field, its achievement can be promoted through the design of educational projects that promote sustainable meaningful learning (SML) hand in hand with learning for social justice (LSJ). In this context, an innovative teaching practice was developed in 2021-22 using biosphere reserves in Nepal, in which students from the International Primary Education Teacher Degree Program designed teaching materials to be offered to nearby primary schools in Nepal, close to the selected biosphere reserve. **Methodology**: The students built knowledge models based on conceptual maps about the selected biosphere reserve, creating teaching units with activities aimed at students in Nepal. A tree of knowledge was also designed that summarized the joint project as a metacognitive tool for sustainable meaningful learning. **Results:** For the evaluation, a double rubric was used that analysed both the oral defence of the project and the different sections of the UD, and personal reflections were analysed, as well as the learning results and motivation. **Discussion:** Sustainable meaningful learning together with learning for social justice and the didactic tools that were used are very valid methodologies to stimulate international cooperation and promote meaningful, autonomous, motivating and sustainable learning.

Keywords: meaningful sustainable learning; knowledge models; natural protected areas; concept maps; primary schools in Nepal; learning for social justice; climate change; education for sustainable development.

Resumen:
Introducción: La crisis climática y la justicia social se encuentran en el foco de la Agenda 2030 de la UNESCO, que presenta 17 ODS (Objetivos de Desarrollo Sostenible) como hoja de ruta para la preservación del planeta. Desde el ámbito educativo se puede favorecer su consecución mediante el diseño de proyectos educativos que fomenten el aprendizaje significativo sostenible (ASS) de la mano del aprendizaje por justicia social (AJS). En este contexto, en 2021-22 se desarrolló una práctica docente innovadora empleando reservas de la biosfera de Nepal, en la que el alumnado del Programa Internacional del Grado de Maestro en Educación Primaria diseñó material didáctico para ofrecérselo a escuelas de primaria de Nepal, cercanas a la reserva de la biosfera seleccionada. **Metodología**: El alumnado construyó modelos de conocimiento basados en mapas conceptuales sobre la reserva de la biosfera seleccionada creando unidades didácticas con actividades dirigidas al alumnado de Nepal. También se diseñó un árbol del conocimiento que resumía el proyecto conjunto como herramienta metacognitiva propia del aprendizaje significativo sostenible. **Resultados:** Para la evaluación, se empleó una rúbrica doble que analizaba tanto la defensa oral del proyecto como los distintos apartados de la UD y se analizaron reflexiones personales, así como los resultados de aprendizaje y la motivación. **Discusión**: Esta metodología y el uso de herramientas metacognitivas permite mantener la motivación del alumnado y realizar un ejercicio de autorregulación, apropiado para su futuro desempeño profesional. **Conclusiones**: El aprendizaje significativo sostenible junto con el aprendizaje por justicia social y las herramientas didácticas que se utilizaron son metodologías muy válidas para estimular la cooperación internacional y fomentar un aprendizaje significativo, autónomo, motivador y sostenible.

Palabras clave: aprendizaje significativo sostenible; modelos de conocimiento; áreas de protección natural; mapas conceptuales; escuelas de primaria en Nepal; aprendizaje por justicia social; cambio climático; educación para el desarrollo sostenible.

1. Introduction

Climate change and social justice are urgent challenges that threaten the equilibrium of humanity, and thus of the planet we inhabit. According to the European Commission (n.d.) climate change affects all regions around the world and its consequences impact many different aspects of our lives, as for example: natural consequences (high temperatures, drought and wildfires, availability of fresh water, floods, sea-level rise and coastal areas, decline of biodiversity, decline in organic matter in soils, salinisation, less predictable rainfall patterns and more intense storms, increase of sea surface temperatures and ocean acidification, among others. The social threats of climate change are related to health (human, animal and plant health), to vulnerable population (low income urban areas with poor infrastructure, unemployed and socially marginalised people…), to employment (productivity and viability of all economic sectors, with labour market implications), and to education. This aspect is really linked to social justice, as education and awareness-raising is an important component of the adaptation process to manage the impacts of climate change, enhance adaptive capacity and reduce overall vulnerability. It is on this point that we will focus as the cornerstone on which the didactic experience presented below will be based.

1.1. The 2030 Agenda for Sustainable Development

The 2030 Agenda for Sustainable Development is a plan of action for people, planet and prosperity (United Nations, 2015) and contains 17 Sustainable Development Goals (SDGs) that are an urgent call for action by all countries and 169 targets which are integrated and indivisible and balance the three dimensions of sustainable development: economic, social and environmental.

This roadmap encourages humanity to focus on the planet by protecting it from degradation, favouring sustainable consumption and production, as well as sustainable management of its natural resources and urgent action on climate change. Among the 17 SDGs, this article specifically builds on 4 (Quality education by ensuring inclusive and equitable education and promoting lifelong learning opportunities for all), 13 (Climate action by taking urgent action to combat climate change and its impacts) and 10 (Reduce inequality in and between countries) and 16 (Promote peaceful and inclusive societies for sustainable development, facilitate access to justice for all and build effective, accountable and inclusive institutions at all levels).

1.1.1. Man and the Biosphere Programme (MAB)

The Man and the Biosphere (MAB) programme (UNESCO, n.d.) is an intergovernmental scientific programme that aims to establish a scientific basis for enhancing the relationship between people and their environments by combining the natural and social sciences with a view to improving human livelihoods and safeguarding natural and managed ecosystems.

Its World Network of Biosphere Reserves is a dynamic and interactive network of sites of excellence that foster harmony between people and nature for sustainable development through participatory dialogue; knowledge sharing; poverty reduction and human well-being improvements; respect for cultural values and society's ability to cope with change.

1.1.2. Biosphere Reserves

Biosphere reserves are learning places for sustainable development (UNESCO, n.d.). They are sites for testing interdisciplinary approaches to understanding and managing changes and interactions between social and ecological systems, including conflict prevention and management of biodiversity. They are places that provide local solutions to global challenges, going from the micro to solve the macro. They include terrestrial, marine and coastal ecosystems. Each site promotes solutions reconciling the conservation of biodiversity with its sustainable use. Each Biosphere Reserve comprises 3 areas: core areas (strictly protected zone that contribute to the conservation of landscapes, ecosystems, species and genetic variation); buffer zones (which surround core areas and are used for activiteis that reinforce scientific research, monitoring, training and education); transition area (where communities foster socio-culturally and ecologically sustainable economic and human activities). In this article we will focus in the buffer zone of the biosphere reserve where education has its place. Surrounding Nepal there are 3 biosphere reserves: Nanda Devi in India, Womolangma in China, Khangchendzonga in India. However, there are not any biosphere reserves within the country, so, in order to perform the activity, the teacher provided the possibility of selecting natural protected areas in Nepal.

1.2. The principles of meaningful learning and meaningful sustainable learning

The current educational landscape is faced with a great diversity of teaching styles, methodologies and ICT. Whereas in previous decades, behaviourist and traditional models

predominated, nowadays cognitive-constructivist models are advocated (Khun, 1962; Kaiser, 2020; González, 2007). Within the constructivist model, and in the line of social constructivism, meaningful learning covers a very relevant place and it is supported by different educational theorists who contribute with complementary ideas. According to Gowin (1981), learning occurs when the meaning of the didactic material internalised by the student is the same as the meaning that the teacher intended it to have for the student. He considered that there was a triadic interaction in the learning process: teacher-student-learning material and designed a heuristic and metacognitive tool, called the **Vee diagram**, to represent theoretical and practical knowledge following the steps of scientific methodology. Ausubel (2000) considered that meaningful learning could be acquired through representations, employing concepts through a conceptual base and using propositions which in turn could be subordinate, superordinate or combinatorial. Following this approach, Novak and Gowin (1984) pointed out that there is a great potential for learning in human beings that remains undeveloped and that many educational practices hinder the expression of this potential. For Novak (1998), meaningful learning occurs when five elements interact: learner, teacher, knowledge, context and assessment. When they interact they produce educational events in which thoughts, feelings and actions shape meaningful learning that leads to human enrichment. He created concept maps as a bidimensional way of representing knowledge in a hierarchical way, by placing most general or inclusive concepts at the top, and the most specific ones at the end, and associated all concepts with linking words which could be conjugated verbs, adverbs and prepositions. The final goal, was to create propositions (semantic units) with a whole sense that configurated sentences and allowed to state principles. Concept maps are very powerful metacognitive tools that can be used in different ways: diagnosis of knowledge, evaluation, design of projects...

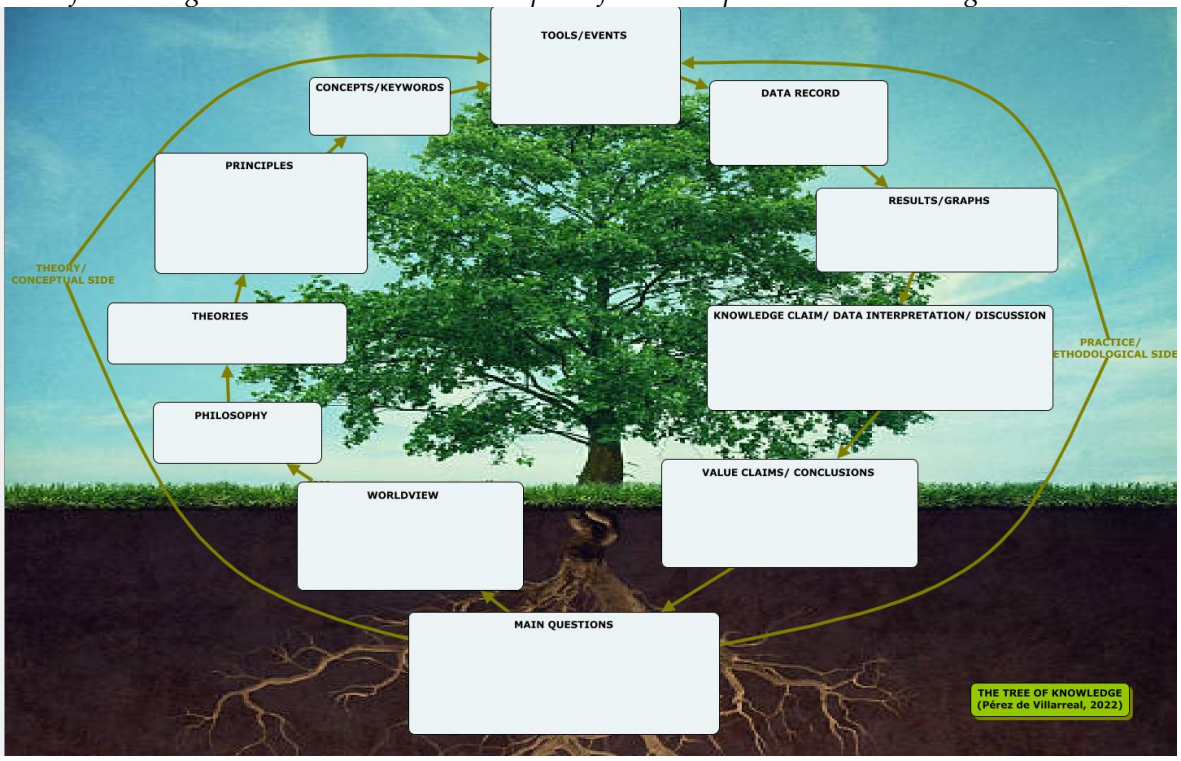
Meaningful sustainable learning (Pérez de Villarreal, 2022) refers, on the one hand, to its significance and, on the other, to its capacity to be prolonged over time by using education for sustainable development as a transversal axis on which the rest of the educational subjects are based. To this end, the Science-Technology-Society-Environment (STSE) perspective considers 3 approaches: humanistic, axiological and environmental.

1.2.1. The tree of knowledge

Metacognition is often referrred to as "thinking about thinking" and this is a crucial cognitive skill. It involves understanding how we learn, the strategies we use to learn and our on awareness on learning processes. It encourages students to become mindful of their leaning process and by fostering these skills students become protagonists of their learning and can monitor their progress, set goals, and adopt strategies to overcome them. In this frame, a metacognitive tool was designed following the structure of the Vee diagram (Gowin, 1981):

Figure 1.

Tree of knowledge with the elements that are part of the conceptual and methodological domains.



Source*: Own elaboration.*

The choice of the tree for its representation has not been random, but rather we wanted to collect an indispensable element of nature, which provides us with oxygen, thanks to which living beings can live, hence its capital importance. This tree of knowledge at its roots would present the central questions (like mineral salts) that guide the research or project and receive information from the environment through the roots. The left part of the tree would be the conceptual or thinking part and the right, the methodological or doing part (Pérez de Villarreal, 2022). The lowest twigs would correspond to the worldview or general vision of the world regarding the topic to be discussed. The next highest branches would be those of philosophy, then theories. Going up the tree, the following branches would correspond to the principles and finally the concepts or key words that define the topic to be discussed or studied or investigated. At the top of the tree are the instruments necessary to answer the central questions, and the events or objects to observe. The right part would begin with the highest branches, which would correspond to the data recording. Later and descending, we would find the results. Next, in the middle branches, we would find the interpretation of the data and finally the conclusions, which must evaluate the work and provide its pragmatic value. The knowledge represented in the tree is cyclical, like the cycles of nature, and on the left side it is ascending (such as abstraction and inductive thinking) and in the right part is descending (like concretion and deductive thinking), with which there is a clear allusion to the scientific method.

However, the tree needs, in addition to mineral salts, water and sun, which would represent the well-being of the students in the classroom, which would include emotional education, granting a more holistic and systemic vision.

Another aspect to consider is the dynamism of knowledge represented by the cycle of nature and by the passage of the seasons of the year. In spring there may be flowers on the tree; In

summer, the tree generates small fruits, which when they ripen in autumn fall. These fruits can be used as food for the students, as if they contained the seeds of knowledge. Finally, in winter, the leaves of the tree would fall (being deciduous) and it would be the time for resting and for the maturation of knowledge (already eaten) that would be consolidated as significant learning in the cognitive structure of the students.

1.3 Knowledge modeling

In 2004, Cañas et al., showed how the free software Cmap Tools (IHMC, Florida), which can be downloaded at the following link (https://cmap.ihmc.us), allowed knowledge to be modeled through the design of concept maps, subordinated to each other, generating dimensions of more general and/or more specific knowledge, allowing, in turn, to share virtual environments through the design of interconnected conceptual maps. They provided a powerful tool to work both individually and collaboratively that allowed knowledge to be represented through the use of conceptual maps and shared with peers and colleagues, favoring epistemic and conceptual discussions. This procedure is accessible and free for non-profit educational organizations and public servants have been established to promote the exchange of knowledge. Regarding our institution (Public University of Navarra/UPNA), the server can be accessed through the following link: cmap.unavarra.es. This knowledge modeling strategy has been developed in a group of future teachers (primary teachers in training) by developing a joint project that seeks to promote ecological awareness through the use of natural protected areas in Nepal.

2. Objectives

The general objectives of the project were:

- Through knowledge modeling, jointly develop a project of teaching units that deal with natural protection zones or biosphere reserves in Nepal.

- Promote sustainable meaningful learning and convey the content for future didactic transposition in primary schools in Nepal close to the selected areas.

- Use biosphere reserves or natural protection zones as a theme for the development of sustainable education.

- Share teaching material for use by other teachers in primary schools in Nepal, close to protected natural areas and thus promote sustainability.

For this last purpose, each group had to decide whether or not they wanted to share their own teaching material with other teachers and student teachers. To do this, all the members of each group had to sign a form provided by the teacher in which they agreed. The requirement was that if only one of the members did not agree, this material could not be shared.
The specific objectives were:

- Acquire basic, general and specific skills in the subject "Teaching the natural sciences" in the 2nd year of the International Program for the Degree of Teacher in Primary Education.

- Create a knowledge model related to a biosphere reserve or natural protection area in Nepal.

- Develop interpersonal and personal leadership skills.
- Develop communication skills in the oral defense of the project.
- Analyze the effect of this methodology on the learning results of the students.

3. Methodology

The educational experience presented in this article was developed with 45 students (distributed into 10 medium groups) of the International Primary Education Teacher Degree Program at the Public University of Navarre in the year 2021-2022, within the framework of the subject of 2nd year "Teaching the natural sciences".

The brief provided was to develop a joint project of knowledge models based on didactic units (UD) on biosphere reserves or natural protection zones of Nepal, using the methodology of knowledge modeling and sustainable meaningful learning. Each group had to choose the natural protection area in Nepal or its surroundings and develop the corresponding teaching unit. Finally, they had to create a joint tree of knowledge, which summarized the project carried out by the students.

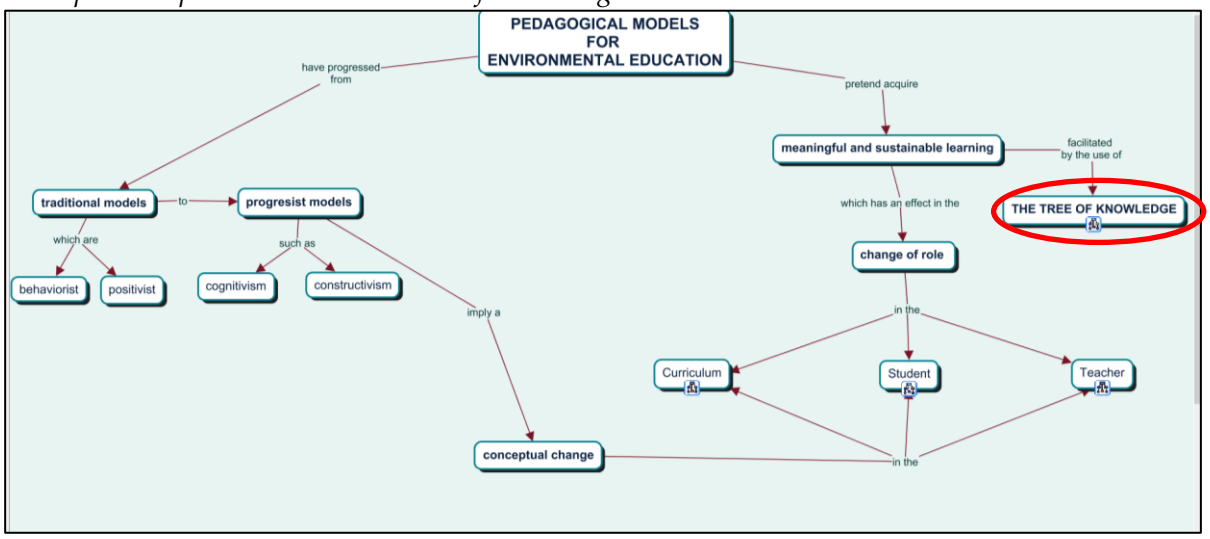
The teaching-learning process lasted 8 sessions in total, 2 hours each. Previously, over two sessions, the students learned to create concept maps (CM) from a simple natural science text that dealt with the country (Nepal) and its landscapes, customs, ethnicities... In the first session, the teacher explained what the tree of knowledge consisted of so that the students could develop it later, since it is a metacognitive tool that accompanies the process but is fully defined at the end of the project. She showed them the website of the global network of biosphere reserves and showed them Nepal. When inquiring about the reserves, they observed that there were none in the country itself, although there were some in its surroundings, so they decided to choose natural protection areas. In the second session, the teacher explained what knowledge modeling consisted of and showed them examples from other years prepared by other students. Subsequently, in the third session, they downloaded the free software Cmap Tools and learned to use. From the fourth session and with the instructions on the design of the knowledge models, each group began to develop a Teaching Unit (TU) on the natural protection area of Nepal chosen to be able to offer it to schools in the nearby. First, they developed the context, schedule, and general and specific objectives. Then, they continued with the most creative part of designing learning situations developing the sequencing of the activities (introductory, development and final or evaluation). They developed the methodology section, which could include specific strategies in some activity, and finally they developed the evaluation section. They were ordered to record microvideos of each activity in English to promote the understanding of teachers in Nepal and thus internationalize their work. For the evaluation of the project, a double rubric was used that analyzed, on the one hand, the oral defense of the project and, on the other, the TU sections required in the subject. The personal reflection on the learning process carried out by each group was also analyzed. The attendance and motivation of the students was considered, as well as the learning results achieved.

4. Results

This section will present the joint project carried out by the students that includes the tree of specific knowledge about the Nepal project. All the concept maps created can be displayed using the username and password: espir.

Figure 2.

Conceptual map that includes the Tree of Knowledge.

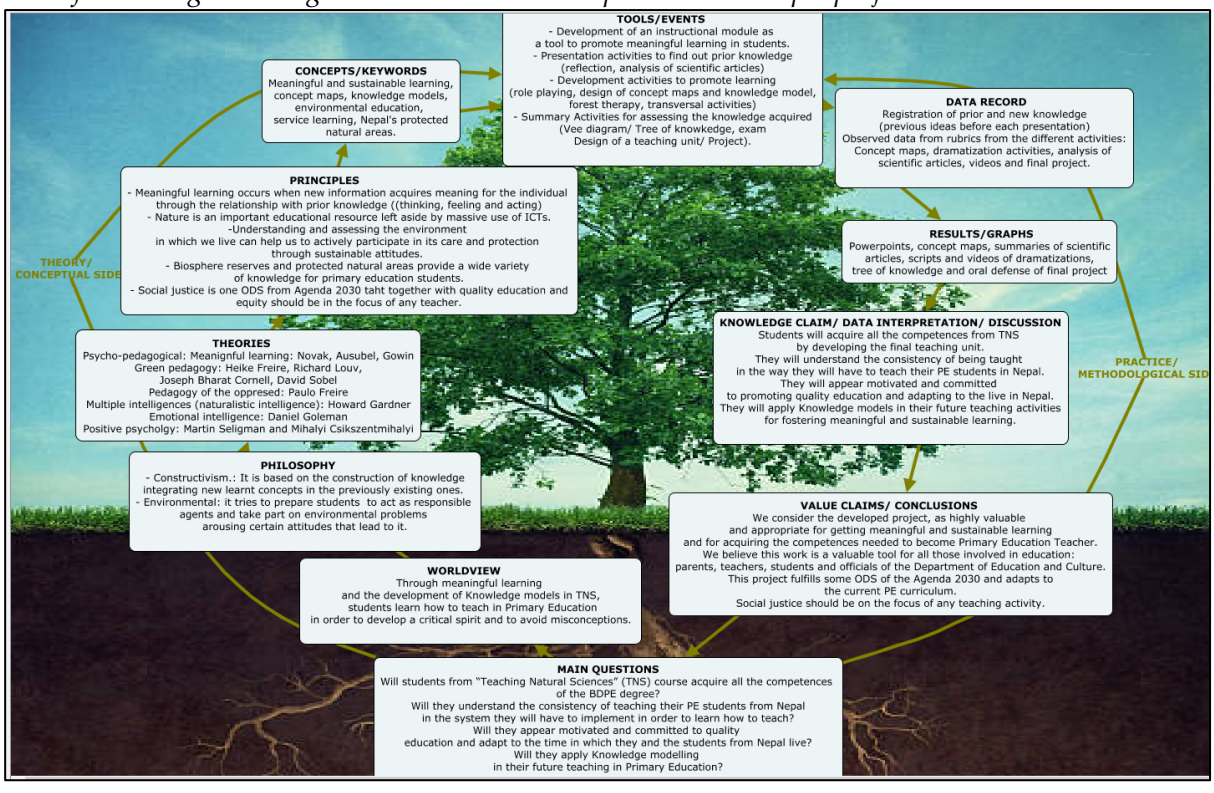


Source: Own elaboration. Accessible at: https://bit.ly/3VXMVdI

By clicking on the Tree of Knowledge, the joint tree that the students created at the end of the project is displayed, which shows all the elements of the conceptual and methodological part found in the scientific method.

Figure 3.

Tree of knowledge showing all the elements contemplated in the Nepal project.

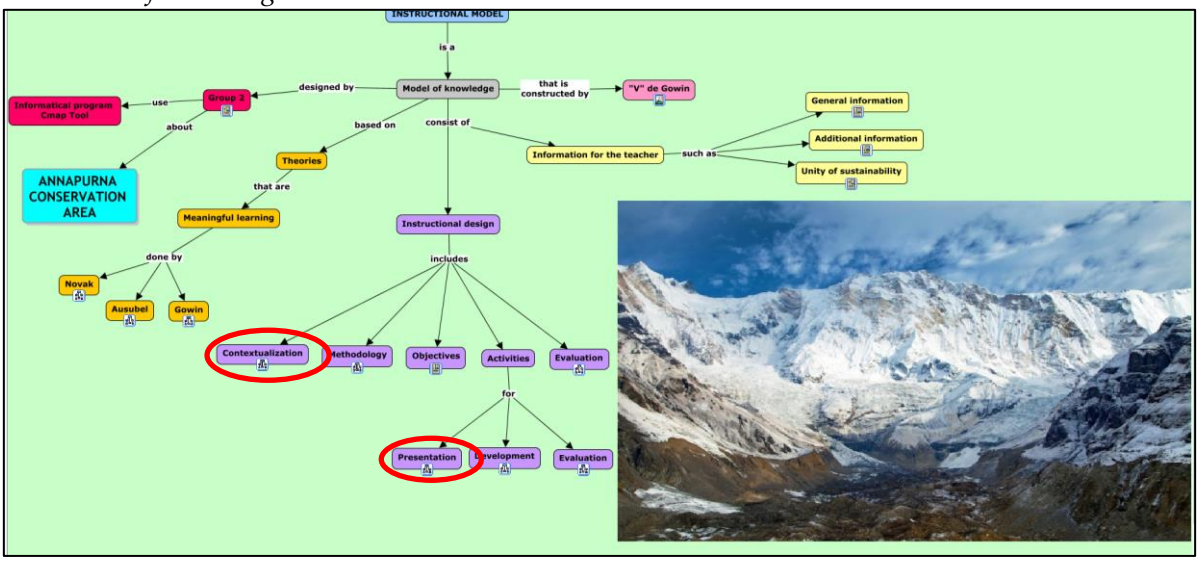


Source: Own elaboration. Accessible at: https://bit.ly/4buYspG

Below we show the knowledge model of a teaching unit of a natural protection area in Nepal developed by group 2 that corresponds to the Annapurna Conservation Area.

Figure 4.

Knowledge model developed by group 2, in which all the elements of the UD developed by the students can be seen. When you display any icon on the map, another resource appears, forming several dimensions of knowledge.

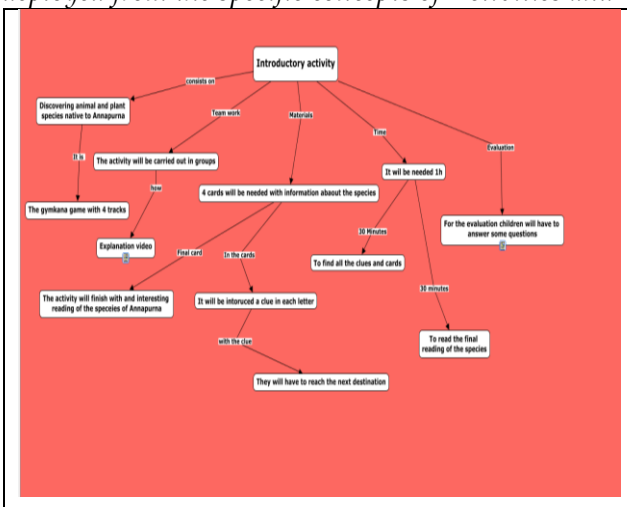


Source: Own elaboration. Accessible at: https://bit.ly/3VXWz02

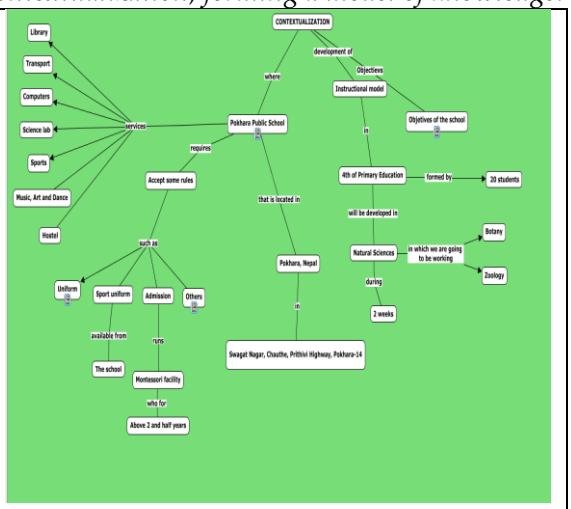
When each icon is displayed, the teaching material prepared by the students appears, such as, for example, in Activities (left) and the contextualization with the chosen school, Pokhara Public School in Nepal (right):

Figure 5.

Prepared materials and resources contributed by the students of group 2 in their project, which are deployed from the specific concepts of Activities and Contextualization, forming a model of knowledge.



Accesible at: https://bit.ly/45Q86C0



Accesible at: https://bit.ly/4ckjAjB

Source: Own elaboration.

For the evaluation of the project, a double rubric was developed (oral presentation of the project and complete work with the TU's own elements) (Pérez de Villarreal, 2022). Of the 10 groups analyzed, the grades were 60% A, 40% B and 10% C in the final project. The average grade of the subject was 4,9% outstanding (A level), 24,9% B (minus level), 58,5% B (plus level) and 12,2% (C level). It is noteworthy that the learning results have been superior to other subjects in the course and group. Student attendance was also higher than in other subjects in the course and in the group, with an average of 45.7% in the final sessions of the project, which normally show a sharp drop as they coincide with exams and the handing in of assignments in other subjects. This leads us to believe that the students have developed the project with quite high motivation.

The groups made personal reflections, some of which have been very profound and denote a high exercise of metacognition and self-regulation in learning as it is shown below:

"The development of this instructional design has been very useful for us to apply everything we have learned in relation to the subject Teaching the Natural Sciences while we have expanded our knowledge and enriched our learning about the biosphere from the Annapurna Conservation Area (Nepal) and Bardenas Reales de Navarra.
Therefore, we consider it necessary to make students aware of the importance of taking care of the planet for the well-being of living beings, being aware of the crucial role that each person plays in the conservation of the biosphere. It should also be stressed that it is very important for pupils to get to know their immediate environment, being aware of its characteristics, possibilities and benefits. This clearly explains why the first activity is based on a school trip to Annapurna. Moreover, outdoor field experiences are considered one of the most enriching and meaningful activities for children's potential development (Patrick, & Moseley, 2017). *We also want to highlight the importance of getting to know other places and environments in the world, not just our own. Thus, we want our pupils to be aware of the enriching diversity of fauna and flora in other places on the planet and what better than to get to know the nearby natural environment (Bardenas Reales de Navarra). In this way, the children will get to know the biosphere of this particular place, encouraging their research skills and, at the same time, increasing their curiosity and motivation. Moreover, they will be able to compare this flora and fauna with that of their immediate surroundings, becoming interested in discovering more and more.*
On the other hand, regarding the methodologies of these didactic activities, we would like to point out the relevance of using innovative, active and participative methodologies, with the pupils being the main protagonists. Therefore, most of the tasks are based on cooperative work through which pupils will develop different values such as empathy, respect and the desire to help, as well as social and communication skills, which are also important for their future. In general, it is considered that students develop and improve transferable skills such as negotiation, leadership, teamwork, reflection through the practical application of this methodology, cooperative learning. In addition to this, some studies show improvements in classroom atmosphere and social interactions among students thanks to it (Larraz, Vázquez, & Liesa, 2017). *Moreover, all these activities try to foster motivation and participation while using different types of resources (ICT, magazines, concept maps, books, etc.). In relation to assessment, we would like to comment that we give special importance to the active participation of learners in assessment. Thus, various types of assessment (co-assessment, self-assessment, etc.) in which students play an important role are carried out depending on the activity and its objectives. Specifically, self-assessment refers to the assessment and judgement of learners on their own work, with the main aim of improving the quality of their work.*
Self-assessment is a potentially powerful technique because of its impact on student performance through improved self-efficacy and increased intrinsic motivation. The evidence for the positive effect of self-assessment on student performance is particularly convincing for difficult tasks (Rolheiser, & Ross, 2001, p. 1). *In conclusion, and in relation to the subject of Didactics of Natural Sciences, we would like to say that, as we have previously mentioned, we have tried to apply all the knowledge we have acquired during this semester to create a Didactic Unit for our future Natural Sciences students.*

In this sense, we consider really useful all the practical work (creation of concept maps using CMap Tools, pedagogical models, Natural Sciences contents in the curriculum, etc.) that we have done during the course, as they have helped our learning to take shape progressively and to be applied and reflected through this didactic module". (Reflection of group 8).

4. Discussion

The Knowledge Modelling methodology is a very powerful and visual tool that can be applied in education, but also in other fields. It can be very useful for future teachers as it allows them to collaboratively create their own didactic materials (co-creating a network of knowledge concepts and designing sequenced didactic activities) in a meaningful way, adding any kind of resources to complement them and avoiding misconceptions, as it allows them to build their own knowledge in a non-arbitrary way.

Selecting the topic "Biosphere Reserves or natural protected areas in Nepal" within the subject "Teaching the natural sciences" allows students to focus on realistic ecosystems of the natural environment that connects them with their emotions and motivation for a wider purpose: in this case, to provide teaching material to primary schools close to the chosen natural area in Nepal. This provides them the possibility of inquire about the country, its landscapes, its animals and plants, its ethnicities, customs, culture and historic and natural heritage.

Furthermore, this form of sustainable meaningful learning supports social justice learning and fosters intra- and interpersonal skills in the students (trainee teachers).

The usefulness of this methodology should be analysed from two perspectives. First from the perspective of the trainee teacher, as it represents the development of their knowledge to be passed on to their primary school pupils. In this case, students are confused at the beginning as they are not used to this type of teaching-learning. However, throughout the process, when they start to see the effects of their own creation, their attitude changes and they end up very enthusiastic about the project and the final result. After the evaluation, it is shown that they acquire all the competences of the subject to become primary school teachers. Secondly, the aim is to generate meaningful teaching material for primary school pupils (future pupils of teacher degree students), and there is a limitation, since this second part cannot be demonstrated because there is no continuation of the subject. Ideally, the teaching projects should be implemented in the given context and be the results analysed.

As for the teaching material, it is free for any interested teacher and can be used to democratise the school through service-learning experiences, to foster a network between the university and the school for real feedback between teachers and independent students and to promote true sustainability. Sustainable and social justice education are essential to promote environmental awareness and guide humanity towards a new social, productive and economic system, to try to achieve the SDGs of the 2030 Agenda.

5. Conclusions

The conclusions obtained show that meaningful sustainable learning together with social justice learning and the didactic tools that were used are very valid methodologies to stimulate international cooperation and foster meaningful, autonomous, motivating and sustainable learning in students who are going to become primary education teachers.

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