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Belief system of future teachers on Education for Sustainable Development in math classes

Sistema de creencias de los futuros maestros sobre Educación para el Desarrollo Sostenible en la clase de matemática

Sistema de crenças dos futuros professores sobre a Educação para o Desenvolvimento Sustentável na aula de matemática

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Abstract

This paper studied the belief system of future Chilean teachers of Early Childhood Education and Primary Education regarding their competencies to incorporate Education for Sustainable Development (EDS) in the classroom, specifically, in math classes. To this end, a survey was applied to 87 Primary Education preservice teachers and 58 Early Childhood Education preservice teachers, which was analyzed from an interpretative approach. Results are not clear regarding ESD and its scope, despite being valued. In addition, there is a clear need for training in this regard and the potential of mathematical education as a tool to incorporate ESD into the school classroom. It is concluded that ESD-related competencies need to be incorporated in initial and permanent teacher training programs in a transversal way, in our case for Mathematics Education.

Keywords: belief system; education for sustainable development; teacher training; math teaching; mathematics education, UNESCO; preservice teachers; prospective teachers



Resumen

En este estudio se indaga en el sistema de creencias de futuros profesores chilenos de educación infantil y de educación primaria respecto de sus competencias para incorporar la Educación para el Desarrollo Sostenible (EDS) en el aula escolar, específicamente, en la clase de matemáticas. Para ello, se aplicó una encuesta a 87 posibles docentes de educación primaria y 58 futuros maestros de educación infantil, la cual se analizó desde un enfoque interpretativo. Los resultados evidencian poca claridad respecto de la EDS y su alcance, pese a ser valorada. Asimismo, se muestra una determinada necesidad de formación al respecto y el potencial de la educación matemática como herramienta para incorporar la EDS en el aula escolar. Se concluye que es importante incorporar competencias vinculadas a la EDS en los programas de formación inicial y permanente del profesorado de manera transversal, en nuestro caso, desde la educación matemática.

Palabras clave: sistema de creencias; educación para el desarrollo sostenible; formación del profesorado; enseñanza de las matemáticas; educación matemática; UNESCO; futuros maestros

Resumo

Neste estudo se indaga o sistema de crenças de futuros professores chilenos de Educação Infantil e Ensino Fundamental em relação às suas competências para incorporar a Educação para o Desenvolvimento Sustentável (EDS) na sala de aula escolar, especificamente na aula de matemática. Para isso, foi aplicada uma enquete a 87 futuros professores do Ensino Fundamental e 58 futuros professores do Ensino Infantil, analisada desde um enfoque interpretativo. Os resultados evidenciaram pouca clareza em relação à EDS e seu alcance, apesar de ser valorizada. Da mesma forma, há uma clara necessidade de formação a esse respeito e o potencial do ensino da matemática como ferramenta para incorporar a EDS na sala de aula. Conclui-se que é necessário incorporar competências vinculadas à EDS nos programas de formação inicial e permanente de professores de forma transversal, no ensino de matemática, em nosso caso.

Palavras-chaves: sistema de crenças; educação para o desenvolvimento sustentável; formação de professores; ensino de matemática; educação matemática; UNESCO; futuros professores.

Introduction

We live in a globalized world characterized by an environmental, economic and social crisis, which generates a real ‘planetary emergency’ (Bybee, 1991) and which requires a new way of dealing with 21st century education through new skills, attitudes and behaviours that promote more sustainable societies (UNESCO, 2018). This fact forces not only the need for literate citizens on sustainability issues (Wals, 2015), but also a challenge for teachers, especially when considering that the latest UNESCO report (2018) shows that:

Countries refer to an insufficient level of support for teacher training on the guiding principles regarding the context of both, teacher training programs prior to teaching experience and those taught once such experience has begun. (p. 9)

From this point of view, UNESCO (2015) establishes as a priority, for the following years, that teacher training should be according to the guiding principles of Education for Sustainable Development (ESD); and thus ensure that all students acquire the necessary theoretical and practical knowledge to promote sustainable development.



Chile is no stranger to this challenge and since 2015, as a member State of the United Nations (UN), has adhered to the 2030 agenda for sustainable development. Currently, according to the diagnostic report and implementation of this agenda in Chile (Mideso, 2017), significant achievements are evident in most of the proposed objectives. In fact, the incorporation of learning skills associated to education for sustainable development, throughout the school year in subjects such as Natural Science, History, Geography and Social Sciences can be observed. However, this diagnostic suggests that there is still progress to be made in the incorporation of ESD at all levels and in a cross-cutting, integrated manner across the curriculum.

In this context, it is urgent to direct efforts towards professional development opportunities in the field of teacher training that allow the inclusion of sustainability through different school disciplines and at different educational stages (UNESCO, 2014; Vilches and Gil, 2012), since teachers are ultimately responsible for leading the process of integrating sustainability into the classroom, and enabling their students to develop the key competencies necessary to promote sustainable development (Calero *et al.*, 2019).

From this research perspective, this study investigated the belief system of future Chilean teachers of Early Childhood and Primary Education regarding their competencies to incorporate ESD in the school classroom, specifically, in the maths class.

Theoretical background

Research agendas in mathematical education that theoretically support the analysis are: future teachers' beliefs and teacher training, focusing specifically on ESD.

Belief system of future teachers

The affective domain is a mathematical education research field increasingly prolific and, therefore, constantly evolving. Ever since Mcleod (1992) distinguished three different constructs within the affective domain (emotions, attitudes and beliefs), its conceptualization has been redefined. Debellis y Goldin (1999) proposed values as a fourth construct, but it is from the creation of the work group on affects in 2003, within the framework of the third Congress of the European Society for Research in mathematical Education (CERME3), that a general framework for affective constructs in mathematical education research started to be established (Hannula *et al.*, 2007).

Concerning beliefs, being the construct of the affective domain in which this work focuses; we assume the view of Gómez-Chacón *et al.* (2006) according to which a belief is never held independently of others, reason why we usually speak of belief systems and not of isolated beliefs; it is not a sum of juxtaposition of these, but an organized network (López, 2010). In the Spanish report of TEDS-M 2008 (Ministry of Education, Culture and Sports, 2012) it is stated that:

In mathematical education, beliefs are subjective knowledge, personal convictions generated by each individual to explain and justify many of their decisions and actions in the teaching and learning of mathematics. They are part of knowledge, belong to the cognitive domain and show simple ways of thinking, integrate affective, evaluative and social elements, and have strong stability. A belief is never held independently of others, so it is usual to speak of belief systems and not just isolated beliefs. (p. 99)



McLeod (1992) established 4 axes in relation to beliefs: a) beliefs about the nature of mathematics and its learning; b) beliefs about oneself as a math learner; c) beliefs about the teaching of mathematics; d) and beliefs aroused by the social context. Later studies such as Caballero's *et al.* (2008) have redefined these different dimensions. From this perspective, we assume that the study of beliefs in mathematical education includes four dimensions: beliefs about mathematics; beliefs about oneself; beliefs about class functioning; and beliefs about the social context. In relation to the objectives of our study, we focus on the analysis of students' beliefs about themselves, and more specifically on their perceptions regarding their competencies to incorporate ESD into the school classroom. In this sense, Di Martino and Zan (2010) present a model that considers 3 interconnected dimensions: the emotional disposition towards mathematics; and the vision of mathematics and perceived mathematical competence. In this model, the dimension about perceived competence is reduced to high/low dichotomy and the authors conclude that "the reflection about the teacher's role in students' attitude towards mathematics leads to the need to reflect with future teachers about their vision

of mathematics and their own success theories (Di martino and Zan, 2010, p. 46).

Education for sustainable development and teacher training

The concepts of sustainability and sustainable development are relatively recent and appeared for the first time in the 80s, under the idea of generating a collective responsibility that allows us to handle the problems and challenges that humanity faces and that seriously threaten our future (Orr, 2013). In fact, in the Brundtland report of the World Commission on Environment and Development (CMMAD, 1987) we can see a first attempt to coin this concept from the perspective that "it is development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs" (CMMAD, 1987, p. 24). Since then, progress has been made in this area and this concept has been refined, understood today as a crucial challenge that must promote practical actions so that everyone around the world can build a better future together, which will end poverty, inequalities, achieve peace and justice, protect human rights and protect the planet (UNESCO, 2015). In this sense,

three major dimensions of action in this field are recognized from the UN: economic, social and environmental, from which the 17 Sustainable Development Goals (SDGs) (UNESCO, 2017) that address a wide variety of themes are suggested (Figure 1):



Figure 1. Sustainable development goals, UNESCO (2017).



Aligned with UNESCO, to achieve these objectives it is necessary to have a holistic, inclusive and transformative education that considers: a) contents and learning outcomes; b) pedagogy and learning environments; c) learning results; and d) social transformation. In short, it is a challenge that requires an evolution from teaching to learning to educate current and future generations in sustainability, with the purpose of “developing skills that allow people to reflect on their own actions, taking into account their current and future social, cultural, economic and environmental impacts, from a local and global perspective” (UNESCO, 2017, p. 7). In this way, it is expected that through ESD current and future generations can achieve specific, cognitive, socio-emotional and behavioral learning, and, above all, develop key sustainability competencies, required to contribute to the understanding and achievement of each of the particular challenges of the SDGs (Rieckmann, 2012). This brings along the necessity to generate instances of professional growth for teachers that allow them to incorporate key sustainability competencies (UNESCO, 2017) and approaches to consider when designing and implementing teaching processes based on sustainability, which according to UNESCO (2014) must foster : a comprehensive, contextual, critical and transformative education. On the other hand, several researches indicate that some of the most successful didactic strategies for training processes are those that have considered: 1) address ESD from an interdisciplinary view, 2) work with project-based learning methodology and 3) solve problematic situations in collaborative environments (Fuertes-Camacho *et al.*, 2019). In addition, as stated previously, a significant number of teachers could be perceived as incompetent for ESD, therefore, it

is essential to explore (prior to training processes) the knowledge and skills to develop ESD from the disciplines they teach (Uitto and Saloranta, 2017).

Currently and in line with the above, Alsina and Calabuig (2019) and Alsina and Mulà (2019) have assumed the idea of responding to ESD during initial teacher training of math teachers beginning with greening curriculum/subjects, which follow the guidelines of several international organizations such as the Copernicus-Alliance network or the Curriculum Greening of Higher Education network (ACES, acronym in Spanish), which has made multiple contributions since its creation in 2002 for the incorporation of sustainability as a cross-curricular competence (Junyent *et al.*, 2003). Based on these references, Alsina and Calabuig (2019) from an exploratory study with 30 informants (10 teacher trainers, 10 current teachers and 10 future teachers), characterize an initial training model of math teachers in connection with sustainability that, at first, considers the following 5 dimensions: 1) links with the setting, to understand the role that mathematical education can play as an agent of change, both social and cultural; 2) didactic-disciplinary knowledge, to establish a good relationship with mathematics on the basis of the specific nature of the discipline, that understands the depth, what knowledge to teach and how to teach it; 3) reflective and critical thinking, to look for solutions and to evaluate them, thus entering a self-regulating dimension; 4) children's needs, to build their own teaching profile that allows them to focus on the real needs of the children; 5) greening based curriculum, in order to be able to train from a curriculum based on sustainable development criteria



that allows, for example, to learn how to select the skills and knowledge from the curriculum with a sustainability perspective (Dahl, 2019). From these data, Alsina and Mulà (2019) characterize the elements of teacher trainers' teaching practice that contribute to future mathematics teachers to carry out deconstruction, co-construction and reconstruction processes of their teaching profile, so as to move towards defining a transformative model of the professional competence of future math teachers that includes ESD. Figure 2 reproduces this model.

Figure 2 shows, in the first place, that one of the main purposes is to progressively transform futures teachers' knowledge, experiences and previous beliefs into competences that contribute to their professional development. A second issue that is essential to keep in mind is that, knowledge is transformed into several phases that must necessarily be

developed symmetrically by the two agents involved: future teachers and teacher trainers. This is a matter of great importance, because if both agents are not synchronized, it is very difficult to achieve the transformation of future teachers' belief system.

Methodology

In order to enquire into the belief system about ESD of future Early Childhood and Primary School teachers, and the way in which they see math education as a tool to incorporate into the school classroom, a qualitative methodology of interpretative approach was chosen (Vollstedt, 2015).

Participants

Eighty seven future Primary School teachers and 58 future Early Childhood

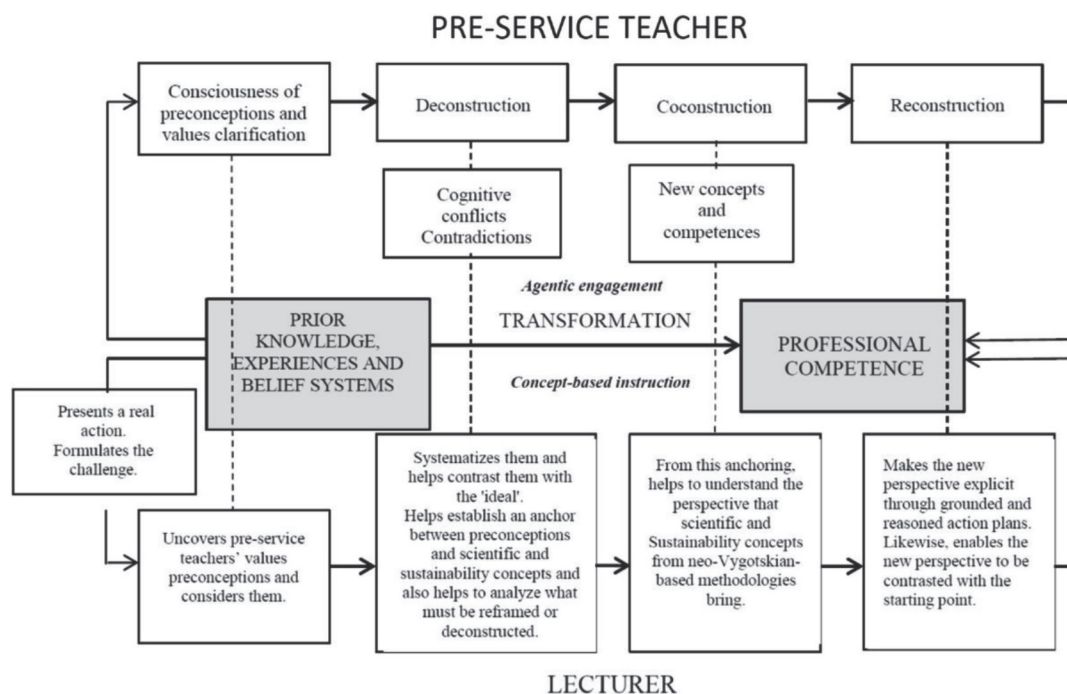


Figura 2. Elements for the transformation of prior knowledge, experiences, and belief systems into professional competence in teacher education, Alsina y Mulà (2019, p. 4039).



teachers, from a Chilean university, voluntarily participated in this study.

Instrument

To enquire into the ESD belief system of future Early Childhood and Primary school teachers, a questionnaire which considered the following 4 open-ended questions was used (Table 1). We consider that the use of these questions “allow respondents to give answers using their own words” (Fink, 2003, p. 35).

Table 1
Questionnaire characterisation

Questions
(Q1) What do you understand by education for sustainable development?
(Q2) As future teacher, do you feel prepared (with the competencies and knowledge) to incorporate Education for Sustainable Development into your lessons?
(Q3) How would you include education for sustainability in your lessons?
(Q4) Do you think that mathematic education can contribute to incorporate education for sustainable development in the school classroom? How?

Note: Own research source.

Procedure

The questionnaire was administered by the authors of the study, who informed the participants of the importance of responding sincerely since their answers would be anonymous and would not have any influence on the subjects to be taken. Prior to data collection, free and informed consent was obtained from the student sample. The maximum time offered to respond was 40 minutes.

Data analysis

Qualitative analysis techniques, based on content analysis, were applied (Rico and Fernández-Cano, 2013). Each author carried out the process separately and, subsequently, discrepancies were discussed until a consensus was reached. In a first stage, a study by questions was carried out in order to define response patterns. Thus, categories of responses were created through a deductive process. Finally, a study of frequencies and percentages for each category found was made.

Results

The main results of this study are presented below and they are organized in 4 sections, one for each question from the questionnaire. They are differentiated according to whether they refer to future early childhood or primary teachers.

What do you understand by education for sustainable development?

Through this question, we seek to inquire about the ideas that these future teachers express about ESD.

From future early childhood teachers' responses, it is possible to distinguish the following 3 categories of responses, expressed in frequencies (F) and percentages (%) shown in Table 2.

Table 2
Future preschool teachers' responses about education for sustainable development

Categories	F	(%)
Education that fosters environmental awareness (A)	53	91.3
Education focused on local issues (B)	2	3.5
I don't know about the subject (C)	3	5.2
Total	58	100

Note: Own research source.



In category A, which includes 91.3% of the ideas registered, responses related to a vision of ESD linked to environmental awareness are collected, for example:

“I guess that it has to do with developing skills that promote environmental care through education” (Future early childhood teacher 37).

“An education linked to the care, maintenance and preservation of the environment” (Future early childhood teacher 24).

In category B, which includes 3.5% of the ideas registered, responses related to a vision of ESD linked to local issues are collected, for example:

“An education that seeks to train citizens with critical thinking and opinion regarding local issues. Besides being participative and aware of what is going on around them, so in this way they will be trained, through education, with tools to transform their community and be a contribution to preserve sustainable development” (Future Early Childhood teacher 2).

“An education focused on finding solutions to local environmental problems” (Future Early Childhood teacher 43).

Finally, in category C, responses in which the future teacher explicitly expresses ignoring the subject are included.

In the case of future Primary teachers, four categories of responses are distinguished, which are shown together with their frequencies and percentages in Table 3.

Table 3
Future Primary teachers' responses about education for sustainable development

Categories	F	(%)
Educate to favor environmental care (A)	79	90.8
Educate comprehensively in all areas (social, economic and environmental) (B)	4	4.6
Education for peace (C)	3	3.4
I don't know about the subject (D)	1	1.1
Total	87	100

Note: Own research source

In category A, which includes 90.8% of the ideas registered, responses related to an ESD vision linked to “educating for environmental care” are collected, for example:

“I associate it to an environmental education, considering that what we do today may have implications in the lives of generations and the planet in the future” (Future Primary teacher 2).

“It is good to act around what we call nature” (Future Primary teacher 16).

In category B, which covers 4.6% of the ideas registered, we find those responses related to a vision of ESD associated with a “comprehensive education that addresses all areas (social, economic and environmental)”, an example of this type of response is the following:

“That education could be integral, where students are raised about their development as people with an economic, cultural, social and environmental balance. Thus achieving equality and equity for everybody” (Future Primary teacher 23)

“An education aimed at the development and improvement of life in all



areas of human beings, that is, cultural, environmental, economic, social, etc.” (Future Primary teacher 34).

In category C, which covers 3.4% of the ideas present in the responses, are those linked to a vision of ESD associated with “education for peace”, for example:

“By education for sustainable development, I understand an education that seeks to promote peace among all of us who live on this planet” (Future Primary teacher 75).

“Provide tools for world peace” (Future Primary teacher 53).

Finally, in category D, responses in which the future teacher explicitly expresses ignoring the subject are included.

As a future teacher, do you feel prepared (with the competencies and knowledge) to incorporate education for Sustainable Development into your lessons?

Through this question, we seek to investigate whether or not these future teachers consider themselves prepared (self-perception), in terms of competencies and knowledge, to address ESD in their lessons. Data is shown in Table 4, where we can see that a high percentage (91.4%) of future teachers of Early Childhood Education state not having the knowledge and competences necessary to address ESD in the classroom. Contrary to future Primary School teachers, who in their majority (71.4%) indicate possessing the knowledge and competences to incorporate ESD into the classroom.

Table 4

Self-perception about competencies and knowledge to address ESD in the classroom

Categoríe	Future preschool teachers	Future Primary School teachers
I feel prepared	5 (8.6 %)	65(74.7 %)
I don't feel prepared	53 (91.4 %)	22(25.3 %)

Note: Own research source.

“Yes, because I feel that it is my responsibility as a future teacher to raise awareness among children about changes in our nature and how to contribute to care for our environment. (Future Early Childhood teacher 2).

“No. I think that further information about the subject is needed, since not many of us know about ESD and their characteristics in detail” (Future Primary teacher 34).

How would you include Education for Sustainability in your lessons?

This question is linked to the answers of the previous question, provided that future teachers responded positively to it.

With regard to future Early Childhood teachers' responses, it is possible to distinguish the 2 following categories of answers, expressed in frequencies and percentages shown in Table 5.

Table 5

Strategies proposed by future Early Childhood teachers for Sustainable Education

Categories	F	(%)
Work with families to involve them in caring about the environment (A)	3	5.2
Use of recyclable materials (B)	2	3.4

Nota: Own research source.



In category A, which includes 5.2% of the ideas registered, we find those responses in which it is considered that ESD can be included in the school classroom through “work with families to involve them in environmental care”, for example:

“In plans that cover several subjects, creating and generating instances of reflection on issues related to the community and the environment, engaging the family in the education of their children, encouraging and fostering the participation of all agents of the educational community” (Future Early Childhood teacher 48).

“Through tasks with the family that involve actions for environmental care, since in Early Education, pre-school children are taught to create habits and routines, so I would raise questions and implement ideas of environmental care in children through teachings such as water care, the use of recyclable materials in didactic materials, the care of trees and plants, among others” (Future Early Childhood teacher 2).

In category B, which includes 3.4% of the ideas registered, are those responses in which it is considered that ESD can be included in the school classroom through the “use of recyclable materials”, for example:

“Using recycled materials and incorporating the 5 R (reuse, reduce, repair, recycle and regulate) inside the classroom, so that they learn how to use them. Not to use so many worksheets or paper tests, use more concrete

material available and TICS” (Future Early Childhood teacher 3).

“Promote the use of recyclable material” (Future Early Childhood teacher 43).

In the case of future Primary teachers, it is possible to distinguish the following 3 categories of responses, expressed in frequencies and percentages which shown in Table 6.

Tabla 6
Strategies proposed by future Primary Teachers for sustainable education

Categories	F	(%)
Work with classroom projects that generate reflection about environmental issues.	43	49.4
Ask questions that bring about debate on environmental problems. (B)	16	18.4
Field trips	6	6.9

Note: Own research source.

In category A, which covers 49.4% of the responses obtained, we find those responses that involve “working around projects that lead to reflect on environmental issues”, for example:

“I would include it through classroom projects, linking the students' natural environment with the capacities, skills and knowledge that a student must acquire” (Future primary teacher 83).

“By working with projects that allow students to reflect on the care of the environment and at the same time enjoy the activity” (Future primary teacher 23).



On the other hand, category B present in 18.4% of the answers, considers those ideas linked to the "questioning that provokes debate about environmental problems", for example:

"I would include it in all classes, through small dimensions related to the contents that are being studied. The idea is to motivate students to take an interest in what has been said and generate greater doubts that as a teacher I can solve, adding perhaps hours of lessons and specific activities about sustainable development "(Future Primary Teacher 67).

"The only thing I can think of is asking questions that allow opening a debate among the students where each one of them gives their opinion about a specific topic. But for this I, as a teacher, must be very prepared, have a lot of knowledge about the subject to be treated" (Future Primary teacher 48).

Finally, in category C with a 6.9%, we find those responses that consider that ESD can be included in the school classroom through field trips, for example:

"Through lessons outside the classroom, in a field trip, but contextualized in science, which is where I observe it the most related" (Future Primary teacher 12).

"Planning outdoor activities where my students can observe, for example the pollution of the parks and reflect on this" (Future Primary teacher 3).

Do you think that mathematics education can contribute to incorporate education for sustainable development in the school classroom? How?

Faced with this question, all future teachers, both Early Childhood and Primary, believe that mathematical education can contribute to the incorporation of Education for Sustainable Development in the classroom. However, when asking how can mathematical educations contribute to Education for Sustainable Development? 97.9% of future teachers surveyed argue that they do not have the necessary tools (disciplinary and didactic) to incorporate ESD into the school classroom through math education. While the rest of the participants outline some ideas about how to incorporate ESD through mathematical education, but in a very general way as can be seen below:

"Of course yes. It can be incorporated through the implementation of classroom projects such as making a greenhouse, through recycling, research, etc."(Future Primary teacher 67).

"Showing children the shocking figures could be useful for them to understand the situation" (Future Early Childhood teacher 3).

"The ideal would be to bring Mathematics to this type of education. Teach it so that students acquire life skills and not just for a test" (Future Primary teacher 12).

Discussion and Conclusions

The purpose of this study has been to investigate the belief system of future



Chilean teachers of Early Childhood Education and Primary Education regarding their competencies to incorporate ESD into the school classroom, specifically, in math classes. The data analyzed show that a large part of the study participants link ESD with environmental education, and only 4.6% of future Primary teachers link it to a holistic education that must address and incorporate social, economic and environmental areas. In this sense, there is a lack of clarity regarding the scope of ESD which could constitute an obstacle when the teacher designs and implements teaching processes aimed at incorporating ESD into the school classroom from a comprehensive, contextual, critical and transformational approach (UNESCO, 2014).

With regard to the competence to incorporate ESD into their lessons, there are significant differences between the perceptions of future Early Childhood and Primary teachers. Following Di Martino and Zan's (2010) criteria, Primary Education students perceive a higher knowledge and competence to incorporate ESD into their lessons. A possible interpretation of this result may be due to the multidisciplinary training that future Primary teachers receive during their initial teaching instruction. While, in the case of future Early Childhood teachers, the vast majority declares feeling incompetent to incorporate ESD into their lessons, that is, they sense that they have low competency, which is consistent with the findings of Uitto and Saloranta (2017) with High School teachers.

It is also possible to observe that when it comes to how these future teachers would incorporate ESD into their lessons, a large part of them (especially in the case of future Early Childhood teachers) considers that it is possible to address ESD through activities

that involve students' families with environmental care and rather linked to the use of recyclable materials. While, in the case of future Primary teachers, they state addressing ESD through classroom projects work that would generate debate and subsequent reflection on environmental issues, a didactic strategy that coincides with that indicated by Fuertes-Camacho et al. (2019).

Finally, when asking these future professors if they consider that mathematical education can contribute to incorporate ESD into the school classroom and in what way, the results show that all of them value mathematics education as a tool to incorporate ESD into the classroom and raise awareness about the issues it addresses. However, they only point out very general ideas on how to incorporate ESD through mathematics education.

In global terms, based on the analysis of the responses and in line with what was posed by Alsina and Mulà (2019), the need to generate training actions that allow reorienting initial training programs is evidenced, so that they consider the curriculum greening criteria proposed by multiple organizations and authors (eg, Junyent et. al., 2003; Bourn and Hunt, 2005; Hopkins and McKeown, 2014) and, thus, improve both the knowledge and skills of future teachers regarding ESD, especially in disciplinary areas such as mathematics which, due to its problem-oriented nature, has much to contribute, above all if we link it with the objectives of sustainable development.



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