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Broadening teacher training: playful learning in non-formal contexts for science and mathematics education

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Abstract

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Currently, new ways of learning to develop skills such as creativity and scientific and mathematical thinking are needed. Teachers need to be prepared to face this challenge by engaging with education in any context, including non-formal ones. Moreover, in such a changing world, non-formal education could be a rich source of jobs. Work opportunities may arise if teachers in training begin to see themselves as entrepreneurial professionals. We might ask: Are future teachers prepared to educate future generations in today's world? In this shifting scenario, would an approach for teacher training concerning non-formal contexts, based on playful learning and specially focused on science and mathematics education, be worthwhile? As part of the higher education of pre-service kindergarten teachers, we undertook such an approach with the aim of broadening their training at the university. We sought the perceptions of the teachers in training, after the development of our approach, regarding its usefulness for their future professional development, giving them the opportunity to express their own reflections in writing. We studied the participants' reflections following the qualitative-interpretive technique of content analysis of the speech. The results of the qualitative analysis provided the emergence of 19 units of meaning (subcategories). The study of the interrelationships among these units revealed the existence of 3 interrelated joined cores (categories). Those cores are: science and mathematics education, playful learning, and non-formal education, and around them the discourse of the educators in training was articulated.

Keywords: Scientific education; mathematical education; playful learning; non-formal education; toy library; teacher training.

1. Problem statement

Currently, new ways of learning to develop skills such as creativity and scientific and mathematical thinking are needed. Teachers must be prepared to face this challenge by engaging with education in any context, including non-formal ones. Moreover, in such a changing world, non-formal education

could be a rich source of jobs. Work opportunities may arise if teachers in training begin to see themselves as entrepreneurial professionals. Places such as toy libraries, farm-schools, educational camps, cultural clubs, and museums offer educators new professional opportunities as alternatives to a conventional teaching career.

Studies on learning, conducted in museums, conclude that an educational activity in a museum stimulates the imagination, intuition, and creativity, fomenting a type of learning which is not limited to the cognitive level but includes emotional and imaginative levels (Perez & Moliní, 2004). Specifically, in terms of extracurricular activities, science museums have been recognized as non-formal educational contexts where scientific literacy can be promoted (Calvo & Stengler, 2004; Pérez & Moliní, 2004). Studies have concluded that participation in extracurricular activities helps reduce anti-social behaviour in young people, who are positively reinforced by the participation of the social network of the individual, family, friends (Mahoney, 2000). This is an example of non-formal education being important in social inclusion and the democratization of knowledge. The same is true of toy libraries (Jackson, Robey, Watjus & Chadwick, 1991; Caldeira & Oliver, 2007; de Angelo & Vieira, 2010), which provide an answer to the lack of equal access to education by their beneficial action when difficulties appear in any of three areas: economic, personal or socio-cultural (de Borja, 1994).

> Toy libraries are specialized centres aimed at children in which you educate through play. Are divided according to their ownership, which can be public or private, being independent or integrated into entertainment centres, schools, businesses, shops ... in which a space for the development of a play workshop is enabled: can be public ownership and management, or private in management and public in ownership, have an agreement with the administration or private both in management and ownership. At the same time, we find models of toy libraries specialized in certain sectors of age, adapted to children with special needs, hospital toy libraries, giants, travelling... (Ruiz de Peralta, 2009, p.522)

Toy libraries were initially modelled after libraries, dedicated to loaning games, but later expanded as facilitators of playing areas, after the recognition of this activity as a right of children (Ruiz de Peralta, 2009). Besides having the right to play, children learn while playing, and, by playing the right games, they can learn a great deal. Particularly, games should be used to attract children to science and mathematics (Haist & Burla, 2010). Playful learning is among the new ways recommended to foster the skills needed in today's world, as Hirsh-Pasek and Golinkoff (2008) have stated:

> Play is, thus, central for school readiness and school performance. It might also play an important role in preparing children for the global world beyond the classroom. Business leaders suggest that in the knowledge age, success will depend on children having a toolkit of skills that include *collaboration* (teamwork, social competence), *content* (e.g., reading, math, science, history), *communication* (oral and written), *creative innovation*, and *confidence* (taking risks and learning from failure). Each of these "Five Cs" is nurtured in playful learning. (p.4)

Those skills include scientific and mathematical thinking, with play constituting a valuable resource for STEM education, i.e. interdisciplinary science, technology, engineering, and mathematics education (Bergen, 2009). The literature offers examples in which play and games have been successfully applied to teaching and learning of science in all stages of education, including higher education (Cabra, 2004, Franco-Mariscal, Oliva-Martinez and Almoraim, 2014; Giménez, Pagés and Martinez, 2011; Muñoz, 2010; Noy, 2011; Rodriguez, 2007; Uría, 2004).

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Furthermore, the analysis, projection, design, and evaluation of playful resources and games are valuable tools for teacher training in science and mathematics (Fernández-Oliveras & Oliveras, 2014a). With this idea, devoted not only to formal but to non-formal educational contexts, a subject matter was introduced in the last year of the Bachelor's Degree in Early Childhood Education at the University of Granada (Spain). We set up this course in the year 2013 and have been developing it for three academic years.

The experience gained so far confirms that the teachers in training have a positive attitude towards play and the development of mathematical and scientific thinking as ingredients in an educational approach (Fernández-Oliveras & Oliveras, 2014b, 2015). However, most teachers still have a traditional way of addressing their entry into the labour market on completing their higher education, in the sense they tend to look for jobs as teachers hired in public or private schools. Therefore, in our way of approaching the subject matter, we emphasize non-formal education with the aim of broadening teachers' training during their higher education at the university. In this work, we investigate the perceptions of the teachers in training who were involved in our approach, enquiring into its usefulness for their professional future in order to ascertain their opinions about facing science and mathematics education in non-formal contexts, once they completed the course.

2. Research Questions and Purpose of the Study

2.1. Research Questions

We ask: Are future teachers prepared to educate the next generations in today's world, in which new ways of learning to develop skills such as creativity and scientific and mathematical thinking are already needed?

In this changing world, would an approach to teacher training concerning non-formal contexts, based on playful learning and specially focused on science and mathematics education, be worthwhile?

2.2. Purpose of the Study

We aim to broaden teacher training during their higher education at the university, concerning non-formal contexts and paying special attention to science and mathematics education.

To know their perceptions after their training, we surveyed the participants regarding the usefulness of our approach for their future professional development.

3. Methods

3.1. Approach for Educator Training

As commented above, we undertook an approach to educator training in non-formal contexts, based on playful learning and specially focused on science and mathematics education. This approach was introduced as part of the higher education of pre-service kindergarten teachers, and developed in an optional course of the last year of the Bachelor's Degree in Early Childhood Education at the University of Granada. In this university subject, we presented diverse games and playful resources for children in preschool and elementary school. Traditional games of different cultures and commercial

educational games on the market were analysed by work teams of teachers in training, using a systematic procedure. In addition to general aspects, the procedure was specially focused on science and mathematics teaching and learning.

During the development of the course, each work team projected, designed, manufactured, and analysed a game or a playful resource, dedicated primarily to educating children in science and mathematics. At the end of the course, the teachers in training presented their games or playful resources to the rest of the groups, adopting a professional role as members of a game-designers' team. The presentation prepared by each team for showing and analysing their own games was subjected to three modes of evaluation (self-assessment, peer assessment, and teacher assessment).

A key part in our approach was the inclusion of visits to real contexts where non-formal education is offered. We call such visits "field trips", after which the educators in training conducted their "field work". With this goal, participants had to prepare the field trip previously and, during the visit, they had to perform the tasks necessary to prepare the field work. Therefore, performing the field work involved working before, during, and after the corresponding field trip.

The visits were made on two different days and included two public centres: an interactive science museum and a toy library, and a private centre managed by an entrepreneur. We choose these educational centres for being initiatives based on playful learning that incorporate aspects especially related to science and mathematics education.

3.2. Research Methods

With the aim of stirring the reflections of the teachers in training after the development of our approach, in the academic year 2015-2016, we used an optional questionnaire that almost 70% of the students of this year answered (N = 39). An online platform was used to design and distribute the survey, which had two parts. Given the optional nature of the subject matter, the first part of the survey served to show the participants' reasons for choosing it and was composed for two semi-closed-ended questions (list of items plus a separate textual answer at the end, which respondents could fill out if they did not select one of the suggested items). The second part of the questionnaire concerned the usefulness of the approach for the participants' professional future. It was mixed, composed of a closed-ended question (Likert type) and an open-ended query, giving the teachers in training the opportunity to express their thoughts in their own written words.

The research was descriptive and based on a qualitative-interpretive paradigm. By means of the interpretation of that expressed by the teachers in training, we tried to display how they assembled in conceptual fields and networks the elements related to the usefulness of the approach, as the teachers were intended to act as implicit mediators of their professional performance when working with children.

The research was interpreted from a pragmatic and social-constructivist theoretical framework. A solid background was provided by the sociology of knowledge, which remains the basis for the methods of qualitative understanding of human societies, especially for the contribution to the understanding of the nature of science (Berger and Luckmann, 1966). Moreover, we took a socio-constructivist perspective of scientific and mathematical knowledge (Ernest, 1997).

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We used the technique of content analysis of the speech (Babbie, 2012; Pérez, 1998) as a model for the qualitative analysis of the query and we added a quantitative analysis of the results found.

4. Findings

4.1. Sample Characterization

As mentioned above, the first part of the survey was intended to characterize the sample, in the sense of knowing the participants' reasons for choosing the subject matter, and was composed around two semi-closed-ended questions. Figure 1 shows the responses to the first question, which was: "Why did you choose this subject matter?". Participants could select only one of the items on the list. If respondents selected the option "Others", they could fill in a textual answer.

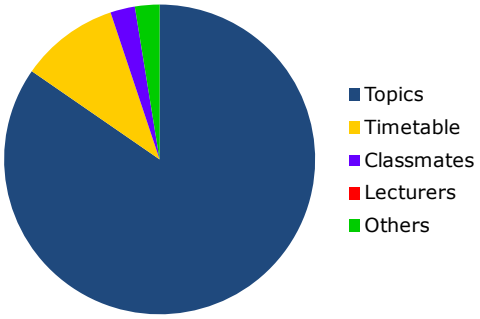

Fig. 1. Responses to the semi-closed-ended question "Why did you chose this subject matter?".

It can be seen that most participants (85%) chose the subject matter due to the topics addressed. Only one respondent marked the option "Others", citing curricular reasons (validation of a subject). It bears mentioning that no participant chose the subject matter due to the lecturers who conducted it, which means that no opinion was influenced for this reason.

The participants who chose the subject matter because of the topics (85%) were asked which specific topic prompted their choice. In this case, respondents could choose as many options as they wished from the list, including the option "Others", filling in a textual answer. Their answers are displayed in Figure 2.

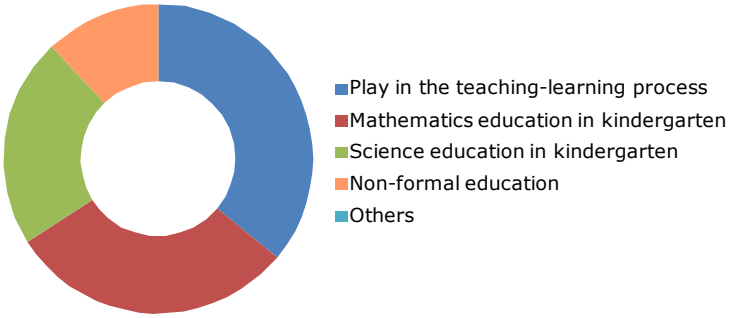

Fig. 2. Responses to the semi-closed-ended question "Which specific topic related to the subject matter prompted your decision?", asked of the respondents who chose the subject matter because of the topics addressed.

As can be seen, the most frequent response option was "Play in the teaching-learning process" (55%), followed by "Mathematics education in kindergarten" (46%), "Science education in kindergarten" (33%) and, finally, "Non-Formal education" (18%). No respondent marked the option "Others" in this case. Of the respondents, 12% chose two options and 9% chose three, while the rest chose only one response option.

4.2. Participants' Perceptions

As indicated in Section 3.2, the second part of the questionnaire regarded the usefulness of the approach for the participants' professional future. It was mixed and composed of two questions. The first one was a closed-ended question (Likert type) and its answers can be seen in Figure 3.

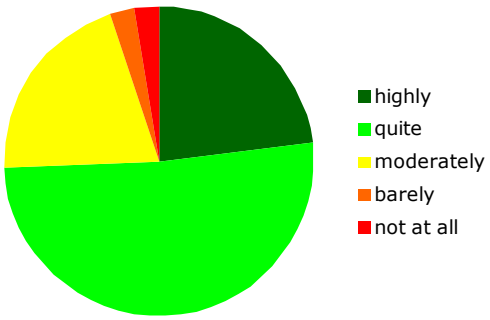

Fig. 3. Responses to the closed-ended question "Did you find the subject matter useful for your professional future?".

The subject matter was found highly useful by a 23% of the participants, quite useful by 51% of them, and moderately useful by 21%. Only one respondent considered the subject matter as barely useful, and another one found it not useful at all. In general terms, we can affirm that the participants perceived the teacher-training approach performed as rather useful for their professional future.

The last question we added to the second part of the questionnaire was open-ended in order to allow the participants' to express their reflections in their own words. The question was: "In which aspects do you consider that the subject matter is useful for your professional future?". The qualitative analysis of participants' reflections, shown by means of the answers to this query, revealed the emergence of 19 different units of meaning. The study of the interrelationships among these units revealed the existence of 3 interrelated joined cores. We call the units of meaning "emerging subcategories", and the joined cores, "emerging categories" (Pérez, 1998). In Table 1, the emerging subcategories, grouped into categories, are listed. Figure 4 depicts the interrelationships found among the emerging categories.

Table 1. Categories and subcategories emerging from the reflections of the teachers in training.

Code	**Category**		**Frequency (%)**
SME	Science and mathematics education		26
Code	**Subcategory**	**Example**	**Frequency (%)**
SMfC	Science and mathematics for children	"Apply mathematical and scientific contents from early ages"	3
SMDL	Science and mathematics in daily life	"The importance of math and science in daily life of anyone, whether children or adults"	5
SMC	Scientific and mathematical contents	"Scientific and mathematical contents"	3

SMR (STEM)	Relations between science and mathematics (science, technology, engineering and mathematics)	"Relate science to mathematics"	3
PMSME	Playful methodology for science and mathematics education	"We learn to work with math and science with our future students in a playful way" "Having knowledge to develop a mathematical and scientific game from the experience"	8
RSME	Resources for science and mathematics education	"Making mathematical and scientific (educational) resources"	3
SSME	Self-confidence as science and mathematics educators	"New ideas for losing the fear to work on mathematics and science with children, since we have discovered that these subjects are present in almost everything"	3
Code	**Category**		**Frequency (%)**
PL	Playful learning		54
Code	**Subcategory**	**Examples**	**Frequency (%)**
PEM	Playful educational methodology	"Learn to use play to teach contents"	3
KG	Knowledge about games	"We collect many ideas for games" "In assessing which games are appropriate for each level and to develop a certain capacity"	8
GO	Game organization	"We have learned to organize them (the games)" "I think toys cards can be very useful for me"	5
EGM	Educational games manufacture	"Make a toy that is truly educative and fits the characteristics of the receiver group" "The preparation of the final game also helps raise awareness that it is not so difficult to develop something for the children in an original way"	18
ER	Educational resources	"Resources to perform in the classroom" "Materials and information" "Everything learned in class that we can use in our future (professional) practice"	10
CC	Children's creativity	"Encourage children's creativity"	3
ML	Motivation to learn	"Look for the motivation of our students (…) to go to the school or for a specific area"	3
CI	Continuous innovation	"Is necessary to be constantly innovating"	5
Code	**Category**		**Frequency (%)**
NE	Non- formal education		56
Code	**Subcategory**	**Examples**	**Frequency**
KNE	Knowledge of non-formal education	"It gives us a some knowledge to know non-formal environments in which to work" "To learn how to move through non-formal education" "We know other professional opportunities"	31
CNEFE	Connection between non-formal education and formal education	"It gives us some knowledge to know non-formal environments in which to work, take our students if we work in a (formal) centre"	3
MWPC	Management and working in a toy library	"Knowing the operation of a toy library" "Idea to set up a toy library"	21
E	Entrepreneurship	"Ability to create self-employment"	3

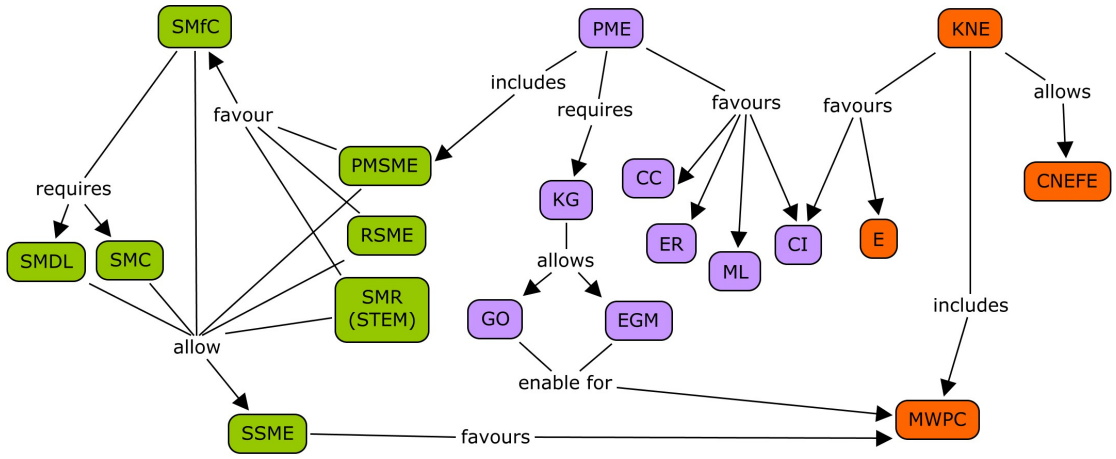

Fig. 4. Interrelationships among the subcategories emerging from the reflections of the teachers in training. The codes are listed in Table 1. Subcategories shown in the same colour are joined into a category. Green, violet, and orange correspond to science and mathematics education, playful learning, and non-formal education, respectively.

We can see that the most frequent category was the one related to non-formal education (56%), although it was the one that brings together the fewest number of subcategories, with only 4 (approximately half of subcategories of that the other categories have). This is because the aforementioned category includes the two subcategories that arose most frequently in the discourse of the participants: knowledge of non-formal education (31%), and management and working in a toy library (21%). That result is particularly striking given that non-formal education appeared as the topic that, *a priori*, least motivated the participants' choice to the subject matter, among other possible topics involved. The third most frequent subcategory was educational games manufacture (18%), grouped into the category regarding playful learning.

It bears mentioning the emergence of some especially meaningful subcategories, even though they had a very low frequency (3%). Those key categories are: relations between science and mathematics (raising the STEM-education idea), self-confidence as science and mathematics educators (dealing with teacher qualification), children's creativity (paying attention to the skills which educators should foster in the children) and entrepreneurship (stressing the self-employment issue).

5. Conclusions

As part of the higher education of pre-service kindergarten teachers, we undertook an approach for educator training in non-formal contexts, based on playful learning and specially focused on science and mathematics education.

In general terms, we can state that the participants perceived the approach as being quite useful for their professional future.

We studied the reflections of the teachers in training after the development of our approach, following the qualitative-interpretive technique of content analysis of the speech. The results of the qualitative analysis provided the emergence of 19 units of meaning (subcategories). The study of the interrelationships among these units revealed the existence of 3 joined cores (categories) interrelated. Those cores are:

1- Science and mathematics education
2- Playful learning
3- Non-formal education

and around them the discourse of the educators in training was articulated.

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