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Early childhood preservice teachers' knowledge of micro-organisms and cystitis

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ABSTRACT
Health literacy should be developed from early ages, but students, including preservice teachers, hold misconceptions about micro-organisms. The objective of this study was to analyse the knowledge that a sample of 102 Early Childhood Preservice Teachers (PST) had about micro-organisms and about cystitis. The PSTs performed a series of activities that included an inquiry-based laboratory activity. Their knowledge about micro-organisms was assessed by pre- and post-questionnaires, and about cystitis, by analysing the responses to an open-ended pretest, the inquiry reports and the performance of the PSTs when changing nappies on dolls. Results show a better understanding about the micro-organisms at the end of the study. In the case of cystitis, in the pretest PSTs did not identify bacteria as agents, but they did after the inquiry activity, and they also mentioned the proliferation of bacteria. Nevertheless, only 32% of PSTs changed nappies coherently with the knowledge.

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Introduction

In the developed world, a large number of children spend a considerable part of their time under the tutelage of their Early Childhood Teachers. To assume the great responsibility of caring for the physical and mental well-being of their pupils, educators must be able to recognise infectious diseases and to know and apply basic hygienic measures to prevent injuries and illnesses (Chalas et al., 2014; Slabe et al. 2016). Moreover, similar to the Turkish Early Childhood Education (ECE) curriculum, which aims to improve the well-being of Turkish citizens by validating their personality and traits in a healthy way (Aktürk et al., 2017), the Spanish ECE curriculum aims at the integral formation of their pupils, contributing to the full development of their personality and preparing them for the full exercise of human rights (Royal Decree 95/2022).

It establishes that one of the duties of ECE teachers is to provide children with routines that favour the development of positive attitudes towards their emotional and physical well-being, which includes hygiene and safety habits (Royal Decree 95/2022). The childhood and youth stages are considered highly suitable for the acquisition of individual and collective responsibilities related to health since it is then that pupils are more receptive to learning and acquire key habits for health (Catalán et al., 2019). There are multiple articles that deal, for example, with the teaching of washing hands or cleaning teeth in ECE (Blanco-López et al. 2015; Franco- Mariscal et al., 2014; García-Barros et al., 2020; Marcos-Merino et al. 2019).

Future ECE educators must therefore be trained to acquire scientific knowledge about hygiene measures and healthy habits and to know how to promote them among their pupils, this necessarily includes knowing about microorganisms. In this sense, it must be borne in mind that future teachers usually hold various alternative conceptions regarding micro-organisms (Marcos-Merino & Esteban-Gallego, 2017). For instance, they may be unaware of the diversity of microorganisms and presume that all of them are bacteria. They may also presume antibiotics to be a common remedy to treat all diseases caused by micro-organisms (Teodoro & Chambel, 2013). In a recent study (Robredo & Torres, 2021) such a misconception regarding antibiotics was also detected among Spanish Secondary School pupils. They also thought that antibiotics were useful against diseases caused by viruses. Consequently, the authors of this work recommended a less theoretical curriculum, but which is more focused on practical cases that instils attitudes towards the responsible use of antibiotics and favours education on their importance in the prevention and treatment of infectious diseases.

Besides these described misconceptions, Marcos-Merino et al. (2019) explained that students may hold negative emotions towards microbiology. Thus, Marcos-Merino et al. (2019) designed and implemented a series of activities for Primary Education Degree students that involved experimental activities as positive emotion raisers (Hofstein & Lunetta, 2004). This consisted of growing micro-organisms from the surroundings and from their hands (before and after washing them) in petri dishes. This is similar to what López (2015) had proposed some years before in his inquiry-based science teaching sequence for Secondary Education to observe antibiotic action and bacterial resistance. Also, that very same year, Mafra et al. (2015) published their findings regarding the positive effect of growing dental plaque before and after teeth cleaning on the dental hygiene habits of primary school pupils. Later, other authors (Puig et al., 2020) have also suggested growing bacteria from pupils' hands in petri dishes at primary school level (Primary Education). At Secondary School level (Secondary Education), Garcia-Barros et al. (2020) suggested growing pupils' mouth bacteria in a carbohydrate-rich medium for the pupils to conceptualise their mouth as an ecosystem.

If the ultimate goal of scientific education is to help learners to become scientifically literate individuals with the skills to critically analyse and change society (Longbottom & Butler, 1999), then they will have to be able to transfer the scientific knowledge acquired in the university to other scenarios. For this to happen, the topic selected to be studied in the classroom must be significant for the learners and facilitate the learning of relevant scientific knowledge that can be transferred to other contexts (Pipitone et al., 2013). According to Jiménez-Aleixandre (2010), to raise interest in science and put them in challenging situations, such scenarios should reflect authentic problems or activities. In such a way, learners will be required to seek adequate and relevant knowledge to identify, understand and deal with such situations (Bolivar, 2010; Sanmartí et al., 2011) and in this way experience the interdisciplinary character of science and its relevance in their life (Mandler et al., 2012). Karakas (2022) found that up-to-date socio-scientific issues which were based on real examples were effective in the improvement of the attitude of Primary School teacher candidates towards the course on life science teaching they attended.

Science is a way of knowing the world (National Academies of Sciences, Engineering and Medicine [NASEEM], 2016) and the need for scientific literacy for the population is often justified with reference to enabling individuals to make decisions regarding health (Esquivel, 2019; Shen, 1975). Someone who is scientifically literate will be able to take better care of those in their charge for they will be able to make more solid decisions regarding actions such as nutritional measures, drug administration, etc. In this sense, care provision may be an appropriate scenario for the science education Early Childhood PSTs are subjected to. Additionally, its inclusion in the ECE Degree classroom is justified for further reasons; it is a way to prepare teachers for their future work in the early childhood field (Beck, 2010) and attenuate the sensation of being "lost at sea" (Kauffman et al., 2002) of novice teachers. Also, it satisfies the demand of most of the Early Childhood, Primary and Secondary Education teachers who refer to the need for more training in health matters (Díaz & Arias, 2018). This is especially true for ECE, since care-related issues have usually not been considered as part of the professional repertoire of teachers (Van Laere, 2017).

Aznar and Puig (2014) reported that Spanish Secondary School textbooks frequently mentioned infectious illnesses but did not deal with specific diseases. They also reported finding a small number of articles in science teaching about the difficulties of Secondary School pupils to understand aspects related to infectious diseases and infection processes. They suggested that the textbooks incorporated tasks that presented real and specific dilemmas which required decision-making by pupils and the development of critical thinking. Later, the same authors (Aznar & Puig, 2016) published their research on the conceptions and models about tuberculosis held by future Primary Education teachers. They found that most participants had difficulties with fundamental concepts, including identifying how the disease is transmitted, the location of the infection, and linkages between the components of the immune response.

There is some literature on students' knowledge on micro-organisms in Primary and Secondary Education stages previous to university, yet, it is scarce (Simard, 2023). There is also some literature on pre-schoolers' knowledge about micro-organisms (i.e. López-Luengo et al., 2023; Martinerie et al., 2021), and on how to teach about microorganisms in Early Childhood Education. Such is the case, for example, for the E-bug International Project (UK Health Security Agency, 2022), López-Luengo et al. (2021) and Ruiz-Gallardo and Paños (2018) who compared a theoretical and a practical strategy to teach about micro-organisms in ECE. However, the literature on what the Early Childhood PSTs, who are going to teach the pre-schoolers about micro-organisms, hygiene habits and so on is scarce, and so is the literature on how they can learn about them. This work refers precisely to such a question. It is an initial approach to a proposal of a series of activities which aims to improve the knowledge on microorganisms and cystitis of Early Childhood PSTs. Ultimately, this will favour their professional performance when taking care of their future pupils and when teaching them how to take care of themselves. The research questions (RQ) are the following:

RQ1. What knowledge of microorganisms do the Early Childhood PSTs acquire via the suggested activities?

RQ2. Using a cystitis context, what knowledge about such infection do the Early Childhood PSTs acquire?

Methods

Sample

The sample constituted 102 PSTs of the Bachelor´s degree of ECE, who took part in all or some of the activities described in Table 1 during the academic year 2021-2022. The PSTs were chosen for convenience, as Authors 1 and 2 were the teachers at group A and B respectively. 31 PSTs of the 4th year course subject "Activities, Instruments and Resources for Teaching Science" (Group A) in the first semester of academic year 2021-2022 and 71 PSTs of the 3rd year course subject "Experimental Sciences in Early Childhood classroom" (Group B) in the second semester participated. PSTs' age range was 20-23 years, in group A 77% of the PSTs were female and in

Group B 90%of them were female. PSTs were named as A1-31 and B1-71 for Groups A and B respectively.

The PSTs had not received previous formation about microorganisms during the ECE Grade.

Comparisons of the results obtained for the groups were made through the Chi-squared test (SPSS-version 27), a significance level of p 0.010 was considered (Kim, 2017). Only the questions or aspects where the performance of both groups was similar after the intervention, and thus showed no significant difference, were considered in this work for the impact of the similar aspects for both groups, i.e. activity sequence, rather than the differences, i.e. teacher´s performance, was the object of study in this work.

Research Tools and Procedures

To address RQ1, a questionnaire on micro-organisms (MQ) composed of questions used in previous studies was responded by PSTs twice, at the beginning of the sequence (MQpre) and at the end (MQpost).

The questions used are detailed in Appendix 1. The questions I such questionnaire were based on previous studies by Bandiera (2007), Molina et al. (2021) and Robredo and Torres (2021), and their objective was to address students´ knowledge about microorganisms, that is, the ubiquity of microorganisms (MQ1, MQ2), the relation between microorganisms and illness (MQ2, MQ3, MQ5, MQ6), the benefits of microorganisms (MQ2, MQ4), prevention (MQ7) and mitigation measures (MQ8). It was answered by 96 PSTs (26 from Group A and 70 from Group B) before the activity sequence and by 44 PSTs after it (21 from Group A and 23 from Group B). MQ4 was not administered to Group B because of a technical error.

Each response was given a mark, as described in Appendix 1. The possible maximum mark was 1 for the correct answer for each question, except MQ7 and MQ8 that had a maximum of 2 as the correct answer must mention two concepts. A mark of half the maximum was given when the answer was not incorrect but was incomplete. A mark of 0 was given to incorrect answers. Appendix 1 shows an example of answers of PSTs that were given each of the possible marks for each question.

The results obtained in this questionnaire by the whole group were relativized regarding the maximum total score that all the participants could have obtained.

To answer RQ2, three tools were used: the questionnaire on cystitis which was designed and distributed to assess the initial knowledge the PSTs had on cystitis; the written report the PSTs produced; and the performance of Group B PSTs when changing nappies on baby-like dolls. The tools and procedures followed to analyse the data are described below.

Questionnaire on Cystitis (CQ)

Four questions were included about what cystitis is, the factors that produce it, the infectious agent that generates it and its symptoms (Table 1). Ideal answers are included in Appendix 2.

Table 1

Questions of the questionnaire on cystitis (CQ) for the Early Childhood PSTs of the Faculty of Education of Bilbao

Number	Question
CQ1	What is cystitis?
CQ2	Why do you think someone develops cystitis?

CQ3	Why does cystitis happen? What infectious agent generates it?
CQ4	What are the symptoms?

72 Early Childhood PSTs (27 PSTs from Group A and 45 from Group B) responded.

The responses obtained for all questions were read as a whole for each PST and were analysed based on the consideration of various aspects related to the infection, such as the organs affected (Anatomy), the agent involved (Agent), the description of the process (Process) and the Symptoms. Table 2 shows the coding of the responses for each aspect. When possible, an illustrative example of a PST is shown. Responses for Anatomy were coded as 0, 1 or 2, the maximum corresponding to mentioning the immune system and the urinary tract. The same codes were used for Agent and Symptoms. In the case of Agent, the maximum corresponded to specifying that bacteria cause cystitis. The best answers for Symptoms related them to immunological responses. One more code was set for Process, as there were PSTs that only mentioned infection (level 1), others the entering of the bacteria (level 2), but others came to refer to the reproduction of bacteria (level 3).

Table 2

Answer categorisation of the CQ for the Early Childhood PSTs of the Faculty of Education of Bilbao

Aspect	Level	Answer categorisation and example
Anatomy	0	No answer or does not know, or organs outside the urinary tract are mentioned (i.e. "…pain in the vagina", PST A6).
	1	Some part of the urinary tract is mentioned (i.e "kidney pain", PST A8).
	2	The inmune system is mentioned as well as the urinary tract
Agent	0	No answer, does not know (nobody), or activity (i.e." due to sexual intercourse", B67) or non-living agent (i.e. "cold", PST A6; "humidity", PST B32…) are mentioned
	1	The word "microorganism" is mentioned
	2	Bacteria are mentioned (i.e. "I believe a certain type of bacteria generates cystitis…", PST A26)
Process	0	No answer or does not know (PST A15)
	1	Infection is mentioned (i.e. "[Cystitis] is a urine infection", A7)
	2	Bacterial colonisation is mentioned (i.e. "it happens when bacteria enter the body", PST B40)
	3	Bacterial proliferation is mentioned (i.e. "A urinary tract infection occurs when bacteria from outside the body enter the urinary tract through the urethra and begin to multiply", PST B68)
Symptoms	0	No answer or does not know (PST A19)
	1	Mentioning of any symptom (i.e." a strong urge to pee", PST B6)
	2	Mentioning of any symptom related to the immunological process (i.e. "a fever in serious cases", PST A16)

Reports

98 people arranged in 25 groups and wrote 25 reports. They were assessed regarding the extent to which they explained that cystitis is an infection frequently caused by the *E. coli* bacteria proliferation, which they had observed.

Nappy Change

The performance of the Group B PSTs when changing diapers on baby-like dolls was recorded on video and evaluated to assess knowledge on cystitis in a transfer context. The aspects analysed were: the direction in which they cleaned the genitals, perineal and anal area of the baby-like dolls (backwards or forwards) and whether they used or not a clean area of cloth or tissue every time they touched the doll. Cleaning the dolls backwards (towards the anus) and using clean tissues was considered to show an adequate transfer.

Twenty four percent of the videos were viewed in pairs by the authors of this work. They evaluated the correct/incorrect cleaning of the dolls by the PSTs and agreed in 89% of the cases. The cases that were not clear were reviewed and evaluated by the three researchers until a consensus was reached. The conversations of the triads when explaining their actions were also studied. It was analysed whether they mentioned infection and whether they referred to the presence of agents that may generate it.

Activity Sequence

Activity sequences are important pedagogical devices for experimental science teaching with a constructivist approach (Jorba & Sanmartí, 1996). Science education pursues the promotion of scientific competence (Organisation for Economic Co-operation and Development [OECD], 2013), especially with regard to contextualisation in genuine circumstances that have a bearing on learners' personal, social, or future professional life (Jiménez-Aleixandre, 2010).

The activities in such sequences can generally be classified in four categories: exploratory activities; activities for the introduction of concepts or procedures, which help learners to identify new points of view in relation to the topic; knowledge structuring activities, in which the learners outline what they have learned; and application activities that, in general, are considered necessary by constructivist teaching models for successful Science and Mathematics teaching (Jorba & Sanmartí, 1996). The activities usually take place in time in the order displayed and they correspond to stages 1. Exploration, 2. Introduction to knowledge, 3. Structuring and 4. Application.

In the present work, the activities (Table 3) were set up around the topic of cystitis. Urinary tract infections, such as cystitis, are one of the most common bacterial infections in paediatrics. They affect from 5 to 11% of the child population and it is the most frequent reason for consultation in hospital services in some countries (Moriyón et al., 2013). Thus, it is a familiar problem that may motivate the students (Eugenio-Gozalbo & Ortega-Cubero, 2022) and thus, in this sense, it seems to be an appropriate choice for teaching about micro-organisms. In their work about the tuberculosis infection model, Aznar and Puig (2014) describe that those who had suffered from the disease showed a deeper knowledge of it. Cystitis can be a consequence of poor hygiene, as, in children, it is generally caused by the *Escherichia coli* (*E. coli*) bacteria of intestinal origin that are in the perineal area and enter the urinary tract through the urethra). It has the potential to produce long-term morbidity (Cisneros, 2015). Table 3 shows the stages of the learning sequence, the activities performed by PSTs and the research question with which each activity was linked.

Table 3

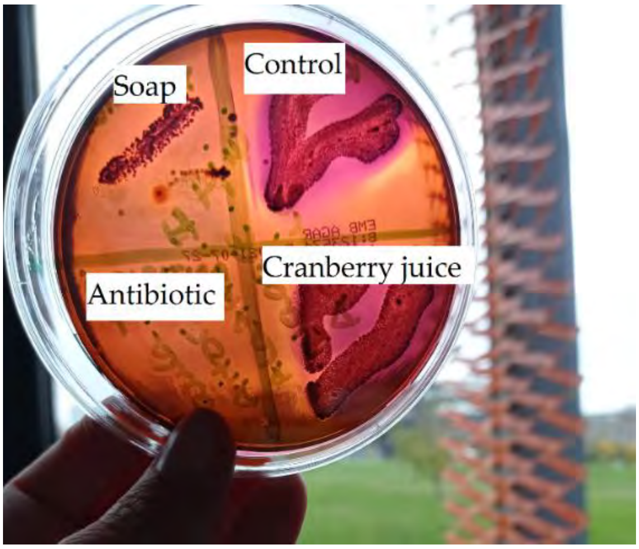
Teaching Sequence Including: Learning Stage, Chronology in Weeks, Objectives and Tasks

Learning stage	Week	Objective	Task	RQ addressed
Stage 1: Exploration	1	Show knowledge	1. Questionnaire about cystitis	RQ2
	3	Show knowledge	2. Questionnaire about microorganisms	RQ1
Stage 2: Introduction to knowledge	10	Gather information about the questions in the questionnaires, focusing on the bacterium *E. coli*	3. Gather information	
		Design an experiment to try to test different hypothesis regarding *E. coli* growing	4. Set hypotheses on the information collected and design an experiment	
Stage 3: Structuring	11	Grow *E. coli* in petri dishes under different circumstances	5. Experiment execution	
	12	Communicate and contrast the results obtained by the different groups	6. Meeting to contrast results	
Stage 4: Application	13	Write a report	7. Writing a report	RQ2
	14	Show knowledge	8. Questionnaire about micro-organisms	RQ1
	15	Express knowledge by simulating nappy changing	9. Diaper change	RQ2

To express knowledge, the PSTs answered questions on microorganisms (Appendix 1) and on cystitis (Table 1). Then, a similar approach to that used in inquiry practices was implemented (Caamaño, 2012). As reported by Cimer (2007), activities that encourage students` inquiry and cooperative learning favour effective teaching. Thus, after the initial questionnaire about microorganisms, the PSTs were asked to gather in groups of three or four and search for information regarding the issues raised by the questions in both questionnaires, focusing on the bacterium *E. coli*. After that, they were asked to design an experiment to try to test in which conditions *E. coli* would grow. For that purpose, they had to consider the resources available in the laboratory of the Faculty of Education of Bilbao. These were the following: sunlit and dark areas, a refrigerator, a stove with a thermostat, petri dishes with *E. coli* selective media, different substances such as the antibiotics ciprofloxacin and amoxicillin, the antifungal miconazole, and any other that they might bring in themselves (blueberry juice, hydro alcoholic hand gel to the lab. We were thus not assuming they had prior knowledge of lab procedures, as we have previously explained, they just brought or used the products they thought about when they formulated their hypotheses The PSTs had to design different situations, predict where *E.* coli would grow and explain the reason. Once in the lab, each group of PSTs sowed the *E. coli* bacterium in petri dishes and subjected them to different incubation conditions for 24 h. The bacteria were sourced in the excrement of a pet belonging to a member of the group. Then, the groups of PSTs collected their petri dishes, observed them (Figure 1), met to communicate and contrast the results obtained by the different groups, tried to respond to the hypotheses initially raised and produced a report on the experiment that structurally resembled a scientific paper (Theoretical framework; Objectives; Materials and methods; Results; Conclusions; References).

Figure 1

Example of Eschericia Coli Cultivation in a Petri Dish under Different Treatments. In This Case, Clockwise: Without Any Additive (Control), With Cranberry Juice, With Antibiotic (Ciprofloxacin) and With Hand Soap, Respectively



Finally, a questionnaire on micro-organisms was administered again (Table 2). Transference is an essential cognitive process in education which consists in the ability to apply what has been learned in a specific context to a new situation (Voss, 1987). According to Schönborm and Bögelholz (2009), students demonstrate understanding (a major goal both for educators and students), when, to meet the demands of a new situation, they can connect existing knowledge with new knowledge during the transference. Thus, a situation where PSTs had to simulate changing nappies on baby-like dolls was set up so that the PSTs transferred what they had previously learned about the causes for cystitis. During the last week of the semester, 58 Group B PSTs were taken to a kindergarten-like room in the Faculty of Education of Bilbao where they were asked to simulate changing diapers on dolls (Figure 2). They entered the room in groups of three, but each PST had a doll. The teacher then asked for an explanation of their actions. For Group A PSTs this activity could not be carried out.

Findings and Discussion

Knowledge about Micro-organisms (RQ1)

The Chi-square test was used to compare the results obtained by Groups A and B in the responses to the questionnaire about microorganisms (Table 5). Differences were detected for MQ5 after the implementation of the didactic sequence, thus this question was discarded.

Figure 2 shows the total number of points obtained by the PSTs who answered the questionnaire relative to the maximum they could have obtained. The PSTs initially obtained an average score of 54% (Figure 2). They showed an initial knowledge level that corresponded to a mark of 80% for questions MQ1-MQ3 that dealt with the ubiquity of microorganisms and their beneficial nature. Comparatively, the last questions (MQ4, MQ6-MQ8), about the existence of beneficial organisms, whether all diseases are caused by microorganisms, and the ways to prevent and treat such diseases, reached scores beneath the average, which ranged from 31% to 41% (Figure 2). The poor result obtained at MQ4 might derive from the wide-spread thought that microorganisms are all potentially pathogenic, highly infectious, and dangerous (Simard, 2023):

Table 5

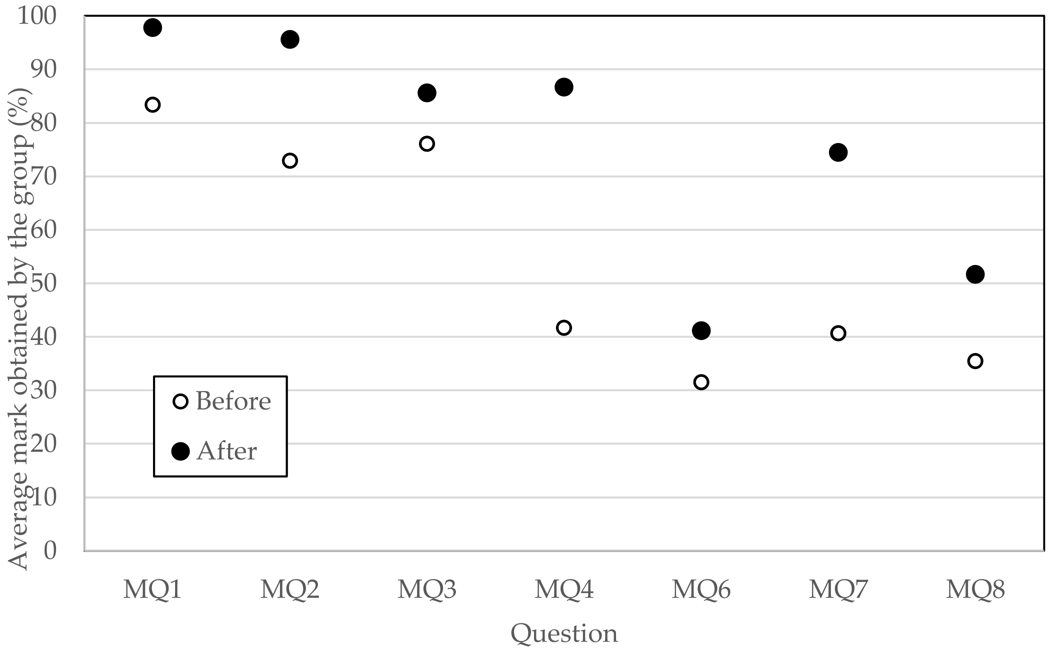
Descriptive statistics of the MQ Questions, χ2 Results and p-Values in Comparisons of Groups A and B.

Timing of the questionnaire	Question	χ^2	p
Before the activity sequence	MQ1	2.822	0.244
	MQ2	5.926	0.115
	MQ3	2.854	0.415
	MQ5	6.130	0.190
	MQ6	5.695	0.223
	MQ7	5.737	0.123
	MQ8	13.474	0.019
After the activity sequence	MQ1	0.026	0.872
	MQ2	1.318	0.517
	MQ3	8.673	0.013
	MQ4	2.230	0.325
	MQ5	14.387	0.002*
	MQ6	4.571	0.102
	MQ7	5.355	0.069
	MQ8	4.888	0.185

Note: *Significant at 0.01 probability level

Figure 2

Responses to the MQ Questionnaire before and After the Series of Activities



Except for questions MQ3 and MQ6, which according to the Chi-square test did not significatively improve after the didactic sequence (Table 6), the responses improved by at least a 10% after the didactic sequence.

Regarding question MQ4, on whether there are beneficial micro-organisms, some of the PSTs understood that this referred to micro-organisms in the human body. In spite of the question being aligned with the recommendation given by Simard (2023) that the centre of the microorganism discourse should better be shifted away from the human being so as to dispel misconceptions, it was the PSTs who brought it back to humans. Also, in line with the idea detected by Bandiera (2007), referring to the fact that microorganisms present in a healthy body are mainly related to protection and defence rather than other functions, four people gave the following answers (which were considered correct): "yes, they help us to be healthy" (PST A14), "yes, beneficial microorganisms help us stay healthy and overcome diseases" (PST A30), "yes, they help take care of our body" (PST B36). However, there were cases in which, by extrapolation of such a conception, the PSTs asserted that antibodies are microorganisms. This can be seen, for example, in the following answers (which were considered incorrect): "yes, for example if there is a virus in our body, they [antibodies] stand up to it" (PST A8) and "yes, defences can be microorganisms" (PST A15). After the series of activities, through which the PSTs had had to establish the functions of *E. coli* in the digestive system and cystitis infection due to the *E.coli* colonisation and proliferation in the urinary tract, the two PSTs who initially answered these questions incorrectly, respectively switched their answers to the following, considered as correct: "yes [..], for example microorganisms in the gut are very important to digest food" (A8) and "yes, when they are in the right place" (A15). Similar to the positive impact reported by Ruiz-Gallardo and Paños (2018) after a practical intervention for Primary School children that involved microorganism cultivation, the knowledge of the PSTs significantly increased not only for question MQ4, but also for MQ1, MQ2, MQ7 and MQ8. This is especially true for questions 4 and 7 respectively where the mark raised from around 40% to beyond 70%, which was the initial score for questions 1, 2, and 3 had initially scored. The answers to question 8 improved the least (10%), and marks for questions MQ6 and MQ8 remained the lowest (Figure 2).

Table 6

Descriptive Statistics of the Questions, X2 Results and p-Values in Comparisons between Before and After the Questionnaire

Question	χ^2	p
MQ1	11.92	0.003*
MQ2	14.603	<0.001*
MQ3	3.249	0.197
MQ4	16.816	<0.01*
MQ6	3.390	0.335
MQ7	21,127	<0.01*
MQ8	50.577	<0.01*

Note: *Significant at 0.01 probability level

Regarding question MQ6, about whether all diseases were caused by microorganisms, three types of erroneous or partially incorrect answers were given before the activity sequence: i) those in which the answer was completely wrong or the person asked stated that they did not know the answer (34% of the incorrect or partially incorrect answers); ii) those in which the person asked answered correctly that not all illnesses are caused by microorganisms, but illustrated their answer with no example or an erroneous one. For example, "No, for example congenital or chronic diseases" (PST A1), ignoring the fact that both congenital and chronic diseases can include diseases caused by microorganisms such as congenital toxoplasmosis and chronic gastritis. iii) those who responded correctly but stated that virus-caused illnesses such as the common flu were not caused by microorganisms since viruses were not microorganisms.

The first and second types of answers indicate the existence of difficulties in understanding terms about the characteristics of the diseases, this is related to the limited medical literacy of society (Falcón & Luna, 2012). The third type of response presumably refers to the lack of knowledge concerning the diversity of microorganisms and to the assimilation of the concept of microorganism to that of bacteria (Marcos-Merino et al., 2019). In this regard, Jones and Rua (2006) also indicated in their work that the lack of clear concepts in this area contributed to misconceptions similar to those described in this work.

It is noteworthy that those people who responded with two words for medications to question MQ8 (8 people out of 96 wrote "medicines and antibiotics") where the word "medication", since it was accompanied by the word "antibiotics", presumably meant "other medications that are not antibiotics", did not answer with a type iii response to question MQ6. That is, there may be a relationship between the integration of the concept of microorganism to that of bacteria and the misuse of antibiotics since, as Robredo and Torres (2021) state, knowing the differences between microorganisms is necessary for understanding that the mechanism of attack and destruction of these infective agents is different and thus may need different treatments.

After the implementation of the didactic sequence, which included the search for information in the literature, the rate attained by the group for questions 4-8, which initially showed a knowledge below the average (54%), improved the least for questions MQ6 and MQ8 (Figure 2). This might be taken as a sign for the previously suggested relation between the assimilation of the concept of microorganisms to that of bacteria and the misuse of antibiotics, as the poor results obtained for question 6 might have had dragged down those of question MQ8, where different treatments for infections caused by different microorganisms had to be specified. Some members of the sample gave answers to question MQ6 in which they implied that they did not consider viruses to be microorganisms and were like the following: "No, in addition to diseases caused by microorganisms, there are others, such as those caused by virus" (PST A10). As previously pointed out, the cause for such answers presumably lies in the lack of clear concepts in this area (Jones & Rua, 2006). In fact, there are different definitions of microorganisms in the literature that exclude viruses, as clearly indicated by the cancer dictionary of the US National Institutes of Health (NIH) (n.d.) for the term "microorganism": "[…] viruses […] are sometimes classified as microorganisms". For instance, at the web of the Centre or Geobiology (2010) viruses are excluded from the microorganism definition while at the online educational science resource e-bug (UK Health Security Agency, 2022) they are included. Another possible source of confusion in this regard is assimilating the terms microbe and microorganism as synonyms which, according to the glossary of the European Society for Neurogastroenterology and Motility [ESNM] (n.d), is not recommended. However, the definition of Royal Academy of the Spanish Language (2022), for instance, equates both terms and thus defines the word microorganism/ microbe as a "unicellular organism only visible under a microscope". If the PSTs link this information with the information that viruses are acellular (Sevillano & Eraso, 2013), they will exclude them from the microorganisms. Or if they assume that all microorganisms are alive (because they are microbes), this may lead to a concatenation of ideas such as the one illustrated with the following example of a PST's response "No. Viruses are not living things and therefore diseases transmitted by viruses are not caused by microorganisms" (PST A2). That is to say, although the person who answered in this way did not subscribe to the aforementioned belief that viruses are living beings (Marcos-Merino & Esteban-Gallego, 2017), they indicated that they do think that all microorganisms are living beings, and that since viruses are not, they do not belong to the microorganism category. In fact, discrepancies among the scientific community about whether viruses are alive or not can also be found in the literature (Koonin & Starokadomskyy, 2016).

After the activity sequence, the marks for question MQ7 about ways to avoid microorganisms entering your body (Table 2) increased by a 34% as more PSTs correctly answered the question, usually by specifying two different hygiene measures amongst which hand washing was frequent.

It should also be noticed that in question MQ1, after the implementation of the didactic sequence, 98% of respondents correctly indicated that microorganisms are ubiquitous, but some of them also clarified that they cannot be seen except under a microscope. For example, a response in this sense was the following: "Yes. They are everywhere but we can only see them with a microscope" (PST A29), an answer that reflects a previous conception described by Marcos-Merino and Esteban-Gallego (2017). As in the work by Robredo and Torres (2021) in this work similar responses have been admitted as correct. Yet, it was surprising to find no further explanations about the fact that microorganisms can be seen with the naked eye when many of them gather, i.e. we can see the colonies – microbes *en masse* – but not the individual organisms, despite the PSTs having cultivated *E coli* and observing its colonies in petri dishes.

Knowledge about Cystitis (RQ2)

To evaluate the results obtained in both groups, the Chi-square test was used to compare the results obtained by Groups A and B. No differences were detected, as shown in Table 7.

Table 7

Descriptive Statistics of the Questions, X^2 Results and p-Values in Comparisons of Groups A and B

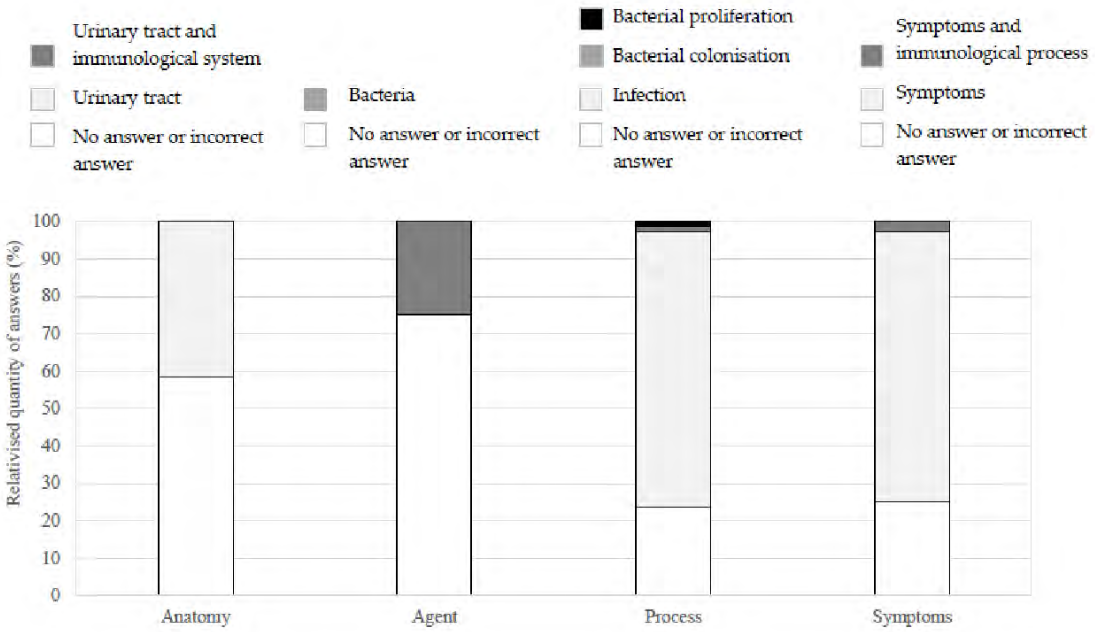
Question	$\chi 2$	p
1	0.747	0.388
2	0.140	0.708
3	1.299	0.729
4	1.169	0.919

In Figure 3, the results regarding the initial questionnaire about cystitis for the whole group of 72 people are shown. More than half of the questioned failed to describe where in the human anatomy cystitis takes place, and the agent that causes it (58% and 75% respectively). In contrast, these frequencies decreased to approximately 25% both for the aspects regarding the infection process and the symptoms of cystitis.

As mentioned, 58% of the questioned failed to define what cystitis is or placed it outside the urinary tract, i.e. in the vagina (12% of the answers considered incorrect) (Figure 3). As Aznar and Puig (2014) detected for tuberculosis in the lungs, the PSTs had difficulties in locating the cystitis infection in the bladder. This may be due to ignorance about human anatomy, particularly feminine anatomy (Pozo et al., 2014; Van Moorst et al., 2012), since some of the PSTs placed the infection in the vagina rather than in the urinary tract. It is also noticeable that 38% of the PSTs whose answers were considered incorrect, responded that cystitis is a “urine infection” which, in Spanish, (the language our PSTs speak), is the usual informal expression for cystitis. In the answers where the words “tract” or “apparatus” were omitted, it is not clear whether this omission was conscious or not. This raises the question of whether the PSTs manifested their thoughts via a metonymy by placing the infection in the urine rather than the surrounding organs as way of expressing themselves, or whether they have a mistaken conceptualisation of the illness.

Figure 3

Responses to the CQ questionnaire



Four people noted that they had suffered from cystitis although they were not asked about this, and a fifth person mentioned that a cousin had had it. Such responses show that cystitis is a familiar problem and one which may motivate PSTs.

Regarding the reasons why someone develops cystitis, (the agent), cold was the most cited reason (74% of the PSTs), while humidity and hygiene were mentioned by 33% of the PSTs and sexual intercourse by 26% of them. Among those who mentioned poor hygiene, 33% identified a bacterium as being the cause for cystitis. Of these, one person (PST B67) who described suffering from recurrent cystitis and identified a bacterium as its causing agent commented: "I've always been told to clean my vulva meticulously, wash it with water only, dry thoroughly, pee after sex, eat red fruits, etc.", thus implying that poor hygiene can be a cause for cystitis.

Approximately 75% of the answers to questions 3 and 4 were correct. In question 3, 74% of the answers referred to an infection when explaining what cystitis was. More detailed answers that entangled bacterial colonisation and proliferation (1.4%) were less numerous. Thus, processes such as bacterial colonisation or proliferation or/and immunological responses, which, for instance, occupy an important space in the infection model suggested by Aznar and Puig (2016), were, at this stage, viewed from afar. Similarly, in question 4, most PSTs (72%) correctly described an urge to urinate and a burning sensation among the symptoms rather than doing so in relation to the immunological processes (1.4%).

No report failed to describe that cystitis was most frequently caused by *E. coli* bacteria from the digestive apparatus. Furthermore, 52% of the reports described that the infection was caused by an *E. coli* proliferation in the urinary tract. In addition, in two reports the recommendation was given that the area should be cleaned backwards (towards the anus) and 28% of the reports described that the urethra is shorter in women and that is why female cystitis is more common.

This might reflect the fact that the PSTs´ knowledge of the anatomy and the agents has increased, especially when compared to their results in the previous questionnaire. It also satisfies the concepts of entrance and proliferation of the infecting agent in a specific organ considered in the Aznar and Puig (2016) infection model. Furthermore, 28% of the reports offered information about the anatomical differences between women and men (women´s shorter urethra) that relate to cystitis being more frequent in women.

It was found that only 32% of the PSTs changed nappies correctly in the sense that they cleaned the baby's nappy area backwards and did not reuse the same tissue or part of the tissue or cloth to clean the doll. After the performance, the PSTs were asked what they thought the objective of the performance was. They usually answered that it was connected to hygiene. When their answer was confirmed, they were further asked in what direction children should be cleaned. Some (10% of the groups) described that boys and girls were to be cleaned differently. However, 55% of them correctly answered that cleaning should be in a backwards direction so as not to spread excrement into the genitalia; sometimes they realised that they had not carried out the cleaning appropriately and corrected themselves. Furthermore, in 14 out of 20 groups, the word "infection" was then used spontaneously in the context of it being avoided by correct cleaning. Only in 9 out of 20 groups were either bacteria or *E. coli* spontaneously mentioned.

Conclusion and Implications

Regarding micro-organisms, the PSTs showed a high initial knowledge on their ubiquity, their presence in a healthy body and the existence of harmful microorganisms. However, they exhibited difficulties when questioned about the existence of beneficial micro-organisms, (which were sometimes confused with antibodies), medical terminology for the description of diseases, and the prevention and treatment of infections.

After the activity sequence, which included the collection of information about cystitis, the formulation of hypotheses about it, and the design and implementation of an experiment to test these, PST knowledge of every issue about microorganisms improved to at least 75% on the scale used. The only exception to this involved the questions that referred to the existence of beneficial microorganisms and the treatment of their infections. This is presumably because of the discrepancy in the scientific literature as to what microorganisms and/or viruses are.

In order to improve the suggested didactic sequence, following Karaarslan-Semiz *et al*. 's (2023) suggestion on equipping teachers in a way that they can access and interpret information about COVID-19 or other similar socioscientific issues in a timely and correct way, we propose to inform PSTs about the existence of the mentioned discrepancies regarding virus in the scientific community, but not encourage them to search for information on microorganisms and/or viruses on the Internet. Instead of this, we would provide them with a definition of both. Secondly, we suggest that knowledge about the correct use and misuse of antibiotics to treat infections caused by microorganisms and/or viruses is also provided by the teacher.

Regarding cystitis, even though initially most of the PSTs knew how to correctly define it as an infection and list some of its symptoms, they showed difficulties in locating it in the bladder, in some cases denoting their ignorance regarding the female sexual anatomy. Also, cold and other factors were more often signalled as the cause for cystitis than bacteria. The laboratory reports show that such difficulties with the location of the infection and the cause for cystitis were apparently overcome but then, when the transference session was carried out, it was observed that the PSTs did not perform coherently. Here, we would propose a further improvement: in the future, a modelling sequence would be implemented, including the construction of a 3D model of the human body, in which the PSTs represent the macroscopic and microscopic elements and processes that take part in the infection. Building 3D models may facilitate the visualisation of the system itself and may lead to a better understanding of both the location of the infection and the processes underlying the cystitis.

This study is, to our knowledge, one of the few focused on Early Childhood PSTs' knowledge on microorganisms, as well as on suggesting a series of activities to teach about microorganisms in ECE degree. Thus, the results obtained are considered in light of its exploratory nature and it is reckoned that more data needs to be collected on the issue, both at the University of the Basque Country and other universities. To that end, the authors of this work will implement again the revised versions of the activity sequence described here that will comprehend, as explained, the following: (1) the teachers will provide the Early Childhood PSTs with information about microorganisms rather than letting them search for it on the web so as to avoid confusion derived from lack of scientific consensus about the issue, and (2) the students will build 3D anatomic models that will later be used for diaper-change so as to promote the comprehension of the infection causes and process. Also, to further ensure safety in ongoing work, non-toxigenic commercial *E. coli* samples will be used.

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Appendix 1

Questions Included in the Questionnaire about Microorganisms, Marking, and Answer Examples with the Corresponding PST´s Code

Number	Question	Marks (points)	Example of answers of PSTs
MQ1	Are there microorganisms around us? Explain your answer	0	I don´t know (B32).
		0.5	Yes (B48).
		1	Yes. Microorganisms are everywhere (B3).
MQ2	Are there microorganisms in your body when you are healthy? Explain your answer	0	There are not. Microorganisms make us sick (B42)
		0.5	Yes, but I cannot explain my answer (B33).
		1	Yes, all over it (B11).
MQ3	Are there pathogenic microorganisms? Explain your answer.	0	I don´t know, but I guess there are (B44)
		0.5	I believe so (B34).
		1	Yes, for example some bacteria may be pernicious for us and cause infections (A31).
MQ4	Are there beneficial microorganisms? Explain your answer	0	I don´t know (B32)
		0.5	Yes (A19).
		1	Yes, there are. For example, in yoghurts or in decomposing bodies (A31).
MQ5	Are there microorganisms in your body when you are sick?	0	I don´t know (A11)
		0.5	Yes, I don´t know where (A19)
		1	Yes. The flu, for instance, in such case, microorganisms are mainly in the respiratory system (A27)

MQ6	"All illnesses are due to microorganisms". Is this true? If your answer is negative, give an example	0	I don´t know (B39)
		0.5	No, it isn´t. Other particles can also cause illness (B4)
		1	No, for instance a heart attack (B50)
MQ7	Mention at least two measures to prevent microorganisms from entering your body	0	No answer (A27)
		1	Hand washing. I don't know any other (B40)
		2	Face masks, screens (B50)
MQ8	Mention at least two measures to eliminate microorganisms from your body	0	I don´t know (B5)
		1	Medicines. I don't know any else (B40)
		2	Penicillin and amoxicillin (B12)

*Note: MQ1, MQ3, MQ4 adapted from Molina et al. (2021); MQ2, MQ5, MQ8 adapted from Bandiera (2007); MQ6 adapted from Robredo and Torres (2021).*The answers were obtained before the activity sequence.*

Appendix 2

Ideal Answers to Questionnaire about Cystitis

Number	Question	Ideal response
CQ1	What is cystitis?	Cystitis is inflammation of the bladder, usually caused by a bladder infection.
CQ2	Why do you think someone develops cystitis?	Because the openings to the urethra, vagina and anus are close together, and bacteria can get into the bladder easily. Sexual practices. Bad hygiene.
CQ3	Why does cystitis happen? What infectious agent generates it?	The commonest cause is bacteria entering the bladder through the urethra. Most cases of cystitis are caused by a type of Escherichia coli (*E. coli*) bacteria
CQ4	What are the symptoms?	Pain or burning when you pee. Needing to pee more often and urgently than normal. Presence of blood in urine. Low fever.