Model and methodology for developing empathy. An experience in Computer Science Engineering

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***Abstract*—*Contribution:* This article proposes and applies a new systemic three-dimensional model and a methodology for empathy awareness and development, integrating different partial approaches found in the literature for developing empathy as a transversal competence. *Background:* Empathy is a competence linked to collaboration and teamwork. Perspective taking is an important component of empathy and it is key for professionals today. Even though empathy is valued in Computer Science Engineering courses, it is not yet fully addressed as an integral part of the training process. *Intended outcomes:* Both the model and the methodology are put into practice with a group of first year Computer Science Engineering students, highlighting the possibilities of the proposal for this course of studies. The experience presented here is an example of a classroom activity in which awareness and perspective taking are addressed, as key components, in relation to the collaborative work towards achieving empathy. *Application design:* The methodological proposal is applied to guide educators' decisions so that they can work on empathy in the classroom. Responses to several standardized and ad-hoc questionnaires by students from two universities are analyzed. *Findings:* The results revealed low to medium empathy levels in participating students, but a higher perception of their own empathic ability. The proposed methodology allows students to become aware of and develop some initial changes in relation to empathy, particularly in its perspective taking component, through classroom work.**

***Index Terms*—Higher Education, Computer Science Engineering, Model of Empathy, Professional Skills, Transversal Competence, Active Learning, Perspective Taking**

I. Introduction

EMPATHY is considered to be one of the essential transversal competences for engineers and computer scientists in the 21st century [1] [2]. Transversal competences are those that do not depend on a specific subject area or discipline, but may be required in multiple and diverse professional and/or academic domains. In the European Framework for the Personal, Social and Learning to Learn Key Competence, empathy is defined as "The understanding of another person's emotions, experiences and values, and the provision of appropriate responses" [3]. It is related to collaboration, cooperation, responsibility, and assertiveness. Perspective taking, a component part of empathy, is a skill that involves an intentional or deliberate process in which the observer tries to imagine the other's world [4], [5].

In the field of Computer Science Engineering, empathy is required to develop computational thinking which involves applying fundamental concepts of Computer Science in order to solve problems, design systems, or understand human behavior [6]. The challenge of solving problems through computational thinking skills requires the development of socio-emotional aspects and language and communication abilities [7], empathy being a fundamental competence in these cases [8]. In this context, empathy plays an important role in the development of teamwork skills [6], [9] and the establishment of relationships with stakeholders [10] in order to understand their needs, for example, in the design and development of technology [11].

As mentioned in [12], skills and abilities that complement knowledge are necessary to fulfill professional expectations in modern workplaces. Engineers, in general, face challenges when they have to manage project groups because such positions demand skills in social competence and empathy. As evidenced in previous studies, engineers usually have a low degree of social competence skills [13]. Haag and Marsden [11] consider the concept of empathic design, and state that empathic participation is particularly important in overcoming egocentric approaches in design; that is, engaging with users who are dissimilar to the members of the specific design team. Furthermore, some authors consider that design- and engineering-related studies should include awareness-raising as to how to develop empathy [11], [14], rather than relying on automatic reactions and intuition. Also, some authors highlight the necessity to work the ability to think from the perspective of others and to develop teamwork skills [15]. This could be important for contributing to societal development and preparing students to work as responsible members of a global society [16].

These works consider that empathy is sustained by abilities that can be taught and learned [17], [18]. Other works recognize the value of including empathy as a training interest [10], [11] and its subsequent impact on the work of engineers and computer scientists [10], [19]. Despite the importance of training these professionals to be able to use empathy, there is a lack of guidelines for carrying out such training [18].

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Some works [20] state that students have a high level of relevant technical training, but lack the mechanisms to put themselves in someone else's position, or even to understand how this concerns them, and therefore they risk taking ill-defined problems as a starting point [21]. This fact seriously limits their skills to develop a good professional performance responding to real user and market needs.

In this paper, specific models, techniques, guidelines, and experiences to develop empathy, specifically in Engineering and Computer Science students, are revised, and a model is proposed (which integrates different aspects considered only partially in the literature) together with a methodology to work on empathy in the classroom, based on the information reviewed. This methodology is unique in that through different phases it guides the design and implementation in the classroom of activities that help students become aware of their own empathy and develop it further. It also suggests instruments for measuring empathy and student perception about this ability. The methodology is put into practice with a group of first year Computer Science Engineering students, highlighting the possibilities of the proposal for this degree. The results are analyzed with an emphasis on the perspective taking component of empathy. In addition, several variables (university and gender) are considered that may be related to student empathy measurement and assessment.

It is important to understand that the development of empathy is a long-term goal. Learning empathy, as an important interpersonal aspect of developing emotional intelligence [22], should begin with an awareness and perspective phase, and continue with different activities that progressively promote the enhancement of the competence. The proposed methodology is a useful tool for designing such activities, including those involved in the early stages of development. The experience presented in this paper is a specific example of a classroom activity in which the initial stages are addressed, from awareness and perspective taking to collaborative working on empathy development. As such, it is an initial contribution to the improvement of empathy in Computer Science studies.

The article is organized as follows. Section II presents the concept of empathy, and the processes involved in this competence. Section III analyzes related works that consider empathy development in education, with an emphasis on Engineering and Computer Science studies. Section IV proposes a systemic model for approaching empathy and, based on this model, a methodology is defined to work on empathy in the classroom. In Section V, the methodology is put into practice in two introductory programming courses in Computer Science Engineering. Section VI presents the results, which are then discussed in Section VII. The limitations of the proposal and future work are described in Section VIII. Finally, the conclusions are presented in Section IX.

II. Theoretical Foundations

Competence is a human quality that appears as a dialectical synthesis in the functional integration of knowledge (diverse knowledges), know-how (abilities, habits, skills and capacities), and knowing how to be (values and attitudes). All of these are part of an ideal performance based on the personological resources of individuals, which allow them to be in a socio-professional and human environment and to adapt to its characteristics and complex demands [23]. Different approaches in education and the industry have adopted competences as a significant reform element, as explained in [24].

This article focuses on the competence of empathy and on perspective taking, as one of its key components. Several authors define empathy as a transversal competence that is fully addressed by social disciplines but is considered a soft competence in the core of Computer Science, Engineering [1] [18] and hard disciplines in general. From the point of view of the process involved in empathy, some works [18] describe this competence as comprising three essential qualities: a cognitive component (knowing what another person is feeling); an emotional component (feeling what another person is feeling), and a response component (responding with compassion based on the other person's experience). Other authors consider empathy as a construct in which three possible types of processes can be found depending on the level of cognitive activity [4] and the level of consciousness that they require: non-cognitive processes, simple cognitive processes, and advanced cognitive processes. Advanced cognitive processes are intentional, which means that individuals need to learn how to differentiate their own maps from those of others, taking context into account. Additionally, these advanced cognitive processes are linked to the notions of empathic design and the needs of Computer Science and Engineering professionals, as argued by the authors mentioned in the introduction.

The importance of developing the processes that underlie the competence of empathy throughout the teaching-learning process is evident [10], [11], [18]. It is important to highlight that the empathy learning processes promoted in different European countries [25], emphasizes the importance of responsible decision-making. In this regard, the development of empathy is based on the advances of the **Skills** that make it possible, but with a view of the learner as a future professional who will have to make decisions, with an awareness of knowing how to be, within a framework of global citizenship. In this sense, the Organisation for Economic Co-operation and Development (OECD) research includes empathy as one of the key elements for social progress [26]. Therefore, considering the learner as a future professional is related to **Professional Performance**, knowing what to do when faced with a given situation at work that requires, as well as personal resources, the willingness to want to act in addition to knowing how to act at that specific moment, in accordance with the six attitudes presented in the conceptual Model of Competences for Democratic Culture [5]. The ontological dimension of **Global Citizenship** connects with the values of individuals in their relationship with themselves and with the world. It is relevant that students learn to value the commitment to social transformation in the different contexts in which they participate: classroom, educational institution, and local-global communities. To this end, it is key to take into account the Sustainable Development Objectives (SDO) [27] and the three aspects regarding global citizenship also from the conceptual

Model of Competences for Democratic Culture [5]. This allows understanding diversity and being flexible in each situation, as well as making the appropriate decisions. In addition to this, the **Skills** mentioned in Walther's model are considered important for developing empathy in engineering students [18]: Self awareness, Emotion regulation, Affective sharing, Awareness of others, Perspective taking, and Mode switching. Within this context, we further analyze perspective taking (PT) in this article as a key component of empathy. PT is present in existing integrative approaches to empathy measurement that have developed scales to measure individual differences in empathy, such as the Interpersonal Reactivity Index (IRI) [4] and the Cognitive-Affective Empathy Test (TECA) [28]. These approaches, together with the Empathy Quotient (EQ) [29], integrate the cognitive and affective aspects. In this research, the EQ is used, showing excellent psychometric properties [30]. The internal consistency value obtained for the EQ questionnaire yielded a Cronbach's Alpha of 0.85 [30]. It should be noted that the Baron-Cohen EQ questionnaire was used because it is a freely distributed test and has been validated with a Spanish university population [31].

In summary, the three dimensions, namely, Skills, Professional performance, and Global citizenship must be integrated to guide the implementation of activities focused on empathy awareness and development. These dimensions have served as a guide for the proposal presented here and its analysis through the research questions that are formulated.

III. Related Work: Proposals and experiences in empathy development

Various works that propose conceptual models, methodologies and guidelines to address empathy training for students were reviewed. In particular, we analyze those articles that consider Computer Science and/or Engineering students. Among them, approaches based on design and oriented to different purposes have been found, such as understanding and knowing how to communicate with clients and end users, which is directly linked to developing the skills required to be able to empathize with others. Some works [20], [32] focus on developing empathy towards end users in future engineers through a technique that considers multidisciplinary group work aimed at learning how to understand the language and point of view of "the other". Other recent works use the "Personas" method for working and improving empathy and teamwork competences in Computer Science students [11], [20] or for developing a multidisciplinary learning experience to show the different perspectives and to help engineering students to include empathic elements when designing software systems [32]. In these works, skills such as perspective taking through group dynamics, and affective aspects to develop empathy are deployed, and the objective is to achieve effectiveness in professional work and to adapt to target users. However, there are important skills included in the model discussed in [18], such as self and other awareness, which are not taken into account in these works. Riemer mentions carrying out activities, such as role playing and peer reviews, that can support the development of emotional intelligence, including empathy [17]. This can contribute to the development of self and other awareness skills, as well as leading to decision making based on professional performance. Beyond the skills linked to empathy, contextualization is essential for ethical decision making. In this context, Batchelor and Bobrowicz [14] address empathy and the ethical aspects to be integrated into a practice related to the design and use of technology by adults over 60. Their strategy revolves around using videos with interviews with older adults to know their points of view and habits. Blanco et al. [20] present a multidisciplinary teaching intervention based on the use of human-centered design methods (such as Personas-Scenarios) to upgrade the competitive capacities of Computer Science Engineering students by fostering a change in their design experience, both from a technology-centered to an empathic design approach [33] and from individualistic to common performance. In particular, this intervention targets those aspects relating to working in multidisciplinary teams and to defining requirements based on the user's empathy and knowledge. Another experience in the classroom [32] uses design thinking techniques with an empathy mapping tool to answer these questions [34]: What do end-users do? What do end-users say? What do end-users think? And what do end-users feel? Levy [32] uses the empathy map to analyze conversations and interviews with stakeholders, especially end customers. Also, they put these techniques into practice with Engineering and Design students, who first worked independently and then in a multidisciplinary fashion.

Rasoal *et al* [13] present and measure the level of empathy in Engineering students using the four subscales of the Interpersonal Reactivity Index (IRI): PT, fantasy, empathic distress and empathic concern. The previous works take into account respect, responsibility and self-efficacy, as well as openness to other cultures and realities, but are conceived not so much from a perspective of a framework of global citizenship, which would be very relevant, as from the point of view of professional effectiveness, to consider the needs, for example, of older adults.

Moreover, some works have been found that model or propose guidelines and specific practices to include empathy in the training of students, specifically for Computer Science and Engineering students. However, no methodology has been found that proposes steps to guide practices for developing empathy and measuring results. For this reason, a general methodology with stages addressing these two components – practice and evaluation - is proposed in this work. This methodology is based on a model that integrates key ideas presented in previous works, considering skills [18], professional development [5], and aspects of global citizenship [5], [27] and understanding that empathy involves cognitive and affective processes, and that PT becomes relevant for developing this competence in students. The main focus is on Computer Science Engineering (CSE) students. At the same time, it is important not only to strengthen the skills required to generate more useful methodologies, but also to evaluate professional performance [5] beyond achievement, to include the perspectives of global citizenship [18], knowledge transfer, and openness to new cultural realities. For this reason, educational proposals need to include a commitment to human rights and to generate sustainability and development projects based on these. This would promote a new enhanced vision and therefore an idea of empathy connected with others, even without knowing them.

IV. Empathy Model and its methodology proposal for the classroom

This section introduces the proposed empathy model and then describes the methodology applied for putting empathy into practice in the classroom.

A. Skills, Professional & Citizenship (SPC) Model for Developing Empathy from a Situational, Systemic and Global Perspective

The design of a model that integrates the different proposals for developing empathy as a transversal competence is required to support the classroom approach and methodology. No model integrating all the aspects understood as fundamental in a transversal approach has been found. Therefore, the model proposed here, called Skills, Professional & Citizenship (SPC), considers empathy as a transversal competence. Competencies include what a person does in a specific situation at a specific time. Also this model considers Perspective taking as a component of empathy that requires that people know how to identify different perspectives, and especially be able to differentiate between their own and those of other individuals. However, understanding that there are different perspectives and knowing that the focus of attention can be changed does not mean knowing how to do this. Moreover, believing or feeling that you can do something does not mean that you know how to do it, particularly in a specific situation or context.

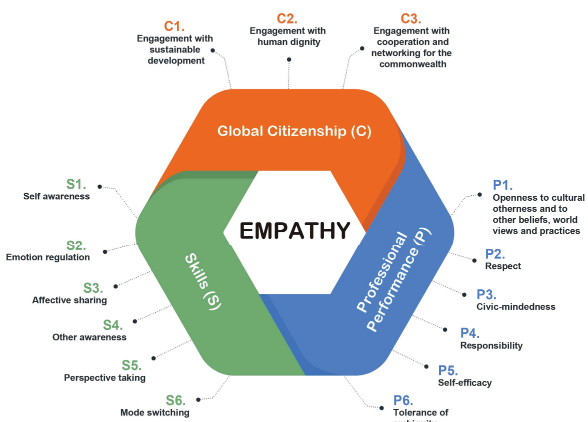

Fig. 1. Skills, Professional & Citizenship (SPC) model for empathy development

The design of the SPC model (Figure 1) allows raising awareness and developing empathy by building the human skills that make empathy possible. Also establishing the scope for attitude development, while being a responsible citizen from a global growth perspective, in accordance with the theoretical foundations and with the study carried out in the related work section. The three dimensions making up our model and their components are as follows:

- **Skills (S)**: The proposal includes six skills (based on the skill scope presented in [18]):
  - S1. Self awareness, which involves a deep understanding of one's emotions, strengths, weaknesses, needs and impulses [1]
  - S2. Emotion regulation, which includes the ability to regulate one's own and other people's emotions, moderating negative emotions and intensifying positive ones [35]
  - S3. Affective sharing, which refers to strictly automatic mirroring of the 'bottom up' aspect of others' emotions, for example, babies crying at the sight of another baby crying [36]
  - S4. Awareness of others, which refers to the ability to feel with others and experience their internal world [37]
  - S5. Perspective taking (explained in the previous sections)
  - S6. Mode switching, which refers to the ability to recognize, consciously apply, or switch between empathic and analytic cognitive mechanisms [18]

  These dimensions provide feedback to each other, and each one involves knowing, knowing how to do and being able to do, that which combines technology (what I know, what I know how to do and what I can do) with methodology (how I do, how it is done and how I can do it).
- **Professional Performance (P)**: The deployment of competence, acting when faced with a given situation at work, requires in addition to personal resources, the willingness to want to act. It also has an epistemological dimension that explains why you want to do what you do in that specific situation and knowing how to be at that specific moment [12]. Student immersion in the ethical frameworks of the profession is essential for the development of these six attitudes in accordance with the conceptual Model of Competences for Democratic Culture presented in [5]: P1.Openness to cultural otherness and to the beliefs of others, world views and practices, P2.Respect, P3.Civic-mindedness, P4.Responsibility, P5.Self-efficacy, and P6.Tolerance of ambiguity.
- **Global Citizenship (C)**: This ontological dimension connects with the values of individuals in their relationship with themselves and with the world [16]. It is important that students learn to value a commitment to social transformation in the various contexts where they participate: classroom, educational institution, and local-global communities. For this, the focus is on engagement in relation to three aspects of value: sustainable development (C1), human dignity and cooperation (C2), and networking for the common good (C3). The first focuses on the Sustainable Development Objectives (SDO) [27], while the second and third are based on the global citizenship competences from the conceptual Model of Competences

for Democratic Culture [5].

B. Methodological Proposal for Developing Empathy Using the SPC Model

The goal of this methodological proposal is to be able to guide educators' decisions so that they can work on empathy in the classroom, knowing that awareness and perspective taking are a vital part of a long-term job. The methodology follows a series of stages or iterative phases that help educators to plan their activities (Figure 2). The methodology considers the components of PT and empathy measurement to be central to the training process, so that educators can assess how empathetic their students are and how they are perceived. Thus, a more personalized planning of the teaching and learning processes of this transversal competence is possible. This can be useful when deciding to delve deeper into developing this competence, considering aspects such as time management, task complexity, motivation, and attention. These components of the methodology were found in other related works. The proposal is based on the fundamentals mentioned in [38], where it is stated that learning is a process by which knowledge is created through the transformation of experience, as explained in Kolb's learning cycle [39]. In addition, it is important to provide both external and internal stimuli [40]. For this reason, the proposed methodology is based on Kolb's classic iterative cycle of 4 phases, incorporating 2 more phases oriented to providing stimuli, both from peers and teachers.

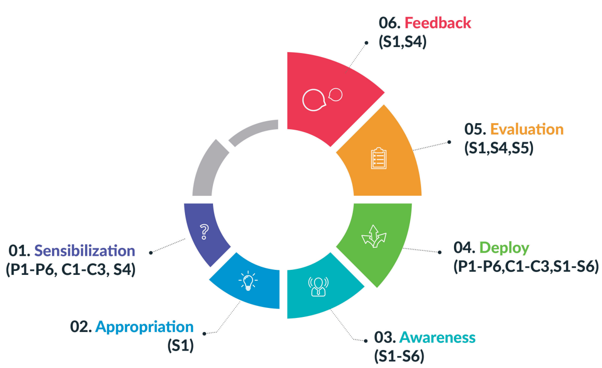

Fig. 2. Iterative cycle of the methodological proposal to develop empathy in the classroom

Figure 2 shows an outline of the phases from 1 to 6, and their link with the three dimensions of the model, also representing the idea that the cycle is iterative. In the literature reviewed, most of the interventions or experiences describe fundamentally Deployment phase 4, where the focus is on developing empathy through different methods, such as Personas or Role playing [5], [11], [41]. When describing the phases (below), connections with scopes and/or aspects of the SPC model will be indicated in parentheses following the codification shown in Figure 1.

Phase 1. Sensibilization. This stage has two goals: bringing students closer to a task to be solved, and learning about the importance of empathy. In this stage, students are asked to work on a problem specific to their discipline, which involves all the professional performance attitudes (P1-P6). For example, a design task, solving a programming problem, etc. within a specific context so that the alternatives available are consistent with those found in a real-life situation. The situation should also generate social value taking into account the three aspects considered in the model (C1-C3). This may involve listening to a problem presented from the point of view of end users, a client, or the educator (S4), which can be simulated through cases or based on an actual experience. In addition to presenting the problem, the educator gives an explanation to show that part of the goal of the activity is to address empathy as an essential competence for the resolution process. The educator also explains the concept to students so that they can focus on it, since in many cases this will be the first time they will have reflected upon these processes.

Phase 2. Appropriation. The goal is that students can approach the problem using their own logic and knowledge. Students analyze the problem on their own, individually processing the task to be carried out in order to delve into it and to assess what they know, what they do not know (S1), and what may require other sources of information. This may involve solving part of the problem, writing down the requirements from their perspective, etc., which will be determined by each particular context.

Phase 3. Awareness. An evaluation is carried out using a standardized questionnaire to measure empathy (S1-S6), such as those reviewed in Section II. EQ is particularly suitable, since it is easy to use and is available for free both in English and Spanish. This will help the educator have an idea of what the students' empathic competence is before seeing them in action. In addition, it contributes to students' reflection and self-assessment, preparing them to acquire the skills necessary for professional work [12].

Phase 4. Deploy. This phase is flexible –educators can adapt this proposal to their context. The goal of this phase is to ask students to solve the task from the perspective of other individuals, considering their emotions and actions (S1, S4 and S5). For instance, they can be asked to share their vision of the problem with a partner or a group. In addition, students can be asked to solve part of the task in collaboration with a partner, or taking over someone else's work and completing the task after analyzing their progress. Thus, through communication, collaboration, and diversity perception, they work on PT (S4) by considering how other students approached the task during the individual work phase. The educator may propose using specific strategies for communicating, exchanging ideas, listening, focusing on something in particular, etc. This will in turn favor creativity, searching for new alternatives and possibilities for resolving the problem, and assessing their suitability based on the given context (S1-S6, P1-P6 & C1-C3). This will help develop empathy following the three dimensions of the SPC model. Depending on the problem, this phase could require different tasks that involve multidisciplinary work [20], [32] or could involve being aware of the point of view of stakeholders [14].

Phase 5. Evaluation. After the deployment phase, the methodology suggests students carry out a self- and peer-evaluation phase to assess their own empathy and that of their classmates (S1, S4 & S5). These results allow analyzing and contrasting the score obtained in a standardized empathy questionnaire with the perception linked to the development of the specific activity proposed in the classroom. This can help the educator, as well as the researchers, compare results and delve into how students perceive themselves. It is also a good opportunity for reflection about classroom work. Additionally, satisfaction questionnaires about the activity and for gauging student interest can be used at this point. This phase provides students with a space for awareness and reflection (S1).

Phase 6. Feedback. After completing these evaluations, the educator should give feedback to the students about the experience and the results obtained, creating a space for reflection and an opportunity for improvement in future experiences (S1 & S4). On the other hand, if the methodology is applied as part of a research project, other variables that could affect the results obtained, such as gender, context, and disciplines, could also be considered during this phase.

The methodology proposed here is considered to be a contribution towards guiding educators and researchers to work on developing empathy. It is aimed at meeting the needs mentioned in the introduction, given the lack of guides for training in this competence despite its significance, specifically for Computer Science Engineering students. It also integrates its own empathy model (SPC), where three dimensions and fifteen aspects relevant to the process are systemically included. We recommend applying the methodology starting from the initial years of a course of studies. A comparative assessment should be done at some point during the final years of studies to determine its effect, using the EQ questionnaire.

V. Application of the Proposed Methodology

A. *Purpose of the experience*

The methodology presented above was used at two universities to design and implement a classroom experience aimed at working and evaluating the empathy competence in Computer Science Engineering students. The following research questions guided the analysis of the experience:

Q1. Regarding the measurement of empathy in participating students: (a) What is the empathy level of the students? (b) Are there any significant differences observed depending on gender? and (c) Depending on the country of residence?

Q2. How do the students perceive their behavior and the behavior of others during the experience, from the perspective taking point of view? What is the relationship between their perception and the results obtained through the empathy tests?

Q3. How do students value this type of experience? What do educators conclude about students' participation in the experience?

B. *Context*

The experience was carried out in 2019 in the first-year "Programming" course of the Computer Science Engineering degree at the National University of La Plata (UNLP) in Argentina, and in the "Programming Fundamentals" course at the University of Zaragoza (UZ) in Spain. Between both universities, 55 students participated (41 men and 14 women), of which 33 were from the UNLP (25 men and 8 women) and 22 were from the UZ (16 men and 6 women). The courses were selected in order to work on empathy in the first year of the degree in both universities, and they are both aimed at introducing the basic concepts of programming based on the idea that a program consists essentially of data and instructions. Different types of data and control structures for combining instructions are presented and applied to problem solving. Additionally, students are trained in the use of the most relevant programming techniques, such as the abstraction and decomposition of programs.

At the methodological level, these courses are organized around three types of activities: theoretical-practical sessions, problem solving, and laboratory practice. All three activities have a clear practical component aimed at solving specific problems, where students have to apply analysis, design, and programming techniques. From the point of view of contents, the courses have two main blocks. The first block introduces simple data types, instructions, and control structures. These introductory concepts allow solving a wide range of simple problems that students use to assimilate programming techniques. The second block introduces composite data types and presents new programming techniques (abstraction and composition/decomposition), aimed at approaching more complex problems.

C. *Design of the experience in the classroom*

This subsection describes the design of a classroom activity aimed at developing empathy competence and its evaluation, considering the context presented above (the statement and the materials of the classroom experience are available online in [42]). The activity consists of solving Sudoku puzzles, a mathematical game turned into a hobby. As part of the activity, students must program a set of methods that manipulate data matrix structures, which are data structures that represent these puzzles.

The experience begins with the 1. Sensibilization phase aimed at introducing the problem to be solved and raising awareness among students about the importance of empathy as a transversal competence. This phase is addressed as a group at the same time as the students become individually familiar with the problem proposed as part of the activity. As regards the model, the discussion focuses on professional dimension attitudes (P1-P6) and context attitudes (C1-C3), and on the fact that students will be working with others to raise awareness towards this (S4).

Then, the 2. Appropriation phase aims at ensuring that students understand the data and algorithms involved in the problem. They have to program individually two methods (or functional modules) to read/write a Sudoku from/to a text file. From the perspective of the model, the methods can be used to test the professional dimension skills (P1-P6) and to know what is understood about the problem and what is not, in a conscious manner (S1).

After the first class, in which the two initial phases are completed, the 3. Awareness phase takes place. The aim of this phase is to establish the empathy coefficient of the group and analyzing the variables that can affect it. Students fill out the EQ questionnaire [29] in its Spanish version with 60 items [43] in their own time, not in the classroom. This questionnaire was programmed as a Google Form and is useful for self-reflection in relation to all dimensions in the model (P, S and C). The students' responses were scored as indicated in [43].

The 4. Deploy phase is the core of the experience. It consists of solving in a collaborative way two tasks aimed at programming a set of methods to check if a Sudoku puzzle was correctly solved. Each task has a duration of 45 minutes. For the first task, students are randomly paired to work together. Then, before starting the second task, these pairs are once again randomly grouped with other pairs, i.e., students work in groups of four. Each pair has to explain to the other pair how they programmed the methods proposed as part of the first task, emphasizing the most relevant design and programming decisions they have made. Then the pairs exchange their solutions and continue with the programming tasks. This phase puts all the model dimensions into practice. By pairing up randomly, the students are exposed to other individuals they do not know (S4 & S5), which is what happens in the real world at work (P1-P6) and in society (S). The students have to consider and understand the perspective of the others (S5 & S6), which forces them to set aside their own perspectives. Similarly, when working on the exchange task, they learn how to listen (S2, S3, S4 & S5), to agree, to consider the essential aspects of the others' perspectives, and to work together to solve, be efficient, and consider diversity (P1-P6). The verbalization of the work carried out by each pair must be such that the other pair understands (S3, S4, S5 & S6), and the solution proposed and the difficulties encountered have to be accounted for (P1-P6 & C1-C3).

Finally, the two last phases of the experience are 5. Evaluation and 6. Feedback. For the former, students deliver the resulting programs and fill out a final questionnaire consisting of 5 items referring to PT assessed on a 5-level Likert scale. The questionnaire aims at assessing one's own empathic capacity and that of others (S1, S4 & S5). For the latter, the feedback phase, the educator presents and analyzes the results obtained from the entire process. These results are discussed as a group, paying particular attention to difficulties in terms of PT and communication identified during the experience. In this phase, the aptitudes related to self-awareness and awareness of others are tested (S1 and S4) from the model point of view.

D. Instruments used in the experience

As indicated in phase 3.Awareness of the activity, the EQ questionnaire has been used and recommended as part of the proposed methodology, since it is short and easy to use and score. The items are used to assess the degree of agreement with the statement on a 4-level Likert scale (from strongly agree to strongly disagree). The levels of empathy established according to the cited authors are: 0-32: Low (most people with Asperger syndrome or autism score around 20 points); 33-52: Average (most women score around 47 points and most men score around 42); 52-63: Above average; 64-80: Very high; and 80: Maximum.

We considered both the general results of the participants' empathy quotient, as well as the score obtained in the items that refer to PT as an advanced cognitive process, which is the focal point in this study. Table I shows the formulation of the 5 items that refer to PT in the EQ questionnaire.

TABLE I
PT ITEMS IN EQ QUESTIONNAIRE. FROM BARON-COHEN [43] (PP.179-184)

Perspective Taking items
5. People often tell me that I went too far in driving my point home in a discussion.
9. In a conversation, I tend to focus on my own thoughts rather than on what my listener might be thinking.
13. I find it easy to put myself in somebody else's shoes.
22. Other people tell me I am good at understanding how they are feeling and what they are thinking.
40. I can usually appreciate the other person's viewpoint, even if I don't agree with it.

At the end of the activity, the students complete a questionnaire about their perception. This was developed by the authors by considering questions present in EQ [43] and TECA [28] questionnaires. More specifically, 5 questions were directly selected from the TECA test (shown in Table 2) which has a reliability of 0.70 considering Cronbach's alpha value. The selected questions refer to PT with a 5-level Likert-type scale (from 1-Never to 5-Always).

TABLE II
QUESTIONNAIRE ITEMS FOR SELF- AND PEER-EVALUATION

1. I have taken into account all points of view before making a decision.
2. When someone in the group seemed to be in disagreement with me or had a bad attitude towards me, I tried to understand their reasons.
3. I have put myself in other students' shoes to understand how they might act.
4. I have listened to other students' opinions, even if I had my own.
5. If a classmate had a problem, I imagined how I would have felt in their shoes.

Through this self-evaluation questionnaire and peer-evaluation, students assess their own competence in PT and that of the peers with whom they worked. It should be noted that this is not a post-test assessment to analyze the impact on the development of empathy, but rather to learn how students perceive their empathic capacity during the performance of a specific task. These results allow analyzing and contrasting the score obtained in a standardized empathy questionnaire with the students' perception after the classroom experience.

E. Data analysis methods

In this work, we have adopted a multi-method approach in terms of research methodology and analysis of the results [44]. A quantitative approach was used in relation to EQ and PT assessment. The data analysis was carried out using IBM SPSS Statistic, V. 22. Firstly, a descriptive analysis and interpretation of the results of the EQ questionnaire was carried out segmenting by universities and gender. In addition, we analyzed whether there were significant differences using the U Mann-Whitney test. A qualitative approach was considered in relation to teachers' observations and students' perceptions of the experience. The frequencies obtained in the answers to the questions related to PT (Table I) were analyzed and these frequencies were contrasted with those obtained in the questionnaire for self and peer evaluation (Table II) to find similarities and differences and to identify the degree of self-awareness. The participating teachers systematically collected observations and comments throughout the work and feedback process, analyzing narratives. The latter was contrasted with the information obtained from the questionnaires. In this way, the multi-method approach increases the validity and reliability of study findings [45].

VI. Results Analysis

This section presents the results obtained when using the methodology for the activity described above. In particular, the results are analyzed based on the research questions presented in Section V-A. Subsection VI-A presents the results in relation to the questions about student empathy measurement (Q1); while subsection VI-B discusses the results related to perspective taking, component of empathy, and self- and peer-evaluation issues (Q2). Subsection VI-C discussess the results pertaining to student satisfaction and perceived usefulness of the activity (Q3).

A. Results regarding the EQ

Table III shows a categorization of the results obtained with the students who participated in the experience. These results show that most scores are in the "Low" and "Average" categories. Furthermore, only some women scored above the average. There were no significant differences between UZ students and UNLP students, which was confirmed by applying the Mann-Whitney U test for non-parametric samples.

TABLE III
EQ results by university, segmented by gender

EQ Scale		%					
		UZ	M	F	UNLP	M	F
Low	0-32	31.82	31.25	33.33	33.33	36.00	25.00
Average	33-52	63.64	68.75	50.00	60.61	64.00	50.00
Above Average	52-63	4.55	0.00	16.67	3.03	0.00	12.50
Very High	64-79	0.00	0.00	0.00	3.03	0.00	12.50
Maximum	80	0.00	0.00	0.00	0.00	0.00	0.00

As regards the issues posed by the first research question, with a certain degree of caution due to the limitations inherent in the size of the sample, the following points of agreement with previous research studies can be stated:

- CSE students have empathy levels that mostly range between "Average" and "Low", compared to the general population [13].
- Differences by gender are observed in favor of women over the total sample, with a difference that can be considered statistically significant (U de Mann-Whitney = 0.021; $p < .05$), in agreement with other studies [13], [15].
- Finally, no significant differences are evidenced when comparing results by country.

B. Perspective Taking Results

Regarding the five items related to PT (Table I), the results are analyzed based on the frequencies obtained by the participants in each item (0: not scored as empathetic, and 1 or 2 points: scored as empathetic), as represented in percentages in Figure 3.

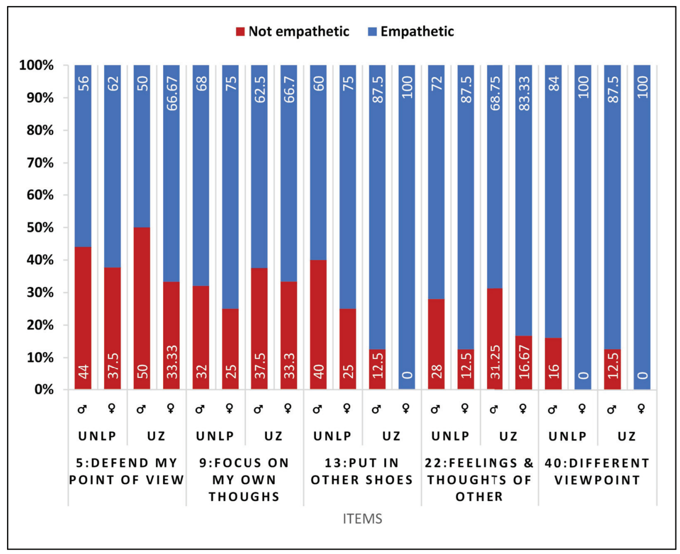

Fig. 3. Results for perspective taking-related items, segmented by university and gender.

The number of people who scored 0 in item 5 (People often tell me that I went too far in driving my point home in a discussion) stands out, since it indicates that 24 of the participants (over 40%) show very low empathy levels in relation to this aspect, since they do not make their point of view more flexible when interacting with others. At the other end of the spectrum, item 40 (I can usually appreciate the other person's viewpoint, even if I don't agree with it) has a high empathy rating; only 6 people scored 0. As discussed later, this is the item in which fewest people scored 0 from both universities, and these were all men. It should be noted that, for the other three items, 0-point scores range from 14 people for item 22 (Other people tell me I am good at understanding how they are feeling and what they are thinking), to 17 people for item 13 (I find it easy to put myself in somebody else's shoes) and 18 people for item 9 (In a conversation, I tend to focus on my own thoughts rather than on what my listener might be thinking). Overall, 33% of the students (on average) scored 0 in 4 of the 5 items related to PT. As a general average for the 5 questions, only a quarter of the students (25.81%) scored a 2, which is the highest level of empathy. These results are consistent with the overall low score obtained in the EQ scale.

Students were also asked about their own perception of their behavior regarding PT, through the self- and peer-evaluation questionnaire (see Table II). The very high score obtained is noteworthy, especially by UZ students, who never scored with the two lowest options on the scale (neither in the self-evaluation nor in the peer-evaluation). In the case of UNLP students, a few scores in the lower portion of the scale were obtained, although not relevant in number. In any case, a large majority of scores are in the upper portion of the scale (3, 4 or 5) for all 5 items; the cases in which lower scores (1 or 2) were recorded by some Argentinean students are below 20% of the total. These results (related to Q2) contrast with the scores obtained for PT items in the EQ questionnaire, which may be an indication of low self-awareness about their level of empathy, especially in Spanish students. The students in both countries tend to overestimate their competence in PT.

C. Student Satisfaction and Perceived Usefulness

During the experience, the educators kept a report of their observations on the students' work process. The aim of these observations was to analyze certain student attitudes relevant to the experience: the importance given implicitly by students to the skills involved in teamwork and which will be relevant to their professional training (Observation 1, O1), students' involvement in programmed tasks and their behavior within the pair (Observation 2, O2), and the way in which students expressed themselves and communicated with each other (Observation 3, O3). The results of these observations were subsequently used during the reflection and feedback phase to value students' satisfaction and perceived usefulness, concluding that the students had a positive experience with the activity (Q3).

More specifically, with respect to O1, most students agreed that it is important to work on their communication skills, and they believe working in groups is useful. In relation to O2, a high level of student involvement and motivation was observed. Despite the fact that the pairs were random and students had to work with peers with whom they had little relation, in general all the students showed a very positive attitude towards the activity. Additionally, it was interesting that students developed a feeling of belonging (to the pair) during the experience. For example, at the beginning, when students asked a question, they usually did so in first person singular. This trend changed as the task progressed, and questions gradually switched to being expressed using first person plural. With respect to O3, it was observed that students maintained fluid communication with their partner during the different phases of the activity. Besides, during the solution exchange in the Deploy phase, many pairs used diagrams and drawings as a tool to explain their ideas. It was also noticed that all the pairs had previously organized themselves so that their two members participated in the explanations. Some students stated that they believed there was a need to work on empathy. In their perception evaluations, one stated: "I would like to have more experience in solving group problems and better visualizing what others want to contribute to the group", while another said: "I think I need to speak more to express my contributions". These expressions of desire are important to highlight the need to continue with this type of experience.

On the other hand, from the educators' point of view, the experience was an interesting alternative to the theoretical and practical classes usually taught in the classroom. It allowed a natural combination of the teaching of technical contents and the development of competences that are relevant to students' training as engineers. An increase in the students' involvement in the teaching process was also observed. As a consequence, the students' learning is likely to be more deep and long-lasting. Moreover, an improvement in the working atmosphere was also noted, enhancing the relationship among the students and between the students and the educators. This positive atmosphere boosted the cooperative work in the classroom leading to highly satisfactory technical results during the programming tasks.

VII. Discussion of the Results

The proposed model and methodology consider in a comprehensive manner the affective and cognitive dimensions of the concept of empathy [9], [20], the development of the professional skills related to that competence [46], and the values (or principles) included in the Global Citizenship dimension [2], [11]. The proposal itself does not contribute advances at the conceptual level on the empathy component of perspective taking or computational thinking, but it provides a framework for designing and developing experiences that work on the skills involved in those concepts. In addition to this, in the case of the perspective taking component, these experiences are useful for students to begin to understand the mental processes applied by their classmates during the analysis and design of problems. From the perspective of computational thinking, some skills related to understanding and solving problems, working in a team, and communicating and collaborating with the team members or other stakeholders are developed as part of the activities programmed in the experiences. This integrated approach represents a further contribution to existing proposals, especially with regard to those applied to learners of Computer Sciences and Engineering [2], [5], [9], [11], [22], [24], [32], [34], [47].

The methodology also provides the tools needed to measure students' empathy coefficient considering both their perspective taking [17], [19] and their self-perception about the development of this competence as part of a learning activity. Using these tools, we concluded that the participants in the classroom experience had a "medium to low level" of empathy (Q1), in particular for the items related to perspective taking. This is in agreement with the conclusions presented in [4], [22], [32]: computer science and engineering students have a high level of technical competences, but they reveal a low level of the skills required to put themselves in the place of others (especially in terms of empathy and its perspective taking component). Therefore, their learning processes should include training in these non-technical skills.

The results also show that female participants have a higher level of empathy than male participants, with a difference that can be considered statistically significant. Various works have previously argued that gender affects empathy levels in students [17], [20], [22]. The results obtained were also analyzed based on the students' country of residence, but no significant differences were found. This could be due to the fact that, in both countries, first-year students have a similar profile in terms of non-technical skills. The analysis of this hypothesis considering the students' profile lies outside the scope of this paper, but it could be an interesting aspect to study in the future.

Students' perception about their own behavior and that of their workmates during the activity and in relation to perspective taking has also been studied (Q2). Students believe that they were able to consider the perspectives of others. However, this contrasts with the results obtained in the EQ questionnaire. This discrepancy may be due to the sensibilization stage in which the students become aware of the importance of empathy. That awareness is likely to have influenced the students' responses. In any case, the sensibilization stage was considered to have played a relevant role in the proposed methodology, as also endorsed in [5], [30].

During the feedback stage, students stated that they became aware of the role and relevance of empathy and perspective taking in their training and professional development, and, as a result, they greatly valued this type of experience (Q3). This stage motivated a reflection on the learning experience from both students' and teachers' points of view. These aspects were revealed in the opinions of the participants that emerged in the feedback phase and also in the teachers' records. It is important to highlight that empathy is based on skills that can be learned and trained, but that methodologies and tools are required to achieve this goal, as also stated by other authors [9], [41].

This paper offers a meaningful contribution by proposing a methodological framework to work on some non-technical skills relevant for computer science and engineering students. The methodological proposal is based on computational thinking and enhanced with processes of awareness and collaboration. Its application has alerted students to the possibility of taking into account other points of views (perspective taking component of empathy), during the search for solutions. These alternative points of view enrich the skills involved in computational thinking (decomposition, pattern recognition, abstraction and algorithms) [11], [20].

VIII. Limitations and Future Work

The proposed methodology addressed empathy awareness, with special emphasis in perspective taking, and established that it should be worked on throughout higher education, before students enter the labor market. The authors are convinced of the importance of starting this work from the early years of higher education, and of planning new actions for the final years to assess how the competence has developed, as a form of long-term post-test. These results could also be useful to enhance students' skill profiles and to find possible correlations between those profiles and available job offers.

It is also important to involve other teachers and help them gain awareness of the importance of defining new activities aimed at enhancing this competence. The design of these activities will help validate the model and the methodology proposed in this paper. Even though the initial effort has focused on Computer Science studies, similar actions should be carried out in other specializations, which would help test the flexibility, versatility and adaptability of the methodology. Additionally, the orthogonal application of the proposal to different case studies may be useful for identifying points of improvement in terms of the needs or the particularities of specific scenarios or stages of development. In summary, the methodology proposed needs to be applied to other educational contexts (for example, to non-technical disciplines) and to a larger volume of students in order to reinforce the validity of the results. Another open question is to apply it to different courses of the same degree to understand and evaluate how the students' empathy evolves during their studies. Currently, we are programming a new experience that will be carried out with students studying the Labor Relations degree. It is expected that more than 100 students will be able to participate. Ideally, the instruments and tools designed as part of the methodology in the current study will be directly reused for the development of this experience. Our efforts will concentrate on proposing a new problem statement to be solved collaboratively by the students. In this case, the statement will be related to the contents of the subject of conflict management and negotiation techniques. This experience will help the authors to validate whether the transferability of the methodology is merely a question of changing the problem to be solved. Nevertheless, the authors are aware of the need of using new instruments of satisfaction analysis for hetero- and self-assessment to achieve a more rigorous validation of the students' opinion. Such instruments could be applied to the experience to be carried out in the degree in Labor Relations to collect observations of educators in a more precise manner.

Finally, the willingness of students to work on empathy in classroom activities is an invitation to consolidate the development of this competence within the framework of their studies.

IX. Conclusions

The SPC model is original since it takes various partial approaches from the literature and integrates them to provide a systematic multidimensional vision. A methodology based on the model is proposed to sensitize and develop empathy in the classroom. It contributes by compiling in a unique model, different dimensions proposed in the literature and includes an evaluation of the students' empathy and self-perception, making use of standardized instruments. The results show a low/medium level of empathy of Computer Science Engineering students in both participating countries. In addition, differences are observed in relation to gender, with female students showing greater empathy levels than their male counterparts. These results are in agreement with those found in the literature. Some other findings become visible, such as the students' appreciation of taking into account the perspectives of others, beginning to speak in the plural, considering others as part of the task, and becoming aware of the need for communication. In addition, the students perceived themselves as more empathetic during the activity than when they answered the EQ questionnaire, opening the door to working on this perception in greater depth.

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