The SCAT-ICT Recommender System: an online support program for teachers with personalized recommendations

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Teachers deal with Information and Communications Technology (ICT) every day and they often have to solve problems by themselves. To help them in coping with this issue, an online support program has been created, where teachers can pose their problems on ICT and they can receive solutions from other teachers. A Recommender System has been defined and implemented into the support program to suggest each teacher the most suitable solution based on her Skills, Competences and Attitude towards ICT (SCAT-ICT). The support program has been initially populated with 70 problems from 86 teachers. Then 30 teachers grouped these problems into 6 categories with the card sorting technique. Real solutions to these problems have been proposed by 25 trained teachers. Finally, 17 teachers have evaluated the usability of the support program and the Recommender System, where results showed a high score on the standardized System Usability Scale.

Keywords: recommendations; ICT support; problem solving; ICT competences; techno-stress; techno-anxiety; techno-fatigue.

1. Introduction

Despite the need for constant ICT (i.e., Information and Communication Technologies) support in teaching, up to our knowledge there are not personalized support programs for teachers that provide solutions to their real ICT problems. Therefore, our research goal is to create an online support program that recommends the most appropriate solution taking into account the teacher's profile, specifically her Skills, Competences and Attitude towards ICT (SCAT- ICT).

Support programs provide solutions for users' problems (Si, Chang, Gyöngyi, & Sun, 2010). When there are different solutions for the same problem, information retrieval algorithms can be used to take into account objective data of the content to provide the result that best matches the query (Frakes & Baeza-Yates, 1992). In addition, algorithms can include also user defined characteristics and context (Dasan, 1998).

In turn, Recommender Systems help users in the decision making process when many options are provided, by suggesting the most helpful one (Resnick & Varian, 1997). Recommendations are based in data from the user, her activity, other users' activity, and the available contents' features (Burke, 2002). For example, online bookshops suggest which title should be the next purchase by gathering all the interactions made at their website (Schafer, Konstan, & Riedl, 1999).

Recommender Systems in the educational domain have mainly addressed the learning needs of the students to support the so called 'technology enhanced learning' (Drachsler, Verbert, Santos, & Manouselis, 2015). From our state of the art review on teachers' support enhanced with Recommender Systems, we found that they just focus on recommending learning objects to be used in their courses. Bozo et al. (2010) recommend learning objects to teachers taking into account the learning object metadata (i.e., curricular context: author, title, educational level, area, concept, unit, topic, and subject), the teacher's profiles (clustered in terms of educational level, subject, area, region, city, school type and school), the learning object evaluations (regarding user satisfaction) and the statistics on the learning object usage (number of downloads, evaluations made, the evaluations average and last updated date). Limongelli et al. (2013) recommend learning objects to teachers based on their teaching style. Fazeli et al. (2014) recommend learning objects taking into account using inter-user trust relationships, which originally come from the social activities of users within an online environment. Sergis et al. (2014) take into account the UNESCO ICT Competency Framework for Teachers (UNESCO, 2011) so learning objects recommended are in line with teachers' current ability to use in their teaching practice.

This Recommender System approach by Sergis et al. (2014) is the most related one to our research, but these authors still recommend learning objects for their students (taking into account the teachers ICT profile), while we recommend solutions to ICT problems for the teachers (taking into account the teachers' SCAT-ICT profile).

Under this light, this paper proposes a first step towards taking into account teachers' characteristics in a support program. A Recommender System has been integrated into the support program to provide the most suitable solution in each case. To this end, we present the definition of a support program on ICT for teachers that takes into account their SCAT-ICT profile to deliver personalized recommendations according to their technological level and needs.

The remainder of this paper is structured as follows. First, we present the motivation of the research, including a review on ICT support programs for teachers. Next, we summarize the state of the art of Recommender Systems in Questions and Answers support programs. Then, we propose the SCAT-ICT Recommender System and we explain how the support program has been designed following the User Centered Design (UCD) methodology. After that, an evaluation of the support program and the Recommender System is described. Results obtained are discussed next. Finally, conclusions are outlined. Screenshots (in Spanish) of the implemented system are included when appropriate.

2. Motivation of the research

In the last decade, technologies have enabled people to communicate, to get informed, to learn and to solve problems in a de-centralized way, empowering each one with the wisdom of crowds (Surowiecki, 2005). The introduction of ICT in education and the need for teachers to adapt to the Information Society has been a source of problems for them (Esteve, 1995). For example, Sangrà & Duart (2000) studied in depth the attitude of teachers towards ICT, and found out that they felt pressured by society to join the ICT world, like a kind of "miracle" that would improve school practice, without even stopping to think if this was true dogma. The feelings found can be summarized as follows: 1) uncertainty, 2) distrust, 3) demotivation, 4) exhaustion, 5) obstruction and 6) stuck without alternatives. Though this position has evolved into a more positive way (ISEI-IVEI, 2004), teachers still feel that ICT goes beyond their capacity (OCDE, 2009), and that ICT changes the relationship between students and teachers (Underwood, 2007). A survey carried out by Jimoyiannis et al. (2013) among 86 teachers established that the difficulties they faced to integrate Web 2.0 tools were: 1) the need of more particular preparation and efforts, 2) the need of more specific knowledge and skills, 3) the lack of security, and 4) the fear that students are more experienced than them in ICT. Tribó (2008) suggests that this is motivated not only by the continuous changes and adaptations they must perform, but also the progressive enhancement they are supposed to get in their career. In fact, UNESCO (2011) recommends an onward development on teachers' competences on ICT, from mere ICT users (i.e., technology literacy), then to experts (i.e., knowledge deepening), and finally to knowledge creators with ICT tools, as depicted in Figure 1.

To educate teachers in ICT, different support programs are provided by institutions. In order to get some insight into existing ones, we have reviewed the situation in Spain during the 2012-2013 and 2013-2014 school years. First, we made an inventory of 32 institutions (government, universities, trade unions, companies and particular persons). Then we contacted them to gather information, resulting in 58 different initiatives. We have categorized them into the five types of support programs, which are compiled in Table 1. None of the reviewed programs provides both a constant and structured support on daily problems with ICT: i.e., courses have structured contents, but once they have finished, students usually cannot interact with the teachers or other students to ask for help; blogs offers permanent support, but their data and information are unstructured (Moens, 2009). Although some courses are recommended for "advanced" or "basic" users, none of them are adapted to their personal profile. In this environment of continuous change and increasing demands, as well as the lack of a permanent support program to questions, our secondary goal is to create a collaborative support program where teachers can look up for solutions to their daily problems in ICT. The main goal is to design, implement and evaluate the SCAT-ICT Recommender System.

3. Question and answers support programs with Recommender Systems

Collaborative web-based Question and Answer (Q&A) support programs are communities of practice where any user can ask for help and any user can propose a solution to other people's problems. The two main reasons behind users looking for information in these support programs are the following (Si, Chang, Gyöngyi, & Sun, 2010): 1) the information may not be available, or 2) the information is available but it is not summarized in a conveniently way to be found. In this kind of communities of practice, simply being an observer does not provide the experience (Carr, Cox, Deacon, & Morrison, 2008) so users must be engaged (Wenger, 1998): 1) to other members, 2) to their actions, and 3) to the repertoire in use. Representative Q&A sites are 'Stack Overflow'[1], 'Yahoo Answers'[2] , 'Baidu Knows'[3] or 'Quora'[4].

[1] http://stackoverflow.com

[2] http://answers.yahoo.com

[3] http://zhidao.baidu.com

[4] https://www.quora.com

When a question has more than one answer, Q&A sites employ voting and reputation mechanisms to help users identify the trustworthiness and accuracy of the content (Anderson, Huttenlocher, Kleinberg, & Leskovec, 2012), and therefore they can recommend one answer over the others. For example, the discontinued Q&A website from Microsoft 'Live QnA' qualified users with levels of points (i.e., answering a question: 5 points; giving the best answer to a question: 20 points, etc.)[5]. Nevertheless 'Quora' bases its reputation on pure statistic data on the activity (no points), and social interactions, both of the users and their answers.

Other factors taken into account in the Q&A websites when choosing the most suitable answer are (Anderson, Huttenlocher, Kleinberg, & Leskovec, 2012): a) the reputation of answerers (the more reputed the user is, the most probable is that her answer is marked as the best); b) relationships between reputation and answer speed (the quicker, the most reputation the user wins); and c) the probability of an answer being chosen as the best one strongly depends on how quickly the answer arrives.

Baidu Knows's uses a Recommender System called 'Enlister' that focuses its recommendations in a different aspect: it selects the questions that are most desirable to be responded by each user (Liu, Chen, Cai, & Yu, 2012). A similar approach has been made at Yahoo! Answers by Dror et al. (2011) and Budalakoti et al. (2009), who identify users who are most capable of providing a satisfactory answer to specific questions.

Another way to integrate a Recommender System is done in the Google project 'Confucius'. When the user posts a question, the system finds similar earlier questions

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[5] https://web.archive.org/web/20080223061134/http://qna.live.com/CommunityContent.aspx?frame=en-US/scoring acceded on 9th March 2015

and their already available answers to reduce the time it takes for a user to obtain a satisfactory answer (Si, Chang, Gyöngyi, & Sun, 2010).

Recommender Systems have also been applied to create and to strengthen networks of users within the Q&A websites, like the model proposed by Tuan Long et al. (2011). This model includes answering, voting, referring, invitations and even interactions outside the Q&A site amongst users with the aim to engage usage. The 'SOS' model proposed by Li (2012) also explores the social networks of the user, but as a way to identify potential answerers in their friend lists in a decentralized manner.

4. The SCAT-ICT Recommender System

As seen before, Recommender Systems are used in Q&A websites to enhance their usage 1) supporting users' interactions, 2) increasing the number of responses, and 3) sorting them according to votes and reputation. However, when questions have more than one good answer, as far as we have found in our review of the state of the art, none of the Recommender Systems sorts the responses taking into account the personal needs and features of each user in order to recommend her a particular answer (i.e., the most appropriate to her needs and profile). For example, if the problem is "my computer cannot access the file server", the most suitable solution for a beginner might be "turn it off and on again", but for an expert might be "write and run a script in cmd" that makes the same effect (i.e., restoring the system initial parameters) and would be faster than rebooting the system. ICT-related problems have a limited set of possible solutions, but when coming into people-related problems (i.e., "my students use their laptops to play instead of taking notes"), there may be many possible solutions (i.e., "computer-requisition", "network filtering", "integrating their games into the contents of the subject", etc.). The research question here is how to determine which solution is the best option for a particular teacher.

Next we describe the three basic pillars of the Recommender System: i) the teachers profile, ii) the solutions metadata, and iii) the matching of both of them to define how the recommendation is generated.

4.1 Attributes of the teachers

The SCAT-ICT profile includes the following information from the teachers: a) their skills in ICT problem solving, b) their competences in ICT, and c) their attitude towards it. In addition, socio-demographic variables (sex, age, subject, experience, children and their age) and activity data in the support program (problems posed and solutions proposed) are collected to be taken into account for further analysis and integration.

4.1.1 Skills in ICT problem solving

Skills in ICT problem solving can be measured regarding: a) their level, b) their copying technique, and c) their priority preference.

In order to identify the teachers' level, we have followed the methodology and classification proposed by Molleda et al. (2011): any solution has six dimensions: 1) understanding of the problem, 2) methodological approach, 3) easiness, 4) efficacy, 5) efficiency, and 6) critical analysis. Each dimension can be qualified as 'Excellent', 'Proficient', 'Low', or 'Not fair'. As a result, depending on an average qualification of all her solutions, teachers' level of problem solving skills can be categorized in four levels ('High', 'Medium', 'Low', and 'Novel').

Every solution can also be modeled depending on its copying technique: teachers can adopt an active role (i.e., following all the steps to implement the solution) or a passive role (i.e., asking someone to provide the solution). For example, a teacher can try to repair her computer by herself ('active') or she can take it to the technician to have it repaired ('passive').

In the same direction, teachers can choose amongst different solutions prioritizing time or easiness. In this sense, some teachers might prefer to implement the quickest solution even it is a bit more difficult; while other teachers might prefer easy steps although it takes them longer. For example, if the computer does not respond, some teachers might display the control panel to stop processes that copes the computer capacity, and get a solution in seconds (‘time preference’); but other teachers might prefer to reboot the computer (‘easiness preference’).

4.1.2 Competences in ICT

Teachers in Spain are forced by law (Gobierno de España, 2006) to have ICT competences in the following areas: 1) basic use of the computer and networks, 2) office, 3) multimedia, 4) internet, and 5) educational software. Their competence level can be measured by the standardized survey PROFORTIC (Suárez, Almerich, Belloch, & Orellana, 2010) with 30 questions using a 5-point Likert scale (from “Nothing” to “Very Much”). The result is a numerical value that sets teachers in one of these four groups: ‘Digital illiterate’, ‘Basic’, ‘Advanced’, and ‘Proficient’.

4.1.3 Attitude towards ICT

Teachers’ attitude towards ICT can be defined by three dimensions: 1) their innovation predisposition, 2) the anxiety they feel when they use ICT, and 3) how tired of using ICT they are.

On the one hand, regarding innovation, according to Rogers (1983), users can be classified into five categories depending on how quickly they integrate ICT in their life: ‘Innovators’, ‘Early adopters’, ‘Early majority’, ‘Late majority’, and ‘Laggards’.

On the other hand, techno-anxiety and techno-fatigue are part of a bigger construct called “techno-stress”. They both can be measured with the standardized tool

“RED_Tecnoestrés” (Salanova, Llorens, Cifre, Nogareda, & WoNT, 2007). This survey uses a 7-point Likert scale (from “Never” to “Always”) to group sixteen items into four concepts: 1) skepticism, 2) fatigue, 3) anxiety, and 4) inefficacy. The addition of skepticism, anxiety and inefficacy scores computes the techno-anxiety score. In turn the addition of skepticism, fatigue and inefficacy scores computes the techno-fatigue score. Both techno-anxiety and techno-fatigue scores can be categorized into six levels: 1) ‘very low’, 2) ‘low’, 3) ‘low-medium’, 4) ‘high-medium’, 5) ‘high’, and 6) ‘very high’.

4.1.4 The SCAT-ICT profile

Taking into account the teachers attributes afore-mentioned (skills, competences and attitude), the user profile used in the SCAT-ICT Recommender Systems is shown in Figure 2. It also considers some demographic information such as gender, age, children, teaching experience and subject (e.g., ‘Geography’), as well as how many problems she has posed and how many solutions she has proposed in the support program. In the Screenshot 1 we show the implemented SCAT-ICT profile with a real user in the first version of the support program.

To fulfill this profile, teachers are prompted with a questionnaire in the registration process. This registration process is explained in the Discussion section.

4.2 Attributes of the solutions

As shown in Figure 3, the solution provides with the instructions (i.e., the procedure) that the teacher should follow to solve her problem, as well as it also shows metadata (i.e., efficacy, duration, difficulty and needed attitude) that helps both teachers and the system to determinate the appropriateness of the solution. In addition, the teacher can give feedback on the utility of the solution by answering if the solution solved her problem.

Table 2 describes each variable used as metadata, explaining what it measures, its value range, and the way the variable is worked out. This metadata can be obtained either by asking the authors when they create the solution or by asking the users after having tried the solution. In the first case, authors are asked (besides defining the title and describing the procedure) the appropriate attitude of the user toward this solution (in their view), the difficulty level required to follow it (also in their view), and how long it is supposed to take, as shown in Figure 4. In the second case, the users of the solutions are asked to provide feedback on the solutions. If the delivered solution worked, as shown in Figure 5, the user is asked how long it really took, and the difficulty level to follow it (from her experience). If the user is logged in the system and has completed the SCAT-ICT survey, the user is asked: a) if she has made any improvement in the competence area of the solution (e.g., 'Networks' in Figure 5), so her competence level is updated; and b) if she felt that the solution was adapted to her SCAT-TIC level, so we can gather feedback on the recommendation algorithm. On the other hand, if the delivered solution did not work, other possible solutions are proposed. Screenshot 2 shows how the solution model has been implemented in the first version of the support program.

4.3 Generation and delivery of the recommendations

When there are different possible solutions for the same problem, the system displays the solutions in the following order (Figure 6 and Screenshot 3):

(1) First, the most effective one (number of users who resolved the problem with this solution).

(2) Then, the system highlights the solution that best fits the user SCAT-ICT profile.

(3) Finally, the rest of the solutions are listed, according to their percentage of effectiveness.

In the case that the most effective and the personalized solutions are the same, the system tags this solution with both flags. If the user is not logged in the system, the personalized recommendation cannot be calculated, so she can only receive the most effective one. In the case that two or more solutions tie in effectiveness, the order is then determined by how many people said ‘No’ (i.e., the solution did not work), the one who need less time, and finally the easiest one.

To compute the personalized solution, we have defined a set of rules that outputs a numerical value for each solution. The higher-valued-solution is the one that gets the “Recommended for you” flag. The system assigns points to the solutions in two different ways: 1) all the solutions get points depending of its internal metadata; and 2) some solutions get points when its metadata is compared to the metadata of the other solutions. To do it, we have analysed the solutions’ and users’ attributes and then we have established the relationships among them, detailed in Figure 7. Next, we have established which relationships get points for its internal characteristics (Table 3) and which solution get points in comparison with the other solutions (Table 4). In the first group, every solution gets points attending the following rules:

(1) In the “Solution Difficulty vs. User Competence level in that category” (Table 5) and in “Solution Difficulty vs. User Skills in Problem Solving” (Table 6) relationships, the maximum scoring is given (2 points) if the user and solution levels match; and only 1 point if there is one step away. No points are given if they are two or three steps away.

(2) In the “Solution needed attitude vs. User Preferred coping technique” relationship (Table 7) the maximum scoring is given (2 points) if both attributes match; and only 1 point if they do not.

(3) In the “Solution Needed Attitude vs. User Attitude – Innovation predisposition” relationship (Table 8) the maximum scoring is given (4 points) for the best matches (passive-laggards and active-innovators). Then, we scale down the delivery of points.

(4) In the “Skills – Priority preference” relationship (Table 9), if the user prefers easiness over time, “easy” solutions are given the maximum scoring (2 points), and “normal” solutions get 1 point; but if the user prefers time over difficulty, 3, 2 and 1 points are given to the three quickest solutions.

(5) In the “Time and Difficulty vs. User Attitude – Techno-anxiety” relationship (Table 10), the more anxious the user is, the quicker and easier solution she needs in order to reduce the stress. However she needs more the speed than the easiness, so points are given to the quickest solutions (maximum 4 points), and “easy” solutions get 1 or 2 points depending on the anxiety degree of the user.

(6) In the “Time and Difficulty vs. Attitude – Techno-fatigue” relationship (Table 11), the more tired the user is, the easier and quicker solutions she needs in order not to compromise her mental workload, but she needs more the easiness than the speed; so “easy” solutions get up to 4 points, and one or two points are given to the quickest solutions depending on the fatigue degree of the user.

Finally we sum up all the points to all the solutions of the problem, and the one with the best score gets the ‘recommended’ flag. If two or more solutions get the same scoring, the most effective of them is selected.

5. Construction of the support program

The SCAT-ICT Recommender System has been implemented in a realistic scenario, a support program for teachers that has been developed under the User Centered Design (UCD) methodology (ISO, 2010), an international standardized process for interactive systems in which products and services are designed taking into account the characteristics of their end users. This methodology has already been successfully used in educational scenarios to extend e-learning systems with personalization capabilities along the e-learning life cycle (Santos, Boticario, & Pérez-Marín, 2014) and to provide personalized support with recommendations that are meant to foster active learning in online courses (Santos & Boticario, 2015).

The UCD considers the following steps: 1) identify the users need; 2) research to specify the context of use; 3) generate requirements; 4) produce design solutions; and 5) evaluate them to verify if they fulfill the requirements. Next, we describe the design process of the support program according to these steps. Due to their relevance, evaluation results are considered in a separate section (i.e., Section 6).

5.1 Needs identification

Regardless of the support programs categorized in Section 2, studies show that Spanish teachers' acceptance and adoption of technology is still an issue to cope with (OCDE, 2009). Drent & Meelissen (2008) identified five factors that obstruct or stimulate teachers to use ICT, including 1) ICT attitudes, 2) ICT competences, 3) Personal entrepreneurship, 4) Perceived change and 5) Pedagogical approach. Besides, barriers to cascading ICT into teaching include (Boulton & Hramiak, 2014): 1) lack of ICT competence in school leaders, 2) lack of time, 3) lack of accessibility and restrictions to the ICT, and 5) lack of support.

The research reported in this paper arose from the teachers' need to solve ICT daily problems, with a stable support program (coping the barrier #5) while developing ICT attitudes and competences (factors #1 and #2). In this way, the support program is intended to promote the information sharing and to make teachers aware of their SCAT-ICT so they can enhance their productivity, self-perception and self-esteem.

5.2 Context of use

The proposed support program is to be available wherever the teacher is, to allow a quick interaction with it, so the most suitable devices in this case are those that she carries on most of the time, that is, her own smartphone or tablet. However, in order not leave behind those that do not have a smartphone or a tablet, a desktop version has to be available, too. Under this context of use, the "mobile first" methodology and "responsive design" paradigm has been applied. The "mobile first" methodology embodies the multi-device design and argues that interface design should start from the design of interfaces for mobile devices, thus the progressive adaptation to larger formats is easier (Wroblewski, 2011). The "responsive design" paradigm proposes crafting sites to provide an optimal viewing experience (easy reading and navigation) across a wide range of devices, from smartphones to desktop monitors (Marcotte, 2011). Screenshots 4 and 5 show the adaptation of the homepage to the device size.

5.3 Requirements

The requirements that any system has to fulfill can be divided into two groups (Pohl , 2010): first, global goals that lay the foundation of the system; and second, the tasks that particularize and prioritize the goals in actions. The main goals that the teachers have to perform are: 1) get possible solutions to her problem; 2) learn that there are different ways to solve the same problem; and 3) enhance her ICT training. The associated tasks to these goals, prioritized according to their importance are:

- The teacher can browse groups of problems or use the search engine to find her problem.
- The teacher can read the problem and its possible solutions.
- The teacher can register and log in the support program to access the personalized options.
- If the teacher is logged in the system, she can answer the SCAT-ICT survey, and she can also modify her answers later.
- If the teacher is logged in the system and she has answered the SCAT-ICT survey, she can get an adapted possible solution to her problem.
- The teacher can post a new solution to any problem.
- The teacher can provide feedback on the solutions proposed, so she can help other teachers.
- The teacher can monitor her performance and progression in the support program.

Finally, teachers should be able to perform all the operations by themselves, so easiness and usability are a must.

5.4 System design

The next step in the UCD process is to produce prototypes that describe the concept, taking into account the previous requirements, from rough to detail. Here we report the information architecture and interaction design of the support program.

As Figure 8 shows, two mechanisms have been provided in order to allow the teacher to look up the available problems: 1) browsing across categories of problems (browsing mode); and 2) searching in the database (search mode). Both mechanisms provide a list of problems that the user may select to read its solutions. If the teacher cannot find the problem she has, she can post it and receive responses from other teachers.

To populate with real problems the first version of the support program, a survey has been posed to 86 teachers (48 male, 38 female, 37 year-old in average) to gather which ICT problems are most common in their teaching practice. This survey has elicited 70 different problems, which can be categorized into two types of problems:

- **ICT-related-problems:** problems related to the functioning of the technology itself (i.e., "the printer is not working")
- **People-related-problems:** problems related to the impact of the ICT in people, both in other people (i.e., "my students do not pay attention in class because they are looking at their mobiles") and even in the teacher (i.e., "I have to study technologies all lifelong").

However, the list of problems in each category was still quite long, so teachers might find it difficult to discover the right one in the browsing mode. To avoid this issue, an open card-sorting test was performed. The card sorting method is an information architecture technique used to generate groups of specific items according to relevant users (Spencer, 2009). 30 users (16 male, 14 female, 35 year-old in average) grouped the 70 problems in the categories shown in Table 12. Besides this categorization, a search engine has been included that recognizes keywords from the text introduced, and it outputs a list of problems that matches these keywords. The keywords are highlighted in the excerpts to enhance the scanning of the results. Each result is tagged with the category, the number of answers it has and how many people have visited that question. If the search returns too many results, the user can use the advanced search functionality, where she can filter by date or by category, or use regular expressions to accurate the search terms.

To populate with real, actual solutions, the first version of the support program, we have followed the same technique as Stack Overflow did to ensure critical mass in the early stages of the site (Treude, Barzilay, & Storey, 2011). We recruited 25 teachers (15 male, 10 female, 32 year-old in average) and gave them a 5-week online course on ICT problem solving. After the course, they were asked to propose different solutions to six particular problems (from the problems elicited in the survey described in section 5.4). Each solution included the instructions, the estimated time, the difficulty and the needed attitude to carry it out. All the solutions were reviewed and curated by the support program administrator to guarantee a minimum quality. In this way, we got at least three qualified solutions for every problem in the initial version of the program.

6. Evaluation of the support program with the Recommender System

Once the first functional version of the support system was developed with the SCAT-ICT implemented, an unmoderated remote usability test was performed to detect possible problems, to gather users' opinions, and to prove if the system matches the identified needs (Nielsen, 1993). Users were asked to perform tasks on the support program, and to provide feedback on the processes carried out when doing them. Besides, to yield statistical data, the standardized questionnaire SUS (System Usability Scale) has been posed (Sauro, 2011). This evaluation is both summative and formative (Cooper, Reimann, & Cronin, 2007), so the sample size has been set to 17 users (9 male, 8 female, 30 year-old in average), as Sauro & Lewis (2012) recommend a sample size of at least 15 participants to get 80% confidence (for studies that have not estimates of variance, either from a previous study or a quick pilot study, like this research).

All of the participants of the study (17/17) liked the support program, and most of them (15/17) would recommend it to a friend. The rest of the participants (2/17) would only do it if it had an active community or staff that ensures good solutions in live time. Detailed feedback on the tasks performed on the support program is summarized in Table 13.

Regarding the Recommender System, participants were asked their opinion about the SCAT-ICT questionnaire when they registered in the site. Most of the participants (12/17) complained about the length of the questionnaire, and some participants (5/17) pointed out that they would have quitted in a real life scenario.

Besides, participants were asked about the "recommended solution" in the problem page. Many participants (9/17) did not understand why the recommended solution was not the most efficient one. Some participants (4/17) requested a contextual explanation of the recommendation, and a few (2/17) demanded a clear way to modify the settings that were taken into account to make that recommendation.

However, many of them (10/17, that is 58,8%) recognized that the suggested solution really fitted their personality, and thanked that the system made the honest effort to personalize the response to them. The rest of the participants were not sure that the recommended solution was the best for them, but none of them identified other solution as a better one.

The global SUS score was 85,94. According to Sauro (2011), a SUS rating of 68 is considered to be above average, so we can conclude that the system has a good evaluation, but still has space for improvements, especially the Recommender System.

7. Discussion

The SCAT-ICT Recommender System seems to properly calculate the best solution (58,8% of the users agreed with the proposed one), but it still can do better. In our next experiments, adjustments in the scoring system (i.e., the rules) will be A/B tested, as well as we will take into account the socio-demographic variables (sex, age, subject, experience, children and their age) for further analysis and enhancements.

In addition, the SCAT-ICT Recommender System faces two big problems. The first one is the need to fill in the SCAT-ICT profile (described in Table 14), which is composed by a total of the 116 items. Four actions will be executed in order to reduce the effort needed to complete the SCAT-ICT profile questionnaire. First, reducing the number of fields (i.e., integrating social networks logins to simplify the registration data from 7 items to 1). Second, gathering some of the variables by other means rather than from the initial questionnaire (i.e., retrieving the competences information from their professional social network profiles or similar databases where users have already stated them; or the problem solving skills from the interaction on the support program). Third, re-designing the questionnaire to reduce efforts and to promote its usability. Finally, the support program will clearly show the benefits of completing the registration form with the required information to enhance motivation and reduce desertion.

The second big problem is the comprehension of the recommended solution. Many users (9/17) demanded to know the reasons that lie behind the recommendation delivered, so an explanation will be provided, considering literature research in this field (Tintarev & Masthoff, 2012). This explanation will have a direct link to modify their profile, so users can update what the system knows about them.

Furthermore A/B tests will be held to exhibit flags in a different order (first the recommended, then the most efficient), or to place just one only flag (the recommended one), and get statistical results on the performance and perceived usability of each option.

Regarding the support program, in this early version the community of users is still not set, and all the solutions have been reviewed and curated by the support program administrators (not in order to determine if the solution works, but to make sure that they are suitable, relevant and understandable for all). However, in future releases, the activity and reputation of the user in the support program and her SCAT-ICT level will be taken into account to automatically curate solutions. A badge system will reward users for their contributions in order to encourage their participation in the program. As stated by Mamykina et al. (2011) for Stack Overflow, adding game mechanics through a reputation system harvested the competitive energy of the community and led to intense short participation for some users, and long sustained participation for others.

Minor enhancements suggested during the evaluation will be implemented in next releases, such as 1) inserting YouTube videos in the solutions; 2) encouraging novel users to join the community and to propose solutions; and 3) re-styling the support program to look more pleasant.

Apart from the Recommender System and the support program, the elicited problems and solutions will be analyzed by psychologists, in order to know what the real problems of teachers with technology are, how they express these problems and how they react.

8. Conclusions

The SCAT-ICT Recommender System has been proposed, defined and implemented in an online ‘Question and Answers’ support program on ICT for teachers. The SCAT-ICT Recommender System takes into account the Skills, Competences and Attitude of teachers towards ICT to recommend the solution that best fits the profile of that particular teacher.

The research began with an extensive review of other support programs, concluding the lack of a permanent, reliable community of practice where teachers can get quick information on common problems with the ICT they have in their job. Questions and answers sites have also been reviewed, and how they provide recommendations. From our review, none of them sorts the responses taking into account the personal needs and features of each user when recommending a particular answer.

Therefore, we have defined the SCAT-ICT Recommender System that suggests the teacher the most suitable solution based on her skills, competences and attitudes towards ICT. The SCAT-ICT approach includes a) which variables are used, b) why they have been selected, c) which standardized tools are used to gather data both from the user and from the solution, d) how the solutions are scored according to these data, and e) how the recommendation is delivered into the support program.

Then we have built an online support program to implement the SCAT-ICT Recommender System. We have followed the UCD methodology, so teachers' needs and context have been identified at the beginning. After that, we have stated the requirements to which the support program should conform. Next, the information architecture and the interaction design are described. In the end, the support system functionalities, including the Recommender System, has been evaluated in a remote usability test.

Results from the user test show that the system retrieves the best solution (58,8% of the participants agreed with the recommended solution), but some adjustments can be made to the scoring rules to get better results. Test results also highlight the need to improve the data gathering (as the SCAT-ICT questionnaire is too long), and the recommendation delivery (as participants did not understand very well the reasons behind this recommendation). Other suggestions and improvements have been discussed and they will be implemented in future releases.

As a conclusion, teachers have been involved in the creation and development of the support system from the very beginning. First a survey of 86 teachers has been carried out to recollect the main problems they face. Then, 30 teachers have been asked to categorize these problems with the card-sorting technique. Next, another survey of 25 teachers has been performed to populate the support program with real solutions. Finally, user testing with 17 teachers has evaluated its usability, detected problems and identified ways to improve the system.

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Figures

Screenshots

Tables

Table 1. Categories of support programs in Spain

Category	Description
Initial Education for Teachers	The mandatory 'Secondary Education' Master, must contain the specific subject "Research and innovation in education and change management", with the aim of giving strategies and techniques to teachers to enhance their work with ICT.
Life Long Learning for teachers	Courses for teachers can be divided into four categories: 1) general software, 2) educational software, 3) how to apply ICT in their classes, and 4) digital culture.
Governmental ICT Promotion on Schools	It has focused on providing 1) information and administrative processes through internet, 2) technology infrastructure, and 3) training and tools for teachers and students.
Private ICT Promotion for Teachers	Some companies have created websites and conferences where teachers can exchange ideas, educational resources, new tools, etc. Commercial interests are quite clear, such as selling equipment, online courses, appearing in news, etc.
Communities of Practice	De Marsico et al., (2014) define them as groups of people who share an interest or a passion for something they do, and aim at learning how to do it better by interacting regularly. In this analysis, we found out that teachers are engaged in writing blogs or participating in groups of social networks, sharing their activities and points of view.

Table 2. Metadata of the solutions

Variable	Explanation	Possible values	Calculation
Efficacy	How many users resolved the problem with this solution?	0 - infinite	Number of users that used this solution and marked 'YES' in the feedback questionnaire.
Duration (time)	How long does it take to complete the instructions?	1-60 / minute – months	The average time between what the author says and what users say.
Difficulty	How complicated is to follow the instructions for an average user?	Easy – normal – hard	The mode or most repeated value between what the author says and what users say. If two values occur, the most difficult value prevails.
Needed attitude	How should be the mind-set of the person to perform these instructions?	Active (fixing it by herself) or Passive (asking someone to fix it)	N/A (the author indicates it).

Table 3. Points for its internal attributes

Solution		**User**
Difficulty	⇔	Competences in ICT – Competence level in that category
Difficulty	⇔	Skills – Problem solving
Needed attitude	⇔	Skills – Coping technique
Needed attitude	⇔	Attitude – Innovation predisposition

Table 4. Points in comparison with other solutions

Solution		**User**
Difficulty	⇔	Skills – Priority preference
Difficulty	⇔	Attitude –Techno-anxiety
Difficulty	⇔	Attitude –Techno-fatigue
Duration	⇔	Skills – Priority preference
Duration	⇔	Attitude –Techno-anxiety
Duration	⇔	Attitude –Techno-fatigue

Table 5. Solution Difficulty vs. User Competence level in that category

Solution difficulty	**User Competence level in that category**			
	Digital illiterate	Basic	Advanced	Proficient
Easy	2 points	1 point	-	-
Normal	1 point	2 points	1 point	-
Hard	-	1 point	2 points	1 point
	-	-	1 point	2 points

Table 6. Solution Difficulty vs. User Skills in Problem Solving

Solution Difficulty	**User Skills in problem solving**			
	Novel	Low	Medium	High
Easy	2 points	1 point	-	-
Normal	1 point	2 points	1 point	-
Hard	-	1 point	2 points	1 point
	-	-	1 point	2 points

Table 7. Solution needed attitude vs. User Preferred coping technique

Solution Needed Attitude	**User Preferred coping technique**	
	Active	Passive
Active	2 points	1 point
Passive	1 point	2 points

Table 8. Solution Needed Attitude vs. User Attitude – Innovation predisposition

Solution Needed Attitude	**User Attitude – Innovation predisposition**				
	Innovators	Early adopters	Early majority	Late majority	Laggards
Active	4 points	3 points	2 points	1 point	-
Passive	-	1 points	2 points	3 points	4 points

Table 9. Skills – Priority preference

Skills –Priority preference	
User prefers easiness over time	User prefers time over difficulty
2 points to every “easy” solution.	3 points to the first quickest solution
1 point to every “normal” solution	2 points to the second quickest solution
0 points to every “hard” solution	1 points to the third quickest solution

Table 10. Time and Difficulty vs. User Attitude – Techno-anxiety

	User Attitude – Techno-anxiety					
	Very low	Low	Low-Medium	High-Medium	High	Very High
Quickest solution	-	-	1 points	2 points	3 points	4 points
"Easy" solution(s)	-	-	-	-	1 points	2 points

Table 11. Time and Difficulty vs. Attitude – Techno-fatigue

	User Attitude – Techno-fatigue					
	Very low	Low	Low-Medium	High-Medium	High	Very High
Quickest solution	-	-	-	-	1 points	2 points
“Easy” solution(s)	-	-	1 points	2 points	3 points	4 points

Table 12. Problem categorization

Category	Number of problems	Including
This does not work properly	18	Errors during the use of specific technologies, both hardware and software, including operating systems, internet sites, particular programs or devices…
I do not know how to do it	13	Lack of knowledge while managing the devices or programs, with mental barriers of not exploring their affordances to learn by herself.
Security and maintenance	12	• Virus • Problems recovery • Updating • Technical support availability
Equipment	10	• Available resources • Compatibility and suitable equipment • Obsolescence and continuous technological advances • Choosing the right technology in each situation
Evolving in the profession	9	• Creation and use of educational resources and contents • Classes and Projects Management • Teamwork • Productivity
Feelings	8	• Attitudes and emotions • Need for training and constant updating • Time factor • The barrier of other languages

Table 13. Tasks, scenarios and results from the user test

Task	Scenario	Results
1. “Homepage” overview	You have a problem with your computer and a fellow teacher at your school has suggested you to use this website. What are you looking at? What can you do? What would you do?	The global concept is understood by all the participants (success rate 100%), but some of them (3/17) expected that a qualified person would answer the questions immediately.
2. “User registration” process	Please register as a new user in the website. What is your opinion about it?	It is described as easy to do (16/17).
3. “Locating a solution to a determined problem” process	Imagine the problem you have with your computer is that you cannot find an important document you were working on yesterday. Try to get a solution to this problem in the support program.	Total success rate (17/17). Most of the participants (12/17) browsed the categories.
4. “Problem page” overview	Once you have located the problem, let’s talk about this page. What are you looking at? What can you do? What would you do?	The global concept is understood by all the participants (success rate 100%).
5. “Providing feedback on a solution” process	Let’s say you have tried the three solutions in this page and the third one finally gets it. How would you provide the feedback so other users can know it worked out?	All of the participants (17/17) understood and completed the process correctly (success rate 100%). Some participants (3/17) pointed out that the time the solution takes to each person is different depending on the equipment, internet connection speed, skills and other circumstances.
6. “Proposing a new solution” process	Let’s suppose you know a better solution for this problem. How would you share it with your colleagues?	All of the participants (17/17) understood and completed the process correctly (success rate 100%). Some participants (4/17) requested a functionality to insert YouTube videos, “which are very popular and convenient to learn computer skills”. Many participants (6/17) consider themselves not enough skilled to help anybody, so they would never provide a solution in a real scenario.

Table 14. Dimensions and items in the initial registration form

Dimension	Questions
Competences	30 items (5-point Likert scale), according to the PROFORTIC survey
Skills – problem solving	12 problems (open questions), selected from the most frequent problems elicited in the previous survey described in section 5.4.
Attitude – Innovation	1 item (5 options). The characteristics of each Rogers' category are briefly presented to users and let them chose the one they consider they best fit in.
Attitude – Techno-anxiety and Techno-fatigue	16 items (7-point Likert scale) according to RED_Tecnoestrés.
Socio-demographic variables	5 items (gender, age, children and their age, experience years and subject)
Registration data	7 items (username, email, repeat email, password, repeat password, captcha, and legal acceptance)
Total	**116 items**