RECONFIGURABLE GAMIFICATION PLATFORM FOR THE AUTONOMOUS LEARNING OF LOW VALUE MEDICAL PRACTICES

César Fernández[1], María Asunción Vicente[1], Susana Lorenzo[2], Irene Carrillo[1] and Mercedes Guilabert[1]

[1]Department of Health Psychology, Miguel Hernández University, Elche, Spain
[2]Hospital Universitario Fundación Alcorcón, Madrid, Spain

ABSTRACT

Failure to follow do-not-do recommendations (also known as low-value practices) is one of the causes of the lack of quality care in all health systems in all countries. Healthcare professionals must be provided with information about these low-value practices that are still frequently performed and their implications for patients and the healthcare system.

Continuous education is a key factor in this scenario, so that health students, health professionals, and even patients are kept updated with the main do-not-do recommendations. Gamified platforms are one of the most valuable options for continuous education, as they combine learning efficiency with a high level of engagement for the students. Besides, the effectiveness of gamification platforms can be improved by adding artificial intelligence techniques.

In this paper, a novel gamified platform focused on improving knowledge about low-value practices is proposed. AI techniques, as well as NLP tools are used to optimize the effectiveness of learning by adapting the platform to each user, at an individual level. Besides, the engagement of students is encouraged by their participation in a common project, namely the creation of a specialized dictionary for do-not-do terms.

Hardware development is currently in progress. A basic gamification platform has already been developed for the two main mobile operating systems. Developing IA and NLP techniques to analyse the training outputs and make the platform adaptable to each student is progressing.

The proposed learning tool can significantly improve healthcare quality and be applied to many other learning fields, particularly when continuous training is required.

KEYWORDS

Low-value practices, Do-not-do, Gamification, Artificial Intelligence, Natural Language Processing, Transformers.

1. INTRODUCTION

Failure to follow do-not-do recommendations (also known as low-value practices, overuse, overdiagnosis, overtreatment, non-recommended practices) is one of the causes of the lack of quality care in all health systems in all countries. It concerns the provision of health services in

David C. Wyld et al. (Eds): SIP, CRBL, WiMNeT, BIOM, EDUPT, NLDM, SOFTFM, COMIT - 2022
pp. 155-163, 2022. CS & IT - CSCP 2022 DOI: 10.5121/csit.2022.121716

circumstances where the potential risk of harming the patient exceeds the potential benefits [1], representing a risk both for patient safety [2] and for the sustainability of health systems [3].

The volume of patients subjected to low-value practices varies, depending on the type of practice and the country, between 1 and 80% [4]. The use of potentially unsuitable medicines might come as high as 57.6% [5] in some studies. In terms of costs, in the USA, where 18% of gross domestic product is spent on the health sector, overuse represents an additional annual cost which, according to the most optimistic estimates [6], ranges from $75.7 to $101.2 billion, whereas other studies put the figure at $158-226 billion [7]. In terms of damages to patients, the study presented in [8] estimates that between 0.2% and 15.0% of hospitalized patients admitted suffering adverse events because of low-value practices. In primary care, a study in Spain [9] estimated that ignoring the do-not-do recommendations resulted in 5.1% of adult patients suffering adverse events

Healthcare professionals must be provided with information about these low-value practices that are still frequently performed and their implications for patients and the healthcare system.

Continuous education is a key factor in this scenario, so that health students, health professionals, and even patients are kept updated with the main do-not-do recommendations. Previous research [10] concluded that gamified platforms are one of the most valuable options for continuous education, as they combine learning efficiency with a high level of engagement for the students. Besides, the effectiveness of gamification platforms can be improved by adding artificial intelligence techniques, as it is also stated in previous research [11].

The term gamification refers to the use of game attributes (mainly challenges and rewards) in a non-gaming context, particularly in education (Game-Based Learning or GBL). When focused on education, GBL techniques make use of games as assistant tools for learning, concept assimilation or knowledge evaluation. One of the main advantages of GBL is its ability to capture the user's attention, since it provides them with a fun and motivating environment. The game presents the users with situations in which they must reflect and make the right decisions, solve errors, and recognize mistakes. Attributes commonly found in gamification include scoring systems, win/lose challenges, rewards, leader boards, and social elements.

Different gamification strategies have been previously used in healthcare education. The effectiveness of these techniques has been widely analysed in multiple studies and reviews. Among the more recent reviews, those presented in [12] and [13] agree on the main conclusion: although rigorous studies are scarce, some of them report improvements, with respect to control groups, in different aspects like knowledge, skills, satisfaction, changing learning behaviours and improving attitudes towards learning.

There are multiple theories that can explain the reasons behind the success of gamification platforms. Among them, the called Social Comparison Theory, which is related to the introduction of scoring systems and leader boards [14]; the Experiential Learning Theory, which states that being part of a game increases the feeling of experiencing new situations and improves learning [15]; the Reinforcement Learning Theory, which explains that rewards and punishments (common in computer Reinforcement Learning algorithms and also in games) allow students to obtain more skills [16]; or the Self-Directed Learning, particularly for gamification platforms where students can choose among different games or tests [17].

In all cases, part the benefits of gamification are also related to the additional development of a social network for learners [18], where leader boards and scoring systems are complemented with different ways of interaction between participants.

An additional tool commonly used in leaning environments is Natural Language Processing (NLP), which includes multiples techniques for the automatic processing of huge amounts of textual information. Among the different applications of NLP, we will focus on information extraction, sentiment analysis, and automatic translation. NLP has evolved considerably in the last few years, mostly thanks to the development of Deep Learning [19]. More recently, the concept of "attention" was introduced [20] and a new architecture emerged: the transformer. Transformers are particularly well suited for translation tasks, where they clearly outperform all previous approaches [21]. Among the main developments in this field, we can cite different open-sourced NLP platforms, like BERT [22], ROBERTa [23] and BETO [24]. The availability of open-sourced code for these platforms allows for an easy integration and extension of capabilities.

It must also be considered that the combination of gamification and NLP is extremely beneficial [25]. Basically, when NLP is complemented with gamification techniques, data gathering becomes easier and all kinds of information extraction are improved. In fact, some gamification platforms are designed with the only purpose of acquiring data for further NLP processing [26].

In this paper, a novel gamified platform focused on improving knowledge about low value practices is proposed. Artificial Intelligence (AI) techniques, as well as NLP tools are used to optimize the effectiveness of learning by adapting the platform to each user, at an individual level. Besides, the engagement of students is encouraged by their participation in a common project, namely the creation of a specialized dictionary for do-not-do terms.
The paper is structured as follows: First, the methodology used for content generation is described in section 2. Sections 3 and 4 present the gamified learning platform developed and a proposal for improving student engagement, respectively. Software development is detailed in section 5; and section 6 analyses the data that can be gathered during platform usage. Finally, some conclusions are summarized in section 7.

2. CONTENT GENERATION

Content selection was performed through searches for do-not-do recommendations in different scientific societies and initiatives such as "choosing wisely". The following sources of information were used:

- American Academy of Orthopaedic Surgeons
- American Academy of Ophthalmology
- American College of Surgeons
- American Society for Transplantation and Cellular Therapy
- Cell Therapy Transplant Canada
- American Society of Haematology
- American Society of Paediatric Haematology Oncology
- American Society of Haematology
- American Society of Nuclear Cardiology
- Appropriateness Evaluation Protocol
- Choosing Wisely initiative

Besides, at a national level, 24 additional Spanish scientific associations were also searched for extra recommendations.

Next, recommendations were converted to teaching material for the gamification platform. The material as questions of different complexity: from short sentences that must be marked as true or

false to practical cases which will need a reasoned answer. In all cases, a reward for the correct answers is established. A total of 186 questions or challenges were created.

To improve the learning efficiency, each question was complemented with a detailed explanation for the students, which was shown after they answered, either correctly or incorrectly.

3. RECONFIGURABLE GAMIFIED PLATFORM

The basic behaviour of a gamified learning system is depicted in figure 1, where the three main components (learning system, gamification elements or rewards, and social network of students) are represented. Basically, by carrying out the tasks, assignments, tests, or games, the students are rewarded with different rewards.

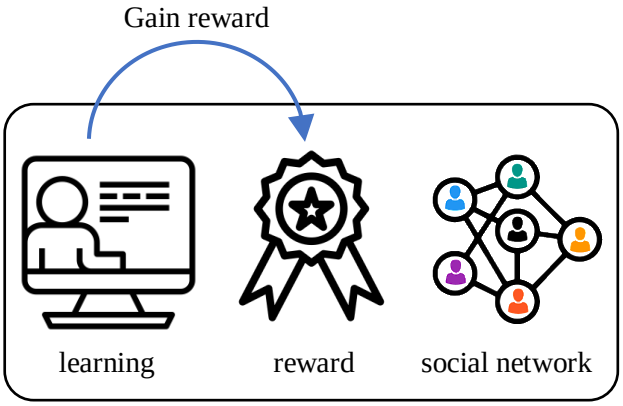

Figure 1. Basic behaviour of a gamified learning platform

We propose to add a continuous evaluation of 1) effectiveness and 2) engagement for each student. This evaluation will be based on all information gathered during training: first, learning results but, also, information extracted via natural language processing (NLP) form the participation of the student in the ad-hoc created social network, which may even include sentiment analysis. All data will be combined by means of artificial intelligence techniques (AI) to infer the best adaptation of the gamification scheme to offer optimized learning performance at the individual level. The proposal is represented in figure 2.

The items that can be adapted to each student are:

- Question level adjustment: should be adapted depending on the previous results of each user.
- Question types: some users may prefer challenges, other may prefer tests, etc. The same concept can be acquired using different question types.
- Level of gamification: some of the game-related elements (medals, trophies, sounds, animations) may be excessive for certain users.

Basically, two types of information are fed to the A.I. algorithms: evolution of the platform evaluation by users (which directly correlates to the suitability of the adjustments for those users); and textual information extracted from the interactions between users, which is analysed through NLP to indirectly detect levels of satisfaction. These NLP techniques include sentiment analysis, among other searches for keywords representing the acceptability of the platform.

A closed-loop control system continuously monitors the information received and adjusts the platform. This process is transparent for the users.

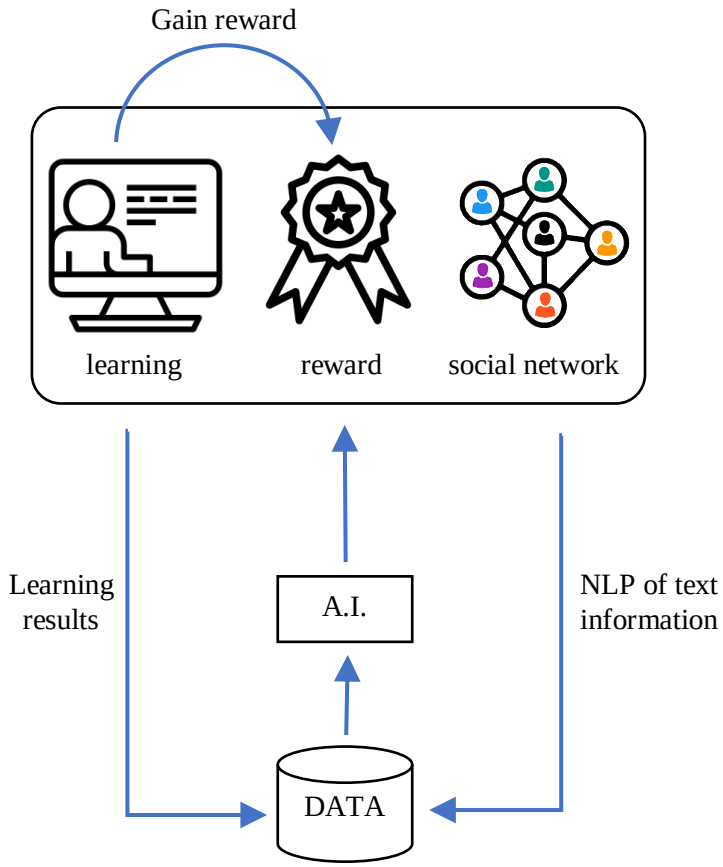

Figure 2. Our proposal of reconfigurable learning platform

4. IMPROVING ENGAGEMENT

To obtain more value from the system, and to increase the engagement of the students, all participants become part of a collaborative project whose objective is to create a dictionary specialized in "do-not-do" terms. Assuming that students from different countries may use the learning tool, each participant will be encouraged to add new items (new translations) to the dictionary (from English to their mother tongues), as well as to evaluate the other participants' translations. Both actions will be rewarded in the gamified platform in order to engage students. The dictionary will be used to train an automatic translation system via NLP and transformers. Besides being a means to engage students, this automatic translation system will finally become an extra source of information for all students, thus creating a learning system that evolves and is partially self-maintained. A schematic representation can be found in figure 4.

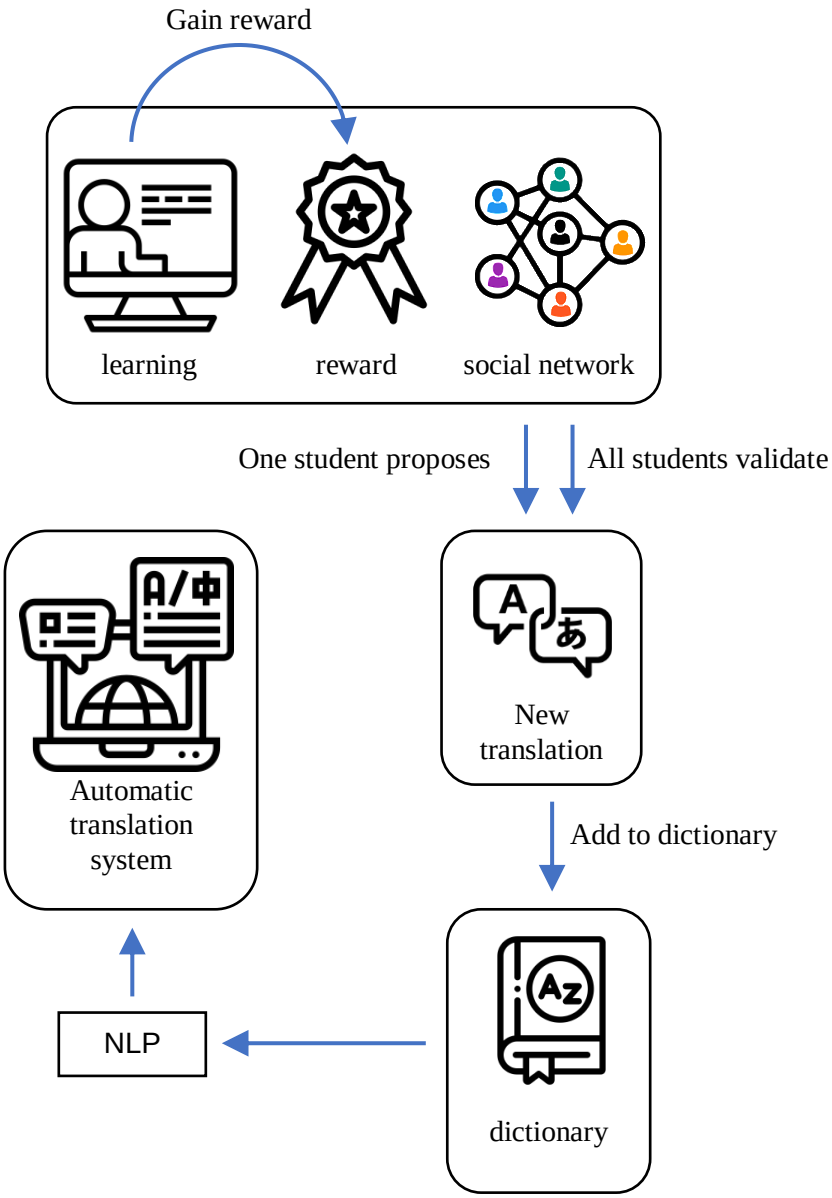

Figure 3. Collaborative creation of a specialized automatic translation system via NLP and transformers

5. SOFTWARE DEVELOPMENT

Software development is currently in progress. A basic gamification platform has already been developed for the two main mobile operating systems and can be downloaded from the store of Apple (for iOS devices) and Google (for Android devices). So far, they have been developed as native applications, which implies a specific development for each operating system. Future work includes a reengineering of the platform in order to develop a hybrid application that can run on both operating systems (Android and iOS), as well as in web browsers, in order to allow students to use it from their mobile devices and also from their computers. The IONIC platform [27] can be used for this purpose.

The development of IA and NLP techniques to analyse the training outputs and make the platform adaptable to each student are still under development. The automatic translation system (fed from the collaborative-created dictionaries) is based on open-sourced code available as a Python API [28].

6. DATA TO GATHER

The data to be collected during the use of the platform includes:

- Demographic, but not identification-capable, data: gender, age, medical specialty, and years of professional experience (the latter two, only for professionals).
- Game usage: questions answered, results, awards.
- Social network interactions, in order to apply NLP techniques to extract information, particularly sentiment analysis.
- Contributions to the collaborative dictionary.

Provided that the registered data will not include any identification-capable information, all these data available for further research, following the recommendations of the MareData network [29] and fulfil the FAIR Data Action Plan, as proposed by the European Commission [30] In brief, the data will be made available to researchers fulfilling Findability, Accessibility, Interoperability and Reusability.

7. CONCLUSIONS

The training of medical students and professionals in the field of low-value practices can have an important impact on the improvement of healthcare quality, as well as in the reduction of adverse effects and the reduction of health care costs, by avoiding overuse of medicines and medical tests. Engagement of students is crucial for increasing the effectiveness of training, particularly when a continuous training is required. The proposed learning platform is focused on reaching high engagement levels, since 1) it is based on a gamified environment, which per-se enhances engagement; 2) includes an adaptative behaviour to adapt to each student at the individual level; and 3) adds a collaborative project where all students are encouraged to participate to obtain additional rewards.

The proposed learning tool, which is centred on training on low-value medical practices, can be applied to many other learning fields, particularly when continuous training is required.

REFERENCES

[1] Chassin MR, Galvin RW. The Urgent Need to Improve Health Care Quality. JAMA.1998;280:1000-5.
[2] Lipitz-Snyderman A, Korenstein D. Reducing Overuse-Is Patient Safety the Answer? JAMA. 2017;317:810-1.
[3] Korenstein D, Chimonas S, Barrow B, et al. Development of a Conceptual Map of Negative Consequences for Patients of Overuse of Medical Tests and Treatments. JAMA Intern Med.2018;178:1401-07.
[4] Brownlee S, Chalkidou K, Doust J, et al. Evidence for Overuse of Medical Services Around the World. Lancet. 2017;390:157-68.
[5] Alhawassi TM, Alatawi W, Alwhaibi M. Prevalence of potentially inappropriate medications use among older adults and risk factors. BMC Geriats. 2019; 19:154.
[6] Shrank WH, Rogstad TL, Parekh N. Waste in the US Health Care System: Estimated Costs and Potential for Savings. JAMA. 2019 [Online ahead of print] doi: 10.1001/jama.2019.13978

[7] Berwick D, Hackbarth A. Eliminating Waste in US Health Care. JAMA. 2012;307:1513-6.
[8] Badgery-Parker T, Pearson SA, Dunn S, et al. Measuring Hospital-Acquired Complications Associated With Low-Value Care. JAMA Intern Med. 2019;179:499-505.
[9] Mira JJ, Carrillo I, Silvestre C, Pérez-Pérez P, Nebot C, Olivera G, González de Dios J, Aranaz Andrés JM. Drivers and strategies for avoiding overuse. A cross-sectional study to explore the experience of Spanish primary care providers handling uncertainty and patients' requests. BMJ Open. 2018;8(6):e021339. doi: 10.1136/bmjopen-2017-021339. FI (JCR, 2018): 2,376 - Q2 Medicine, General & Internal - SCIE.
[10] Fernández C, Lorenzo S, Vicente MA, Checa ML. Estudio comparativo de metodologías de enseñanza online para la reducción de las prácticas de poco valor. Actas del VII Congreso Internacional en Contextos Psicológicos, Educativos y de la Salud. Volumen I, 2021.
[11] Fernández C. Lorenzo S, Carrillo I, Oveja R. Utilización de técnicas de inteligencia artificial en una plataforma digital de enseñanza de las recomendaciones nohacer. Actas del VII Congreso Internacional en Contextos Psicológicos, Educativos y de la Salud. Volumen I, 2021.
[12] van Gaalen, A.E.J., Brouwer, J., Schönrock-Adema, J. et al. Gamification of health professions education: a systematic review. Adv in Health Sci Educ 26, 683–711 (2021). https://doi.org/10.1007/s10459-020-10000-3
[13] Gentry SV, Gauthier A, L'Estrade Ehrstrom B, Wortley D, Lilienthal A, Tudor Car L, Dauwels-Okutsu S, Nikolaou CK, Zary N, Campbell J, Car J. Serious Gaming and Gamification Education in Health Professions: Systematic Review. J Med Internet Res 2019;21(3):e12994
[14] Huschens, Martin & Rothlauf, Franz & Rothe, Ricarda. On the Role of Social Comparison Processes in Gamified Work Situations. Hawaii International Conference on System Sciences, 2019. 10.24251/HICSS.2019.176.
[15] Kolb, D. A., Boyatzis, R. E., & Mainemelis, C. Experiential learning theory: Previous research and new directions. Perspectives on Cognitive, Learning, and Thinking Styles, 2001, 1, 227–247.
[16] Chen, P. H., Roth, H., Galperin-Aizenberg, M., Ruutiainen, A. T., Gefter, W., & Cook, T. S. Improving abnormality detection on chest radiography using game-like reinforcement mechanics. Academic Radiology, 2017, 24(11), 1428–1435.
[17] Salinas Navarro, David Ernesto, Pacheco-Velazquez, Ernesto, Arana-Solares Iván, Mendoza, Jaime. (2020). Gamification and Self-Directed Learning. Proceedings of the European Conference on Games-based Learning, 2020. 10.34190/GBL.20.159.
[18] Amy K Saenger, Michael Berkwits, Simon Carley, Shannon Haymond, Marie Ennis-O'Connor, Jonathan Sherbino, Stephen W Smith, The Power of Social Media in Medicine and Medical Education: Opportunities, Risks, and Rewards, Clinical Chemistry, Volume 64, Issue 9, 1, 2018, Pages 1284–1290, https://doi.org/10.1373/clinchem.2018.288225
[19] Y. Bengio, A. Courville and P. Vincent, Representation Learning: A Review and New Perspectives, in IEEE Transactions on Pattern Analysis and Machine Intelligence, vol. 35, no. 8, pp. 1798-1828, Aug. 2013, doi: 10.1109/TPAMI.2013.50.
[20] A. Vaswani, N. Shazeer, N. Parmar, J. Uszkoreit L. Jones, A.N. Gomez, L. Kaiser, I. Polosukhin, Attention is All You Need, 2017, NIPS, arxiv.org/pdf/1706.03762.pdf
[21] S. Karita et al., A Comparative Study on Transformer vs RNN in Speech Applications, 2019 IEEE Automatic Speech Recognition and Understanding Workshop (ASRU), 2019, pp. 449-456, doi: 10.1109/ASRU46091.2019.9003750.
[22] J. Devlin, M.W. Chang, Open Sourcing BERT: State-of-the-Art Pre-training for Natural Language Processing. Google AI Blog, November 2, 2018
[23] Y. Liu, M. Ott, N. Goyal, J. Du, M. Joshi, D. Chen, O. Levy, M. Lewis, L. Zettlemoyer, V. Stoyanov, RoBERTa: A Robustly Optimized BERT Pretraining Approach. Preprint, 2019.
[24] J. Cañete, G. Chaperon, R. Fuentes, J.H. Ho, H. Kang, J. Pérez, Spanish pre-trained BERT model and evaluation data, International Conference on Learning Representations, 2020.
[25] J. Chamberlain, R. Bartle, U. Kruschwitz, C. Madge, M. Poesio, Metrics of games-with-a-purpose for NLP applications, 15th European Chapter of the Association for Computational Linguistics (EACL), 2017.
[26] A. Scharl, M. Fols, uComp Language Quiz - A Game with a Purpose for Multilingual Language Resource Acquisition, 15th European Chapter of the Association for Computational Linguistics (EACL), 2017.
[27] IONIC, cross-platform app development tool. https://ionicframework.com/
[28] Hugging Face Transformer API. https://huggingface.co/docs/transformers

[29] Maredata, thematic network of open research data. https://maredata.net/
[30] Final Report and Action Plan from the European Commission Expert Group on FAIR Data. https://ec.europa.eu/info/sites/info/files/turning_fair_into_reality_1.pdf

AUTHORS

César Fernández is Associate Professor at Miguel Hernandez University, Telematics Engineering area, since 1997. He obtained his Industrial Engineering degree from Polytechnical University of Madrid (Spain) and his PhD degree from Miguel Hernandez University in Elche. His main research topics are machine learning, computer vision and telemedicine. https://orcid.org/0000-0002-9391-9192

María Asunción Vicente received her MS degree in Electronics Engineering from University of Valencia in 1999. In 2007, she obtained her PhD degree (extraordinary doctorate award) from Miguel Hernandez University. Associate Professor at Miguel Hernandez University, Telematics Engineering area. She has carried research on innovation in engineering education, computational neuroscience, and computer vision. Currently, her research is focused on mobile health. https://orcid.org/0000-0002-8630-7251

Susana Lorenzo is PhD in Medicine by the Complutense University of Madrid and has a master's degree in public health policy administration by the University of Michigan. She is head of the Quality and Patient Management Area of the Fundación Alcorcón University Hospital. Director of the Journal of Healthcare Quality Research and member of editorial committees of other national and international journals. She has been president of the Spanish Society for Healthcare Quality. She is author of more than a hundred publications in books and national and international scientific journals. https://orcid.org/0000-0003-0954-7830

Irene Carrillo is Assistant Professor of the Department of Health Psychology at the Miguel Hernández University of Elche (UMH). Degree in Psychology (2013), Master's Degree in Health Psychology (2014), Master's Degree in General Health Psychology (2016) and PhD (2018) by the UMH. Main lines of research: quality of care, patient safety, second victim phenomenon, technological solutions in health and recommendations not to do. https://orcid.org/0000-0002-6981-7284

Mercedes Guilabert is Professor in the Department of Health Psychology of Miguel Hernández University (UMH). Degree in Psychology from Miguel Hernández University (2005). PhD in Psychology from Miguel Hernández University PhD program (2011). Master's degree in Patient Safety and Healthcare Quality (2014). Researcher in several projects, earning competitive research contracts financed by national and international agencies. Specialist in qualitative research techniques. Co-author of national and international publications. Invited speaker in national and international conferences and writer of technical reports for both public and private institutions. https://orcid.org/0000-0002-0706-9911