Motivate learning using new technologies: Continuous glucose monitoring

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Abstract- The innovation aims to: motivate, "turning knowledge into action", "promote the use of new technologies", develop "creative talents" and so on. We believe this project encompasses all of the above. Diabetes is the most prevalent endocrine disease and the 7th leading cause of death in the world. Continuous glucose monitors are of great help in controlling blood glucose levels and reducing the risk of diabetic disease. We have taken advantage of this idea to motivate and engage medical students in this Flipped learning proposal that led us to create a video entitled "*Continuous blood glucose monitoring*", in which themselves explain the usefulness of this technological advance through social networks. With this project we achieved that students could: a) directly verify the importance of the pancreas funtion in glycemic control (comparing their results with those obteined in diabetic patients); b) approach and implement the use of new technologies for learning; c) motivate and promote autonomous and collaborative learning; d) become protagonists and responsible of transferring what they have learned to their colleagues; and e) create a quality teaching material, useful also for health sciences professionals and diabetic patients, all them potential users of these devices.

Keywords: teaching-learning innovation, motivation, active learning, cooperative learning, higher education skills, virtual learning environments, digital skills, Information and Communication Technologies (ICT)

1. INTRODUCTION

In the traditional teaching model, the general and specific skills of subjects are acquired through face-to-face classes in which students spend most of their time listening to the teacher and completing work assignments outside of class. Although this is the major adopted model, its usefulness and effectiveness were questioned as early as the 1970s, and since then learning paradigms and practices are undergoing enormous transformations. In 2012, J. Bergmann and A. Sams developed a didactic strategy called the Inverted Class (*Flipped classroom*), which is based on providing students with the contents of the syllabus (notes, books, articles, videos, etc.) prior to class, to facilitate self-learning. During in-class time, social interaction among students should be encouraged, making it easier to learn from each other and support peers. While circulating and facilitating the lesson, teachers can spend more time with each student individually and provide guidance, detect errors, provide individualized instruction, update contents, and offer extension learning opportunities for those who are working "beyond the content." (Bergmann, 2012). Classroom time can, thus, be used more effectively and creatively. The role of the teacher is to help students clarify content and monitor their progress and level of understanding. The teacher's role is to be a "guide on the side" instead of a traditional "sage on the stage".

Among the advantages of the inverted classroom are the following:

- It gives the student a more active role in the teaching-learning process and favours the reinforcement of what has been learned in class.
- It allows students to learn according to their needs, thanks to the fact that they can use the uploaded material "on demand" in the virtual classroom.
- It enhances commitment to the teacher and classmates, encourages the development of communication skills and empathy, and favours collaborative work with classmates (Costelo, 2020), establishing all of elements as transversal competencies of the Degree in Medicine (Ministry of Education and Science, BOE-A-2008-2674).
- When this methodology is developed in small groups (as we have done), teachers are aware of who has accessed and reviewed the information, and they have more time available to attend to individual learning needs (Tourón 2015).

According to the learning pyramid model, "teaching is the best way to learn", as students retain an estimated 90% of what they have learned when they teach it to others or use it immediately (Miller, 1990). Moreover, teaching provides the satisfaction of helping others, and you'll also get asked questions you'd never expect, being reminded that you must keep studying. It is true that the percentages are debatable (Lalley, 2007), and that we must consider the context of the experience, the involvement of students and how learning is measured. However, based on our own experience as teachers, the veracity of the "principle" is undeniable, since "we reinforce our knowledge every day we teach." The challenge lies in getting the students to adopt an active role, and to prepare, participate and collaborate; otherwise, the task will be unsuccessful.

Everything that has to do with clinical practice and contact with new technologies engage and motivate medical students. Active learning helps to end the typical entrenched passivity associated with the traditional class format, generating contexts that promote deep learning, in which students become the protagonists, fostering relationships with their classmates, with

the teachers and with the faculty. Cooperative work encourages learning by integrating diverse personalities with varying skills within a group to carry out tasks that should be completed by all (Pujolàs, 2005). In addition, it is easy for debates between equals to be established, encouraging students to present valid arguments that help to strengthen the theory and practical knowledge acquired. In this way, greater degrees of autonomy, responsibility and commitment are achieved. Throughout this process, the support and guidance of the teacher is essential (Girod, 2002; Ríos, 2009), since adequate feedback allows to recognize mistakes, improve results, and the efforts made by group members to be balanced.

Competency is defined as "the ability to do something successfully and efficiently" and obviously includes the set of knowledge, skills, attitudes, values and aptitudes that, when interrelated, allow efficient professional performance in accordance with the state of the art. Competencies involve not only knowledge and techniques, but also ethical commitment and values (Peiró and Gregori, 2012). "Competency-based medical education" (CBME) has been suggested and tried to tackle these concerns, ensuring that the graduates develop the competencies required to fulfil the patients' needs in the society. Training a doctor is a complex task that involves the domain of biomedical, sociomedical and humanities applied to the clinic, in order to solve the health problems of patients and communities (Durante, 2011). To enable this, the educational process requires teamwork, the collaboration of teachers, compliance with academic programs, the proactive role of the student and the development of comprehensive assessment systems (Reyes, 2010). If professors and students know and use competencies, the teaching-learning process become more coherent and consistent. Competency education implies:

a) Moving from a teaching-centered approach to a learning-centered approach.
b) Ensuring that students take control of their training process.
c) carrying out direct work with the student through tutoring or advisory activity.
d) Achieving the alignment of each subject, module or area with competencies.
e) Applying a diversity of teaching-learning strategies appropriate to the academic programme.
f) Achieving basic-clinical and theory-practical integration throughout the curriculum.
g) Using ICT on a daily basis and in an efficient way.
h) Promoting collaborative work to favour a constructivist approach.
i) Developing comprehensive evaluation systems that consider the curricular process, learning, teaching, feedback and updating.
j) Constantly updating educational content and materials.
k) Promoting multi- and interdisciplinary activities.

In short, competency-based Medical Education facilitates the integration of knowledge, know-how and being, that is, the integration of knowledge, ability, attitudes, values, and skills (Durante, 2011), and in many ways this has been our objective in this Teaching Innovation Project (TIP).

The University of Valencia (UV) finances TIP in which videos to support teaching are produced. These videos are disseminated "online" through the Ongoing Training Service channel on *YouTube* and can be accessed through the links published in the practical class workbooks and / or the Moodle platform. They contain explanations and examples that are very useful for improving the preparation and scope of the classes (theory and practical), the preparation of exams and the acquisition of skills. Indeed, during these last two academic years, they have come to replace face-to-face classes due to the limited numbers imposed by the recent pandemic. Our department teaches physiology of the endocrine system theory classes and "determination of glycaemia" practical classes within the subject Medical Physiology II, which is taught in the 2nd year of the Degree in Medicine (UV). In our practical classes, with the help of a conventional glucometer, capillary blood glucose is determined in fasting conditions, after ingestion of food and during physical exercise. Continuous glucose monitors (CGM), considered in 2018 to be one of the 10 most innovative medical devices, are extremely useful for monitoring changes in blood glucose 24 hours a day, and are essential to guarantee the correct treatment of diabetic patients (Lin, 2021). The University of Valencia granted us a TIP (UV-SFPIE_RMD18-954130), with which we purchased several CGMs and introduced them in the classrooms, developing educational innovation techniques (Peris-Ortiz, 2014) and preparing a video in which the contents of the practical class and the use of these devices are explained. Virtual teaching and ICT have been essential in carrying out this TIP.

2. CONTEXT

Experimental science students usually attend practical classes without previously reviewing the manuals and without prior preparation. This leads to errors, loss of time available for experimentation and loss of potential benefits of the class, which limits the acquisition of knowledge and skills. Currently, students have a high degree of mastery of information and communication technologies (ICT), and this offers enormous educational possibilities (Palomo, 2006). The rise of these technologies has led to the development of so-called mobile learning (Trillo, 2015), which allows the implementation of new teaching methodologies, complementary to traditional ones and which are more attractive to students, arouse their curiosity and facilitate the improvement of the teaching-learning process (Peris -Ortiz, 2014). Through video, students and teachers can prepare better, evaluate clinical cases, approach scientific and current state-of-the-art assignments in a more efficient way, clarify concepts, reinforce and apply knowledge and become familiar with expert opinion. It is a tool that generates discussion and reflection, and which combines images, sound and colour, which is attractive for students, and a motivating element (Ricardo, 2017).

The classroom environment and space limit learning in many ways. It inhibits more introverted students, and the limited time available limits the possibility of raising questions and the teacher's ability to respond, among other disadvantages. In this sense, practical groups, which are usually smaller, are ideal environments to implement innovation strategies. In addition, establishing contact outside the classroom, using less formal, more relaxed and / or different environments from those of the academic environment, contributes to learning (Hervás-Gómez, 2019). Therefore, most of this TIP has been carried out in the practical session classroom and/or outside the faculty, in an environment prone to new experiences and learning. Regarding the practical class of glycemia determination, CGM is a novel technique that allows 24-hour monitoring and guarantees the correct treatment of diabetic patients. With this TIP funding

(UV-SFPIE_RMD18-954130) we acquired 4 CGMs which motivated the participation of students in the project.

Objectives:

- To motivate students in the study of Physiology, to promote active learning with ICT, and to turn students into teachers who, through the CGM video, explain to their classmates the contents of the practical class and how these devices work.
- To create a favourable environment that favours the closeness of students and teachers, which helps to disinhibit students, encourages subjects to express doubts, curiosities and / or concerns, and establishes links that promote learning and the acquisition of competencies.
- To help students acquire the necessary skills for the future development of their profession: teamwork, knowledge of scientific language, public speaking, etc.; in short, to promote learning through competencies associated with Medical Degrees and other Health Sciences Degrees.
- To create a quality educational video, freely accessible on the YouTube channel, which will be useful for students taking our subject and for students and / or professionals from other disciplines within the field of Health Sciences, as well as for diabetic patients and those around them.

3. DESCRIPTION

We offered the students in the 4 groups of Medical Physiology II (2nd Year of Medicine) the possibility of making use of a CGM (for 14 days, which is the life span of the device) to monitor their blood glucose levels, share in real time the results with their classmates, and participate in the preparation and creation of the video for this TIP. There were many volunteers (more than 30), to whom we provided information on how to operate the CGM (links to the manufacturer's website, research, etc.) by email (this was during the recent pandemic). Subsequently, a meeting was arranged outside class, in which we explained in more detail what the project would consist of, how to attach the CGM, and the tasks to be carried out to prepare the video. We explained that, to participate, it was essential to prepare in advance the theory and practical contents of the subject and to use online resources to learn by themselves: the procedures for attaching and activating the sensors, for downloading and activating the applications to enable readings with mobile phones, and for sharing the blood glucose tests through said mobile phone applications, thus allowing students to access and interpret the results obtained by their classmates who were also wearing the sensor. With these premises in mind, we initiated flipped learning dynamics (favouring self-learning), collaborative work and the use of ICT (Ricardo, 2017). After the meeting, other students expressed their interest in participating, even though they were aware that we did not have a CGM for everyone, which demonstrated that we had managed to arouse their interest. Only 4 glucose sensors were available, so we faced the first problem of how to distribute the task to avoid leaving some students out of the practice.

From here on, the sequence of events was as follows:

a) To avoid making distinctions between the 4 groups of theory lectures, we assigned a sensor randomly to a student from each group, along with Smartphones compatible with the CGM (Abbott 2018). To avoid excluding individuals and to maintain the students' motivation, we agreed that the sensor wearers would share their blood glucose levels with their classmates using the brand's mobile application, which they installed on their mobile phones. Thanks to this mobile application, we were able to involve more students in the project; all the participants were able to monitor changes in blood glucose throughout the day and the multiple factors that influenced these changes. In this way, the students learned that not everybody has the same values, nor the same capacity to compensate for the changes associated with daily activities. The mobile application highlighted the usefulness of new technologies, showing how diabetic patients can instantly share information about their blood glucose levels with relatives and / or people close to them, which is of special interest to children.

b) Among the volunteers, there were 2 type 1 diabetic patients who were regular users of CGMs and shared their knowledge and experience of living with diabetes with their colleagues, which fostered empathy with patients (development of what is known as hidden competences of the Degree in Medicine). Their participation allowed us to carry out a comparative study between the blood glucose levels of healthy people and diabetic patients, highlighting the importance of the physiological mechanisms of glycaemic control. By sharing their medical data and knowledge of the subject with classmates, collaborative work (Hadwin, 2017), learning through clinical cases and education in values were all promoted (Peiró i Gregori, 2012).

c) We brought the volunteers together again for them to explain what they had learned while searching the Internet, which highlighted their interest in the task and their group work. We provided them with CGMs and glucometers, and we explained how to use them (attaching and activation of the sensors, determination of blood glucose with a traditional glucometer, sharing data using a Smartphone, etc.) to prepare them for recording the video in the laboratory.

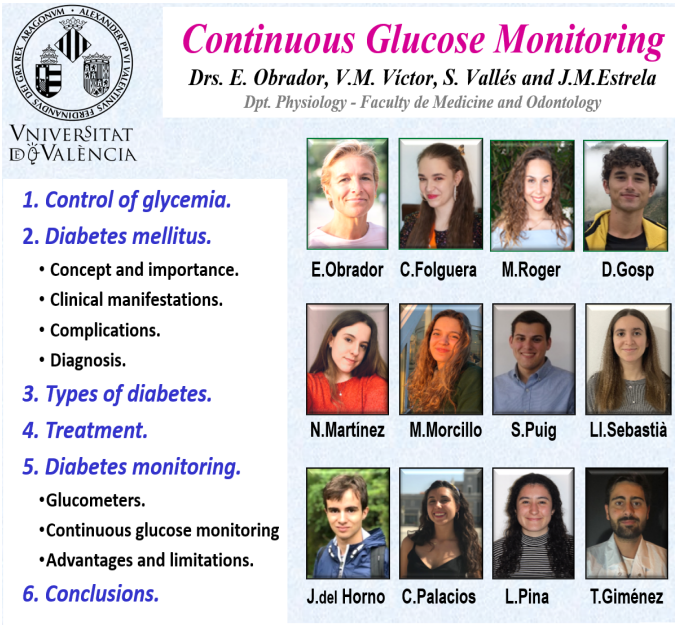
d) On the day of the recording in the laboratory (November 3, 2020), the volunteers explained in front of the camera how to determine blood glucose levels with the traditional glucometer and the procedure for attaching and activating the CGM. From that moment on, and for the next 15 days, everyone had instantaneous information of the blood glucose levels of their colleagues. It was evident that we had motivated and awakened the interest of the students, because every day they raised questions, observations, and ideas, which contributed to favouring the student-teacher approach. We took advantage of the feedback and teamwork to recommend that the students themselves use what they had learned in Physiology classes to interpret the results and to justify how changes in diet, oral glucose overload, exercise, stress situations, and changes in the ovarian cycle affect blood glucose and the endocrine system. In this way, active learning and the development of innovation techniques were promoted, in accordance with the proposals of the European Higher Education Area (Tejada, 2006).

e) Once the results had been obtained, and with our help, the students prepared a power-point presentation that was later used in the recording and editing of a video entitled "Continuous blood glucose monitoring", in which the students explained the following concepts: the hormonal control of glycaemia, the management of capillary glucometers and / or CGM, the interpretation of their results, the use of AGP reports (ambulatory glucose profile) and the

advantages and disadvantages of using each of these devices. In this way, we use flipped learning and ICT to promote the acquisition of horizontal and transversal competences of the Degree in Medicine (Ministry of Education and Science, BOE-A-2008-2674); namely: "Understanding and recognizing the structure and normal function of the human body at the molecular, cellular, tissue, organic and systems level, at the different stages of life, and in both genders, the appropriate use of scientific language, transmitting information, ideas, problems and solutions to both specialized and non-specialized publics, understanding and recognizing the effects of growth, development and aging on the individual and their social environment, etc.". Originally, the second part of the recording and assembly of the video was to have been carried out in December, but due to the pandemic, administrative problems (sick leave and termination of the technician's contract) and the impossibility of student participation during the month of January (due to exams), everything was delayed much more than expected, leading to the disengagement of some students, which is easily understandable if we take into account that, once they have passed a subject, they focus on the activities of the new quarter.

f) As soon as we were assigned a new recording technician, we contacted volunteers (at that stage 14 remained involved in the project) to see which of them were interested in helping us finish the project by recording the video in the studio. The new technician advised us that not more than 4-5 people should appear in the video. The students themselves were the ones who carried out the selection process, which depended on their availability and that of the recording technician. The rest of the students continued to be involved in the project until the end, helping us in the preparation of the power point presentation and the video.

4. Results



https://www.youtube.com/watch?v=Hx6_-AfXaKY

Figure 1. Cover of the video with participants.

A. Video: "Continuous Glucose Monitoring"

The students have been the protagonists of the video entitled " Continuous Glucose Monitoring", available in open access format through the *Youtube* channel of the University of Valencia. In the video, the students explain: the hormonal control of glycemia, the concept of diabetes and its types, the current diagnostic criteria, the use of glucometers and glucose sensors, and the advantages and disadvantages of each of these devices. In the Figure 1 you will find: the link to access the video, the list of the contents and the participants.

B. Motivate and promote active learning.

- We have implemented active learning strategies that, beyond helping to pass the assessment exam, have familiarized students with the latest technological advances and have promoted collaborative work (Girod, 2002; Hadwin, 2017), enhanced the knowledge and use of scientific language and ICTs (Palomo, 2006; Ricardo, 2017) and, of course, strengthened student-teacher ties, thereby favouring the acquiring of skills that are an essential part of a doctor's training (Ministry of Education and Science, BOE-A-2008-2674; During, 2011; Reyes, 2010).
- The volunteers who remained involved in the TIP until the end answered an anonymous survey, and these were the opinions expressed:
- 100% stated that: a) their participation in the TIP had helped them to acquire the competences of the subject, b) it had helped to establish closer ties with the teaching staff, c) they would recommend classmates to participate, d) video is a useful medium for future students and / or fellow students and for diabetic patients.
- 85.7% considered that what they had learned would be useful in other subjects and in their professional activity. The remaining 14.3% did not state an opinion.
- 92.9% stated that the project: a) had promoted the use of new technologies and b) collaborative work and that c) they would volunteer again. The rest did not state an opinion.
- 71.4% thought that their participation has helped their classmates, and 28.6% did not state an opinion.

C. Future results.

In future academic years we will use the video to develop flipped classroom strategies. To assess the usefulness of the video, we will conduct opinion polls and will confirm whether preparation for practical classes and evaluation results are improved thanks to this material. Beyond the educational field, the usefulness of the video will be evaluated by monitoring the number of visits on *YouTube* and the opinions of viewers.

5. Conclusions

As a result of this project:

- Students have used state-of-the-art CGMs, reviewed and interpreted their reports, and simultaneously monitored changes in blood glucose associated with daily activities, transferring what they have learned in class to their day-to-day life. We have changed "know-how for knowledge".
- The project has promoted the student-teacher approach and the establishment of links that facilitate active learning.

- Students have become teachers responsible for creating quality educational material. We have used ITC to facilitate learning and have implemented flipped learning strategies through which we have managed to awaken interest and motivation and to favour active learning and the acquisition of horizontal and transversal competences of the Degree in Medicine.
- The CGM video will help future students to prepare better and to get more out of the practical class, which will facilitate the acquisition of skills. Free access through the internet will also benefit students enrolled in other courses and / or degrees in Health Sciences, as well as health professionals and diabetic patients, the other potential users of these devices.

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