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ORIGINAL RESEARCH

Effectiveness of Twitter Threads to Improve Medical Student Electrocardiogram (ECG) Reading-Skills. The TwittUVa-ECG Non-Randomized Pre-Post Study

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Abstract

Introduction social media is increasingly used in medical education, but its real educational effectiveness is unclear. In this study we assess the effectiveness of Twitter threads (TTS) in improving electrocardiogram (ECG) basic reading skills (ECGBRS).

Materials and Methods Seven TTS describing ECGBRS were published from October 28, 2021, to November 24, 2021. Tests were used to assess medical students ECGBRS pre and post intervention. All third and sixth-year medical students were invited to participate. Sixty-three students were enrolled (33 third year and 30 sixth year). Nine (14.3%) participants dropped out.

Results Sixth year medical students had higher ECGBRS at baseline. The number of correct items increased after the Twitter intervention; median correct pre-test items were 20 out of 56, (interquartile range (IQR) 14–23), and median post-test were 29 out of 56, (IQR 21–36) ($p < 0.001$). The improvement in sixth year students was greater than for third year students; 10 more correct items (IQR 4–14) vs. 7 (IQR 1–14) items ($p = 0.045$). The more TTS followed, the greater the improvement in ECGBRS ($p = 0.004$). The QRS axis calculation was the ECG reading skill with the lowest scores. Most medical students were definitely (35%) or very probably (46%) interested in repeating another on-line learning experience and found the TTS extremely (39%) or very (46%) interesting.

Conclusions The use of specifically designed TTS was associated with improvement in medical students' interpretation of ECGs. The effectiveness of the threads was higher in the final years of medical school when basic skills had already been acquired.

Keywords Education, Medical, Undergraduate · Social media · Pre-post Tests · Students, Medical

Introduction

Today, social media has become almost indispensable in daily life, especially in young people such as university students [1, 2]. Some university students studying science have adopted social media because they perceive it as positive for their training, demand more digital learning sources and massively follow social media in educational experiences which have promoted social media focused on scientific content [3–6]. Nevertheless, there are not all advantages in relation to social media and education. Firstly, not all the students are engaged on social media. Bruguera et. al. identified 5 separate "learner profiles" according to the way they interacted with learning resources and their use of social media, with 18.3% classified as "detached" due to low use of learning resources and only sporadic use of social media [7]. Secondly, some studies have suggested a possible negative role of the greater use of social media on academic results on undergraduate medical students, with a significantly higher use of social media among academically low-performing medical students compared with high-performing medical students [8]. Thirdly, the students need to have developed critical reading skills to identify misleading information on social media [9]. Lastly, they should be able to avoid the

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Extended author information available on the last page of the article

exposition of unprofessional content in their post and also have the skills to address colleagues in the case of unprofessional online behaviour [10].

Given its widespread use, social media is considered a potential tool for medical training. Medical educators use social media as an easier way to connect with medical students and engage them in study, although there are still large differences between medical students' preferences on social media and medical educators' proposals [11]. Various studies have described the potential use of social media in medical education [12–15].

Twitter is one of the candidates for introduction in health education *[Of note: on April 2023, Twitter was rebranded as X Corporation and on July 2023, its blue and white bird logo, was substituted by an X].* Twitter is a free, easy-to-use tool able to support teaching materials such as texts, images, videos, polls, or links to other network materials. It has been used in medical teaching with different objectives such as improving knowledge, supporting curricular activities, increasing medical students' engagement, reducing student anxiety about teaching material and improving communication between faculty and students or between students themselves. [16–20]. However, Twitter it is not the most popular social media between the students. In one study [21], Twitter was selected by only 3% of students, who preferred other online tools as Facebook or Instagram. In addition, the students preferred the use of Moodle, the university official Learning Management Systems, over social media. Complaints about Twitter were the overload information, competence frustration and the extrinsic motivation [22]. However, despite its limitations, this platform combines the opportunity of blogging and instant messaging, has a high versatility as it allows multimedia attachment of video, images, or the addition of hyperlinks to the text. Moreover, the use of Twitter threads (TTS), i.e., a set of linked tweets on the same issue, enables users to elaborate a complete combination of text, hyperlinks, and images to explain complex subjects beyond the limitations imposed by a single message or images.

To date, there is little data on the added value of Twitter as an educational tool in health to improve students' skills. Most studies on the use of Twitter as an educational tool in higher education have focused their attention on students and lecturers perceptions about the use of the different tools and on the user's satisfaction [17, 23]. Its potential to enhance the students' learning capabilities it is not fully assessed as the results are still ambiguous. Examples of this ambiguity are the following studies. A study in second year medical students showed that those who actively engaged with a weekly case presentation published on Twitter achieved better results on an end of course quiz than those who did not [24]. In contrast, mean final exam scores were not significantly different among veterinary students that engaged with radiographic cases delivered via Twitter and those that did not [21]. The use of Twitter polls increased geriatric knowledge in third year students compared with non-users [25] whereas a prospective observational study of third year medical students where objective surgical facts were daily delivered to medical students via Twitter, did not show any difference in the level of acquired skills after the use of the social media [26] although on a post-clerkship survey, 59% of students believed that Twitter had improved their educational experience. In the studies described above, those that contained elaborate educational material, such as clinical cases, or involved student participation, such as the use of polls, performed better than those that used Twitter as a mere repository of information. It seems interesting to continue assessing the value of Twitter as an educational tool by developing specific material for their use in this social media.

The aim of this study was to investigate the effectiveness of the use of TTS to improve medical students' basic electrocardiogram (ECG) reading skills (ECGBRS) and to assess whether the previous level of knowledge in ECGBRS has any influence on the degree of improvement achieved in the knowledge of that subject after the use of social networks. We hypothesized that specifically designed TTS could improve medical students' skills. In addition, we proposed that the improvement would be greater for junior medical students vs. senior medical students since the first had a lower background level of knowledge about ECGBRS.

Material and Methods

Design

The TwittUVa-ECG (Twitter for improving students' skills on ECG on the University of Valladolid) study was an investigator-initiated, single center, quasi-experimental study to assess medical students' skills before and after an educational intervention on Twitter. The study was approved by the Research Ethics Committee of West Valladolid Health Area (21-PI171). The study was part of a teaching innovation project "*Semiología en imágenes (Semiology in images)*" approved by the Online Education, Training and Teaching Innovation (VirtUVa) of the University of Valladolid. Informed consent was obtained from medical students participating.

Setting

The study was conducted in the Medicine, Dermatology and Toxicology Department of the Faculty of Medicine, University of Valladolid.

Medical education system in Spain. Medical schools in Spain have a 6-year curriculum. In the University of

Valladolid, the initial two years are devoted to basic science as biology, physiology, gross anatomy, histology, or immunology. From the third year we start core clinical subjects, alternating classroom learning with periods of clinical clerkships (average 3 to 6 weeks per rotation). Lastly, the sixth year is completely devoted to clinical clerkships, with medical students primarily embedded within an inpatient rounding team, working closely with resident physicians and an attending physician all the university course.

Participants

Third- and sixth-year medical students were invited to participate. Participation was voluntary. Participation was not used for the qualification of any subjects in the medical degree. The third and sixth years were chosen because they represent two levels of medical training. In the first semester of third-year, training with real clinical cases is about to start. Third-year students had not yet participated in any ECG reading course. In the sixth-year medical training is nearing completion. Sixth-year students had already participated in ECG reading courses in previous years. In UVa curriculum, ECG training course is included in the second semester of third-year.

Educational Intervention

We chose ECGBRS to be developed on Twitter. The reasons for choosing ECGBRS as the subject for the educational intervention were the possibility to easily create infographics and video for e-learning, that ECG attracts a great deal of interest for the undergraduate students and previous experiences that demonstrated the possibility ECGBRS teaching with e-learning [27, 28].

To teach ECGBRS we created seven TTS (Supplementary eTable 1). TTS are a set of tweets written by the same user and containing 280 characters or less, numbered, and linked. TTS allow the inclusion of images, polls, links and video. We used the most commonly used ECG-manuals in our region [29, 30] as a reference for the development of the educational content delivered via Twitter and to elaborate the guide of the TTS and decide which would be the main themes of each one the TTS. In addition to the seven TTS, several images and six YouTube videos were created with PowToon to be included as a part of the TTS. We decided to create videos for the most complicated part of ECGBRS skills to facilitate learning The seven TTS were published weekly from October 28, 2021 to November 24, 2021. Participants received an e-mail alert. There were no other educational activities focused on ECGBRS and no tutorial support outside Twitter during the study period. There were no additional materials for students who do not use Twitter. Participants could ask questions only by using the Twitter reply icon. The questions were answered by the researchers.

TTS were designed to avoid content overload by focusing only on the basic aspects of ECG reading skills. All the TTS were elaborated by the researchers to validate content expertise. Only curated links for other authors were included in the tweets. We try to include as little information as possible to synthesize all the content given to the students. All the TTS could be visited. Links are showed in eTable 1, Supplementary. Re-tweets and likes were assessed.

Assessment of Twitter Educational Intervention Effectiveness

To assess ECGBRS we designed two tests, each of which included 4 ECGs. The eight ECGs were randomly selected from a sample of thirty ECGs from hospitalized patients admitted to the Hospital Universitario Rio Hortega, Valladolid in October 2021 (Supplementary Material). For every ECG, the participants had to answer 14 questions, grouped in ten categories: rhythm, rate, QT interval, QRS axis, P wave, QRS complex, ST segment, T wave and ischemic heart disease. The original Spanish tests are shown in Supplementary eTable 2a–c. The first test was carried out on October 28, 2021, just before the first TTS was published. The second test was carried out on December 1, 2021, one week after the publication of the last TwitUVa-ECG TTS. Both tests were done in person at two classrooms of UVa medical school. The test was the same for all participants, regardless of year. The correct answers of the test were determined by the researchers.

Post Hoc Assessment of Twitter Educational Intervention Effectiveness for Retention of Knowledge

After the first peer-review of TwittUVa manuscript we decided to include an additional analysis of TwittUVa effectiveness to compare participants' outcomes with their peers and to assess knowledge retention over time. During second semester of 2021–22 course, the third-year student had an ECG reading course on the MSPCS course. In the exam for this course, they must answer 11 questions regarding ECG. We analysed the entire 3rd year cohort's (185 students, 25 of them included in TwittUVa-ECG study) MSPCS course exam score and compared the results of just the medical students who participated in the TwittUVa study 1) with their peers who did not participate in TwittUVa-ECG study and 2) among them according to the number of TTS followed. We did not have any data for sixth-years students additional to those of TwittUVa-ECG itself.

Outcomes

The primary outcome was the change in the number of correct items comparing the pre and the post TwittUVa tests. The secondary outcomes were the change in the number of incorrect and unanswered items and the change in the number of correct items for each of the ten ECG sections. In addition, we assess as a secondary post-hoc outcome the number of correct answers in the MSPCS second semester exam for the third-year students. We also polled participants to assess their perception of the teaching intervention and the level of satisfaction with it.

Sample Size Calculation

Due to the exploratory nature of the study and the lack of previous data, we did not calculate a sample size. The sample size was established for convenience according to the actual number of volunteers who agreed to participate.

Statistical Analysis

All medical students who completed the two tests were included in the analysis. Categorical variables are presented as numbers and proportions and continuous variables as median and interquartile range (IQR). Due to the small number of medical students included, we used nonparametric tests. For the primary outcome, the change in the number of correct items before and after the Twitter intervention we used the Wilcoxon signed rank test. To compare the differences in variables with more than two categories we used the H Kruskal–Wallis test. To compare the differences between third-year students and with their peers, we used the Mann–Whitney U test. All p-values are 2-sided and are shown without adjustment for multiple testing and $p < 0.05$ was considered statistically significant. The analyses were performed using IBM SPSS Statistics for Windows, Version 26.0. Armonk, NY: IBM Corp.

Results

Sixty-three medical students were enrolled (33 third year and 30 sixth year, median age, 23 IQR, [IQR, 20–23] years; 45 [71%] women), with 9 (14.3%) participants declined to take second test (Fig. 1). There were no post-test scores for these students.

Medical students' demographics and social networks usage at baseline are shown in Supplementary eTable 3.

Primary Outcome

After the TTS teaching intervention, the results on the ECG test improved with an increase of 9 correct items out of 56 (IQR 4 to 14) (Supplementary eTable 4). Test score increased in both groups (Fig. 2). The increase in the number of correct items was greater in sixth year students (10, IQR 5 to 14) than in third year students (7, IQR 1 to 14) ($p = 0.045$). Pre and post teaching test results are shown in Table 1.

The change in the number of correct items was associated with the number of TTS followed, with better results in medical students who followed most of the TTS ($p = 0.004$ for the whole sample, 0.039 for 3rd year and 0.197 for 6th year) (Fig. 3). Of note, there were differences in the baseline rate of correct answers in the first test in third year students (0 to 2 TTS followed vs. 3 to 6 or 7 TTS followed), with a higher rate of correct answers in the students who were then going to follow more TTS (Supplementary eFig. 1). There were no differences in the rate of correct answers in the first test in sixth year students.

Secondary Outcomes

Data of incorrect answer and unanswered questions are shown in Supplementary. The change in the number of correct items for each ECG section are detailed in Supplementary eTable 5. The QRS axis calculation, QRS complex, ST segment and T wave interpretation had the greatest improvement.

Post Hoc Analysis (Analysis of ECG-MSPCS Course Exam Questions)

One hundred eighty-five medical students completed the MSPCS exam on June 2022. Included in this group were the 25 third-year students that completed TwittUVa study. The number of correct items was higher in TwittUVa study participants than in their peers (6 correct items out of 11 (IQR 4.5 to 8) in TwitUVa participants vs. 4 (IQR 3 to 8) in the rest of classmates ($p = 0.002$). This difference was higher when the students were classified according to the number of TTS followed (Fig. 4).

Medical Students' Perception of the Teaching Intervention

Most student followed five or more of the seven TTS (70%) and most felt that their ECGBRS had significantly (39%) or moderately (41%) improved. Students found the use of social media to complement normal classes extremely (39%) or very interesting (46%) and most would repeat the experience. The feeling of improvement, the interest in the use of social media and the willingness to repeat the experience

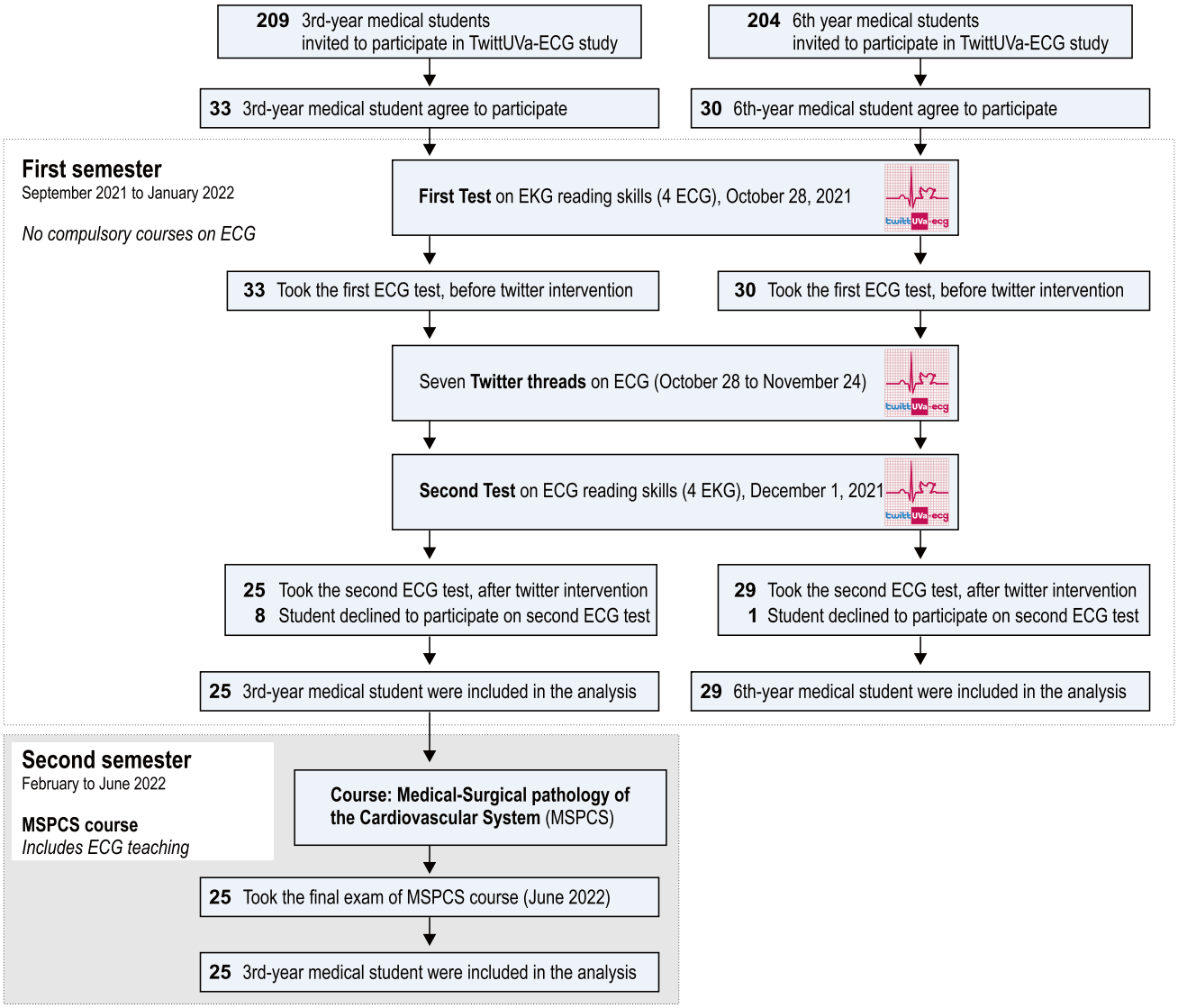

Fig. 1 TwittUVa study flow diagram

were higher in sixth year students than in third year students (Table 2 and in Supplementary eTable 6).

Discussion

We assessed the use of TTS to improve knowledge and skill development in third and sixth year medical students. Pre- and post-test ECGBRS results showed that ECG knowledge increased in most of the students, especially in sixth year students, who started from a better training level and greater knowledge of ECGBRS. To the best of our knowledge, this is the first study to compare the effectiveness of a social media educational intervention in two medical school years together. Contrary to our hypothesis, it was not the medical students with less initial knowledge who achieved greater improvement with the use of TTS, but those who started with a higher knowledge base.

The best performance of the higher-level learners with the TwittUVa educational intervention could be explained using two educational facts. On one hand, higher-level learners possess better self-regulation skills and a greater capacity for self-directed learning [31]. Both abilities align with the flexibility and autonomy offered by social media. In our case, TwittUVa-ECG provide them with tools to tailor their learning by choosing relevant content and add them to previous content. On the other hand, the educational theory about the Zone of Proximal Development (ZPD) [32, 33], could be relevant to justify the higher-level advantage in our study. In the classic ZPD learners can perform a task, but only with support from someone with more knowledge or expertise. In our case, for 6th-year

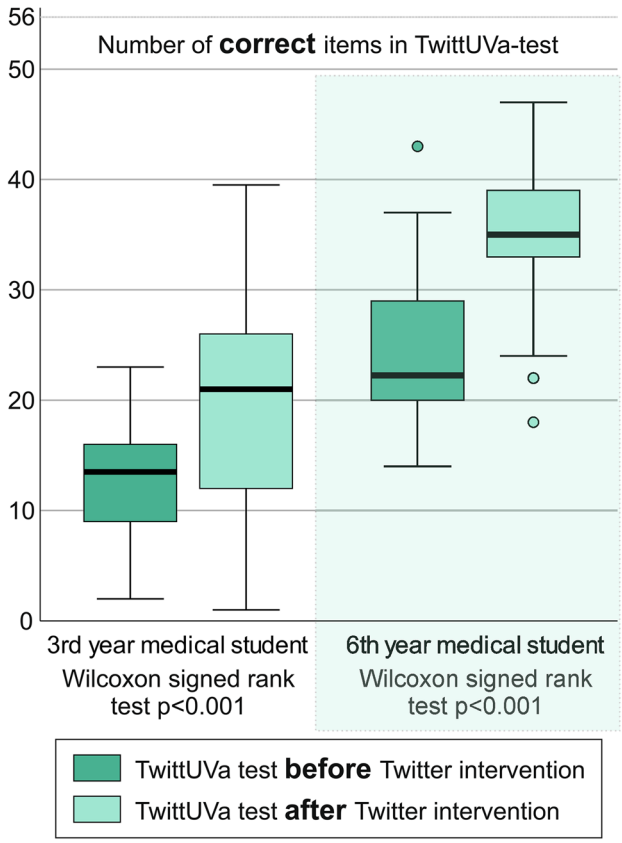

Fig. 2 Box plot of the changes in the number the of correct items in TwittUVa-ECG test before and after Twitter intervention. Median is represented as a thick line inside the box and first and third quartiles are represented as the bottom and the top of the box. M The whiskers show the maximum and minimum values, with the exceptions of outliers (circles)

student, ECG skills are between their ZPD where Twitter material acts as a facilitator, whereas for some of the 3rd-year students, due to their absence of previous basic ECG knowledge, Twitter material was not sufficient to act as a facilitator in their ZPD as they need higher support to achieve better improvements in ECG skills.

According to our data, we can hypothesize that social media may be more effective when used to reinforce previously acquired knowledge as a part of the self-direct study, than when it is used as a substitute for traditional classes. The higher impact on education of traditional classroom over Twitter is illustrated in a previous study that compared the retention of knowledge and images between lecture hours and Twitter. This study showed that students retained less information from Twitter than from the traditional classroom [24]. Dialogue and discussion, and not just the presentation of material, improves comprehension and overall learning. The combination of traditional lectures with specifically formulated online material may be the best approach to the use of social media [34].

In addition to the higher performance in higher-level learners, the use of social media seems to be also more useful for those who have more interest in the subject that is being studied. This is exemplified in our study by the initial differences in the pre-test scores in third-year students before Twitter intervention. It is likely, that the differences seen in the pretest scores were associated with students' interest in the subjects and/or in the use of social media as educational tools.

One of the concerns of the use of social media is the grade of acceptance by the students. In our study, most of the students agree with the use of Twitter as they felt that they have improved their ECG reading skills. Our data agree with a recent systematic review that highlighted the opportunities to improve medical teaching by using social media [15]. Medical students willing to get involved in the use of social media for teaching found that their use made study more intellectually interesting, faster or more creative [35, 36]. The use of social media offers three principal benefits to teaching and learning: medical students can learn on the move, they have continuous connectivity and they can enhance collaborative learning [37]. In addition, it is likely that following social media would enhance medical students' interest in the subject and amplify sources of information.

We are not aware of any negative effect of our educational intervention over our students' performance. Some studies have shown a negative effect of the use of social media in medical education. For example, a study of the use of Twitter to engage students in neuroanatomy learning showed a negative correlation between time viewing tweets and examination scores [38]. The fact that our study did not substitute any curricular activity and that all participation was voluntary limit the possibility of negatively affecting our students. Therefore, we recommend that social media content should be carefully curated and drawn up by faculty members, and the addition of empty content should be avoided, specifically repetitive or irrelevant content without educational or inspirational value or poorly executed content as low-quality videos. We encourage to the use of interactive content to engage the student with learning. This way, we can avoid content overload, reduce students' confusion, and facilitate them to focus on what is important.

Our study has several limitations. Firstly, the study was offered to medical students at a single medical school and the results may not be generalizable. Second, we used a convenience sample size, which was relatively small. However, despite the limitations on the statistical power due to the small sample size, the study was able to detect significant differences. Third, participation was voluntary and there were no academic incentives offered. This may have affected the sample size, but it also meant that Twitter could be considered as a stand-alone tool in our design, less influenced by other teaching resources. The assessment of

Table 1 ECG reading skills at baseline and after TwittUVa-ECG threads on Twitter

	3rd year medical student			6th year medical student			Total		
	Before TwittUVa-ECG (Total) (n = 33)	Before TwittUVa-ECG (with second test) (n = 25)	After TwittUVa-ECG (n = 25)	Before TwittUVa-ECG (Total) (n = 30)	Before TwittUVa-ECG (with second test) (n = 29)	After TwittUVa-ECG (n = 29)	Before TwittUVa-ECG (Total) (n = 63)	Before TwittUVa-ECG (with second test) (n = 54)	After TwittUVa-ECG (n = 54)
TwittUVa-ECG test (total 56 items), median (IQR)									
n of correct items	14 (9–16)	14 (10–17)	21 (11–27)	22 (20–29)	23 (20–30)	35 (32–39)	17 (13–23)	20 (14–23)	29 (21–36)
n of incorrect items	18 (12–23)	18 (11–22)	15 (13–23)	26 (18–27)	26 (18–27)	14 (11–19)	20 (16–26)	21 (17–26)	14 (12–20)
n of unanswered items	24 (17–34)	23 (17–34)	13 (8–32)	7 (3–10)	7 (3–10)	5 (2–9)	15 (7–24)	13 (7–22)	8 (3–15)
N of correct items (n/4 ECGs), median (IQR)									
Rhythm diagnosis	2 (1–3)	2 (1–3)	2 (1–2)	3 (2–3)	3 (2–4)	3 (3–4)	2 (1–3)	3 (2–3)	3 (1–4)
Hearth rate	0 (0–3)	0 (0–3)	1 (0–3)	3 (2–4)	3 (2–4)	3 (3–4)	2 (0–3)	2 (0–3)	3 (0–4)
PR segment interpretation	1 (0–2)	1 (0–2)	2 (1–2)	2 (2–3)	2 (2–3)	3 (2–3)	2 (1–2)	2 (1–2)	2 (1–2)
QT interval interpretation	0 (0–1)	0 (0–1)	0 (0–1)	1 (0–1)	1 (1–1)	1 (0–3)	1 (0–1)	1 (0–1)	0 (0–2)
QRS axis calculation	0 (0–0)	0 (0–0)	0 (0–1)	0 (0–0)	0 (0–0)	1 (0–2)	0 (0–0)	0 (0–0)	1 (0–2)
P wave interpretation	1 (1–2)	2 (1–3)	1 (1–3)	3 (2–3)	3 (2–3)	3 (2–4)	2 (1–3)	2 (2–3)	3 (1–3)
QRS interpretation	1 (0–1)	1 (0–1)	1 (1–2)	2 (1–3)	2 (1–3)	3 (2–4)	1 (0–2)	1 (1–2)	2 (1–3)
ST segment interpretation	0 (0–1)	0 (0–1)	1 (1–2)	2 (1–3)	2 (1–3)	3 (2–3)	1 (0–2)	1 (0–2)	2 (1–3)
T wave interpretation	0 (0–1)	0 (0–1)	1 (1–2)	1 (0–2)	1 (0–2)	2 (1–3)	1 (0–1)	1 (0–2)	1 (1–2)
Ischemic hearth disease	0 (0–0)	0 (0–0)	0 (0–1)	1 (0–2)	1 (0–2)	2 (1–2)	0 (0–2)	0 (0–2)	1 (0–2)

IQR interquartile range

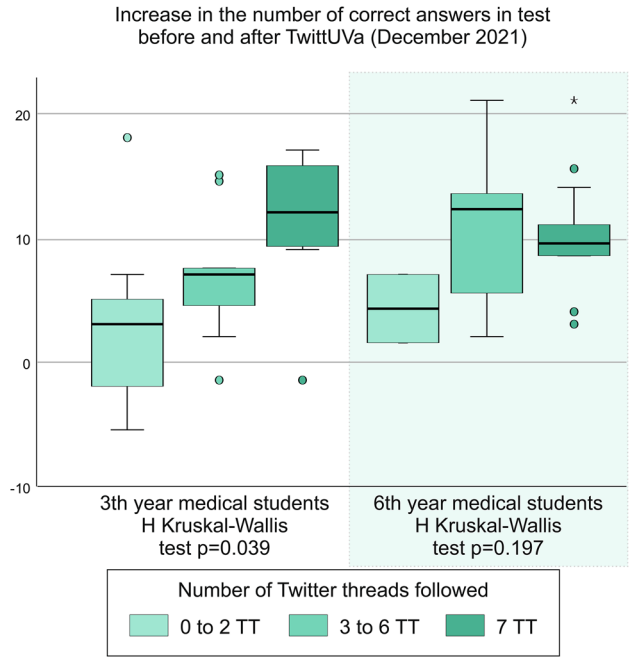

Fig. 3 Box plot of the changes in the number of correct answers in TwittUVa-ECG test (pre-post difference October-December 2021) according to the number of Twitter threads followed (third- and sixth-year students). Median is represented as a thick line inside the box and first and third quartiles are represented as the bottom and the top of the box. M The whiskers show the maximum and minimum values, with the exceptions of outliers (circles)

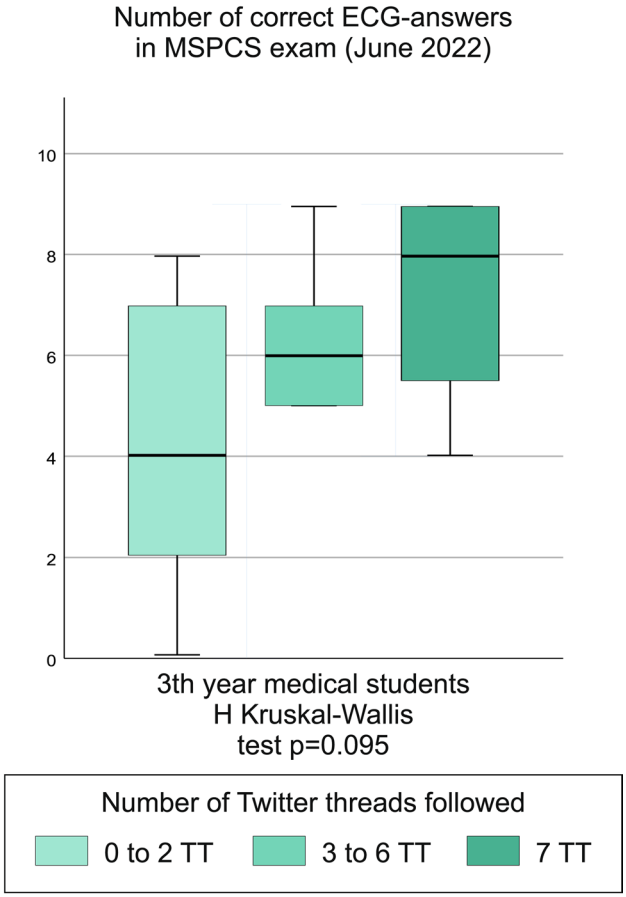

Fig. 4 Box plots of the changes in the number of corrects answers in the Medical-Surgical Pathology of the Cardiovascular System (MSPCS) exam of June 2022 according to the number of Twitter threads followed (third-year students). Median is represented as a thick line inside the box and first and third quartiles are represented as the bottom and the top of the box. M The whiskers show the maximum and minimum values, with the exceptions of outliers (circles)

the effectiveness of a social media as an educational tool, beyond the self-reporting student engagement, is difficult [39]. Isolating the influence on students' skills improvements due to the social media from the impact of all the other factors related to learning (regular classes, interactions with teachers and/or peers, or self-study) it is nearly impossible. When we designed our study, we assume four conditions to try to isolate Twitter impact from the impact of other teaching resources: a) The intervention was not part of any specific subject of the third-year curriculum. TwittUVa was developed during the first semester of the course 2021–2022. For third-year students there is a mandatory course of ECGBRS during the second semester, six months after the TwittUVa study, as a part of the Medical-Surgical Pathology of the Cardiovascular System (MSPCS) course. There is not any course of ECGBRS for sixth-year students. b) The researchers did not provide medical students with any other study material for ECGBRS than TTS themselves during TwittUVa study. c) The students could only solve their doubts about ECG via Twitter. No other types of educational meetings between students and researchers were established. d) The intervention was not considered for the student's qualification and participation of medical students was voluntary. We made this decision to avoid that medical student feel compelled to participate. With these assumptions, we were aware that we were sacrificing the possibility of obtaining a larger sample, but in return we were getting a design in which Twitter was the stand-alone tool and its role on the acquisition of knowledge for the medical students was less influenced by other teaching resources. Fourth, the drop-out rate was high in third year students, which may have been because the study coincided with examinations. The low rate of losses in sixth year students partially compensates for this limitation, giving more strength to the group with greatest improvement. Fifth, the original study protocol included only one assessment test after the teaching intervention. The assessment for long term knowledge retention using the MSPCS exam results was later included as a part of the assessment and their results should be interpreted with caution. Finally, the largest limitation of our study was that there was no control group. To try to assess the effectiveness of TTS when compared our study participants

Table 2 Medical student perception of TwitUVa-ECG

	3rd year medical student (n = 25)	6th year medical student (n = 29)	Total (n = 54)
Self-assessment of the improvement in ECG reading skills, n (%)			
Extremely	0 (0%)	0 (0%)	0 (0%)
Significantly	8 (32%)	13 (45%)	21 (39%)
Moderate	8 (32%)	14 (48%)	22 (41%)
Slight	8 (32%)	2 (7%)	10 (19%)
Not at all	1 (4%)	0 (0%)	1 (2%)
Do you recommend these threads to other students? n(%)			
Definitely ye	14 (58%)	16 (55%)	30 (57%)
Very probably	11 (44%)	11 (38%)	22 (41%)
Possibly	0 (0%)	1 (3%)	1 (2%)
Probably not	0 (0%)	1 (3%)	1 (2%)
Definitely Not	0 (0%)	0 (%)	0 (0%)
Did you find the use of social networks to complement traditional classes interesting? n (%)			
Extremely interesting	11 (44%)	10 (35%)	21 (39%)
Very interesting	8 (32%)	17 (59%)	25 (46%)
Moderately interesting	6 (24%)	2 (7%)	8 (15%)
Slightly interesting	0 (0%)	0 (0%)	0 (0%)
Not at all	0 (0%)	0 (0%)	0 (0%)
Would you repeat the experience of on-line learning? n (%)			
Definitely yes	6 (24%)	13 (45%)	19 (35%)
Very probably	14 (56%)	11 (38%)	25 (46%)
Possibly	5 (20%)	3 (10%)	8 (15%)
Probably not	0 (0%)	2 (7%)	2 (4%)
Definitely not	0 (0%)	0 (0%)	0 (0%)

with their peers supposedly no exposed to the TTS, we have performed a post hoc analysis using data from the exam of MSPCS on the second semester, after receiving the ECGs course included in normal curriculum. These results should be interpreted with caution as a volunteer bias is likely. The students that were included in our study were all volunteers and they could differ in engagement in learning, attention or interest in ECG from those medical students who do not participate in TwittUVa-ECG study. In addition, since the Twitter threads were visible to everyone, it is not possible to guarantee that non-participating students saw the TTS before the exam.

Conclusion

In our study, the use of specifically designed TTS were associated with improvement in medical students' interpretation of ECGs. Additionally, TTS were more effective in reinforcing ECGBRS previously acquired than in teaching them for the first time. However, we must keep in mind that the simple use of Twitter in teaching is not enough to make this social media an effective educational tool. We need to develop attractive, quality, and interactive material to share on Twitter with our students. The effort we will invest in their elaboration is worth it to complement our personal educational environment.

Abbreviations ECG: Electrocardiogram; ECGBRS: Electrocardiogram basic reading skills; IQR: InterQuartile Range; MSPCS: Medical-Surgical Pathology of the Cardiovascular System (); TTs: TwiTTer Threads; TwittUVa-ECG: Twitter for improving students' skills on ECG on the University of Valladolid

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Availability of data and materials The data that support the findings of this study are available from the corresponding author, upon reasonable request.

Declarations

Competing interests All authors declare that they have no conflict of interest.

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