Original Article

WhatsApp in *mHealth*: an e-learning tool in the COVID-19 era to share dynamic images in hemodynamics

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Background: COVID-19 has stimulated distance learning activities. This activity becomes particularly difficult when it comes to supporting internship activities. This applies to all study courses and to degree courses focused on Health Care. The study proposed here takes place as part of one of these degree courses and focuses on internship activities related to diagnostic imaging.

Methods: The study refers to an architecture previously proposed for the exchange of dynamic images (among the most complex) in hemodynamics through mHealth solutions based on WhatsApp and proposes: (I) the integration of architecture into a distance learning model; (II) evaluation of the model on the actors involved (students and tutors).

Results: The *mHealth* model has been configured. The assessment of the model in terms of acceptance on two independent groups of 15 students showed a high statistical significance and returned useful and positive comments/observations for the use during the pandemic period and future applications after the end of the pandemic in routine use.

Conclusions: From a global point of view this contribution demonstrates our alignment with the scholars in the field with regards to the use of WhatsApp in medical imaging and didactics. Furthermore, the study suggests: a reinforcement of the research actions: (I) to face simple solutions (e.g., WhatsApp) to allow the use of tele-imaging; (II) the use of these solutions in didactics also to free the laboratories.

Keywords: Hemodynamics; COVID-19; e-learning; mHealth

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Introduction

E-learning at the time of the COVID-19

The COVID-19 pandemic has had a disruptive aspect on all human activities, forcing us to accept new models of interaction in various activities, from work to educational, communicative, and social ones. Among the activities that have undergone an important remodeling to allow social distancing we have had those related to teaching. In teaching, in fact, new models have been developed that have foreseen different modalities, both completely remotely or in a hybrid way.

As far as the university is concerned, no exception has been made and certainly many critical issues have arisen due to the difficulties in carrying out the internship and training in presence of tools/procedure/equipment, and the criticality was accentuated when it concerned the medical faculties, dealing with aspects of public health.

By focusing, for example, on medical universities, it is now possible to take stock, given the emergence of wide-ranging works.

A research on PubMed on reviews and overview with key: *(e-learning) AND (COVID-19) AND (review) AND (university) AND (medical)*

returns 12 papers (1-12). These papers highlight both:

- The development of new models of teaching [with great diversity and possibility of approach (2,8)] which have touched all disciplines, from pediatrics (1,12), dentistry (4), oncology (5), rheumatology (6), anesthesia (7), urology (8), neurosurgery (9);
- The difficulties in adapting these models. Difficulties that in many cases have had a strong impact on mental health (3-11).

The focus of the study in a master's degree program

We focused on a master's degree program for the diagnostic technical health professions. Distance training activities have been planned in this course. Furthermore, internship activities are also foreseen in this course.

Students with three-year degrees related to medical radiology and radiotherapy, audiological, biomedical and neuro physio pathological techniques can access this degree course.

In our study we have proposed a model, for contents suitable for students with extraction coming from the techniques of medical radiology and radiotherapy.

We should carefully consider that:

- In this sector, the exchange of images in the internship activities is of great importance, for example in the preparation and sending between centers;
- The internship didactics must also include the possibility of training on these issues, without possibly accessing the places work routines, already overloaded with problems and limitations due to the pandemic.

Study aims

mHealth is a valid support in health care in general and has important potentialities in the exchange of information and images through easy and user-friendly systems, such as WhatsApp even when it comes to images (13) and also useful in difficult conditions of imaging (14) and successfully tested into several medical areas (15-18). In this period, mHealth (19) has shown itself to be useful in all activities.

As regards teaching, even prior to COVID-19 some studies had shown a successful use of a tool based on WhatsApp (20,21). With reference to hemodynamics, an architecture for sharing hemodynamic images based on WhatsApp had already shown its potential (22). The reader can find in this study (22) a broad and detailed description of the architecture that we will summarize below in this study.

The idea of this study is:

(I) To focus to the course described in *The focus of the study in a master's degree program* section and in particular to the internship activity such as that focused on images;
(II) Select an extremely critical image sector for this activity, such as the hemodynamics (with motion images);
(III) Prepare a sharing model;
(IV) Test it on stakeholders in this activity.

We present the following article in accordance with the MDAR reporting checklist (available at http://dx.doi.org/10.21037/jphe-21-24).

Methods

The methodological flow consists of two steps:

(I) The description of the architecture;
(II) The validation of the model of teaching (using the architecture) on two samples of independent students using short feedback form.

Description of the architecture

We recall the architecture presented in reference (22) and describe the adaptation to the teaching.

The architecture is described in the following briefly. See in reference (22) for the further details.

The two functionalities of WhatsApp used in the architecture are:

- The quite common and user-friendly function used to create a group in WhatsApp. This function is used to manage the exchange of the images. In the group there are both tutors and the students. The group was named "*e-learing-radiology*";
- *WhatsApp Web* as a means to send images from central PCs (managed by the tutors), where are the Picture Archive Computerized Systems (PACS*) (or images from the PACS) to the students having the smartphones.

**The PACSs are power PC where images are stored from radiological studies. These systems allow a centralized access from remote users using the networks.*

Figure 1 highlights the two side of the architecture:

(I) The tutor side (near the PACS or the PC with the images from the PACS);

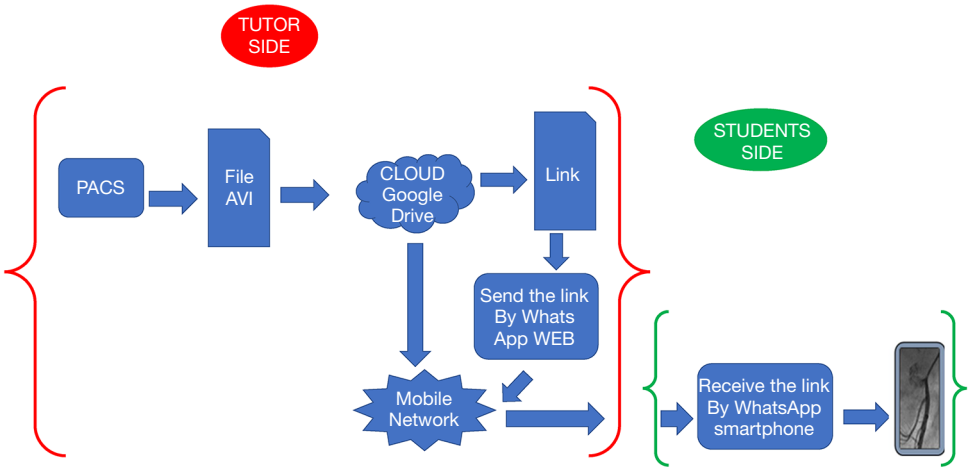

Figure 1 Flow chart describing the proposed model.

(II) The student side (with their smartphones).

More technological details are available in reference (22).

With the aim of our study we explain the architecture without going in deep to technological issues.

As shown in *Figure 1*, starting from the tutor's side, we can see that:

- ❖ Images from the PACS are extracted and converted into the audio video interleave (AVI) format using an image converter;
- ❖ These images are stored in the *google drive* (the same used cloud for the android smartphone account);
- ❖ A link is therefore easily generated;
- ❖ The link is sent using WhatsApp WEB at the tutor's side;
- ❖ The link is received using WhatsApp at the student's side in the smartphone;
- ❖ The student opens the hemodynamics study by a click of the link.

Google Meet (Google, USA) is used for the *Video A*udio communications as for other traditional teaching activities at the Sapienza University during the pandemic.

The validation of the model of teaching

The study dedicated to the validation:

(I) Involved 15 students of a specialization course with a medical technology radiology background;

(II) The students were arranged into two different and independent groups (group 1: 7 males; 8 females; averaged age 22.3; SD =1.1; group 2: 8 males; 7 females; averaged age 22.8; SD =1.2);

(III) Each group performed an independent trial.

It was proposed to the two groups a lesson module using also the previously described model.

A feedback form to assess the satisfaction was proposed based on 5 simple parameters to rate.

Statistical analysis

We used a proper statistical approach in the study to face the validation of the model reported in (22).

The student t test was used between each couple of the parameters assessed in the two groups. It was chosen as reference a P value >0.1 (higher than the conventional 0.05) to indicate no significance in the difference between the two considered averaged values. It was chosen as reference a P value <0.01 to indicate a high significance in the difference between the two considered values.

The study was conducted in accordance with the Declaration of Helsinki (as revised in 2013).

Results

The feedback form was submitted using Microsoft forms sending the link by means of WhatsApp.

It comprehended five questions, based on 5 parameters, on the acceptance of the lesson module

Each question includes a graded evaluation (Min =1; Max =6) of one parameter.

The evaluated parameters were the following:

(I) Easy to use in e-learning;

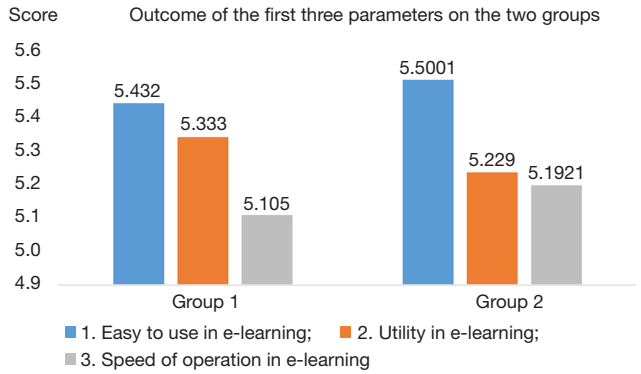

Figure 2 Scores registered in the two groups for the first three investigated parameters.

Table 1 Statistics for the first three parameters with the Student's *t*-test

Parameter	P value
Easy to use in e-learning	0.21
Utility in e-learning	0.19
Speed of operations in e-learning	0.13

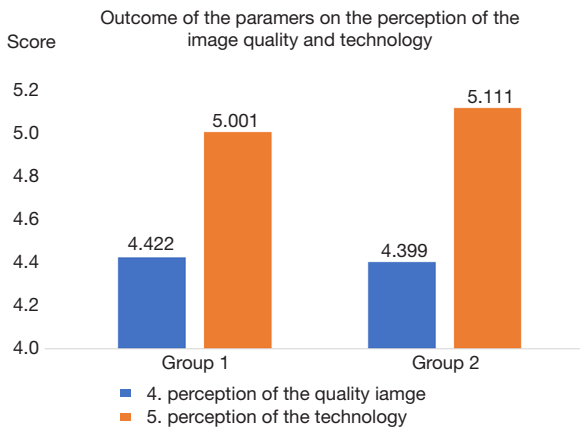

Figure 3 Scores registered in the two groups for the last two investigated parameters related to the perception of image quality and technology.

(II) Utility in e-learning;
(III) Speed of operation in e-learning
(IV) Subjective perception of image quality;
(V) Subjective perception on technology.

They students were asked to use the same smartphone device they used for e-learning and/or the interaction with their colleagues.

Table 2 Statistics for the last two parameters with the *t*-student test

Parameter	P value
Perception of the image quality	0.22
Perception of the technology	0.18

Figure 2 shows the encouraging results for the two groups for the first three investigated aspects 1–3 related to the model of e-learning and for the two times repeated experiments.

It should be noted that:

The first three parameters were rated above 5.0 in average in the two groups.

We used the Student's *t*-test between each couple of the parameters assessed in the two groups, we used as reference a P value >0.1 (higher than the conventional 0.05) to indicate no significance in the difference between the two considered averaged values. Results showed coherence in the results and no recorded significant differences between each one of the couple of the values (*Table 1*).

The two parameters related to the perception (I) "subjective perception of quality of the image" and (II) "subjective perception of technology" returned an average value higher than 4.3 (*Figure 3*).

The perception of the technology was higher than the perception of the quality in the two groups.

Results showed coherence also for these two parameters. No recorded significant statistical differences between each one of the couple of values (*Table 2*) was detected.

Each student was also invited to report a comment/observation (not mandatory) on the model. We collected these comments and classified them (joining the similar ones).

Table 3 shows the classified comments highlighting a positive impact of the model.

Discussion

This work proposes a model of e-learning using WhatsApp. The model was used in a master's degree program for the diagnostic technical health professions. It comprehended a lesson module with:

- The sharing of hemodynamics images according to a previously proposed architecture (22) adapted for teaching activities;
- Lessons using Meet.

The model showed a high degree of acceptance on two different groups of students in two independent trials. The

Table 3 The list of the classified comments

N	Classified comment	Number of similar
1	Very useful during the pandemic	5
2	It will be useful also in the post pandemic period	3
3	It could be expanded in other medical imaging fields	3
4	It could be integrated in several modules	2
5	Useful but I prefer the in person teaching	2
6	Useful it could be standardized in didactics offer	1

two trials showed no difference in terms of acceptance (Student's *t*-test, P>0.1).

This work from a global point of view shows how simple solutions based to the common technology (as for example the instant messengers mostly used in the social networks) as for other telemedicine applications (13-18,20,21) could contribute to the images teleconsulting using the mobile technology also in didactics. In particular, the study shows that the use of WhatsApp for teleconsultation is possible also in the e-learning activity. The results are indicating that the methodology could give a great contribution in the field of the *telemedicine and e-Health* delivered using the *mHealth* also in the distance learning. The creation of a dedicated study on health technology assessment (HTA) should provide indications for stabilizing and spreading the methodology. At the moment we are moving into two directions: (I) the planning of a specific environment for the evaluation of the HTA of the methodology in the e-learning starting from a previous approach designed in other studies (23-26); (II) the focusing to the field of hemodynamics and echography where, as suggested by this study and two other ones (13,22) there are important perspectives in the e-learning. A lot of work must be done to face both the acceptance of the scientific societies in the field and the adequacy to regulations. However, this study shows an important direction of research for pilot experiences directly related to the application of social-media in the health care provision in medical imaging during the training activities in e-learning.

Conclusions

The study proposed a successfully model for e-learning to be used in the experimental activities of the students using WhatsApp. Dynamic images extracted from the PACS in the format AVI were used in the module. The acceptance analysis was very high. From a global point of view this contribution demonstrates our alignment with the scholars in the field with regards to the use of WhatsApp in the medical imaging (13-18,20,21) and in didactics (20,21) showing its potentiality during the pandemic and also useful for the post pandemic period. The general added value of the work is the contribution in the same direction and in agreement with other studies on the opportunities of WhatsApp in the medical activities such as the training ones (20,21). The first added value is the configuration of the model of the e-learning proposed to share the dynamic medical images based on the functionalities of WhatsApp, starting from the component (WhatsApp WEB) as mediator with the PACS. The *second added value* is the study on the acceptance of the model on two independent groups of students with a statistics confirming the significance of the results. The *third added* value is the direct application of the methodology in an e-learning package that can be exported into other realities. The *fourth added value* is the scenario of the future employment of the model during and after the pandemic period.

Limits of the study

The study is mainly a feasibility investigation. It was demonstrated the feasibility to enclose applications of image sharing in an e-learning module. The generalization to routine teaching applications needs a careful tuning based both to HTA studies and careful check to the adequacy to the standards of the University, including internal and external regulations.

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