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HUMAN-COMPUTER INTERACTION IN MEDICAL EDUCATION

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Abstract

As a pivotal and critical constituent of medical education, notable Human-Computer Interaction (HCI) conduct emphasizes attention for building a domain in which each and every employee develops and excels. HCI, as is always an essential partner in medical field, is here understood as the central idea or the thematic statement of the study. The aim of this study is to summarize the analysis of the selected sample into a compound article that move within the circle of Human-Computer Interaction in medical education. The study was conducted as a review of 55 articles selected from refined 250 ones, within the concept of technology in medicine in a period of 3 years (2016-2019). Descriptive approach is used through an evaluative analysis, where literature review is considered as a tool for data collection.

Keywords: Medical education, human-computer interaction, technology, health professionals, medical schools.

Introduction

‘Human computer interaction (HCI) evolved as a recognized discipline that attracts innovation and creativity. It inspired new solutions, especially for the benefit of the user as a human being, making the user the focal point that technology should serve rather than the other way around.’ Claude Ghaou, (2006), Encyclopedia of Human Computer Interaction.

Medical technology innovation is becoming anonymous with technology, where it is mainly computers and, in all places, and directions.

“Hopkins” model, that requires admissions of earning undergraduate degree to join the medical school, was for more than a century. This is behind solidity and deep-rooted base of knowledge in biomedical sciences and clinical medicine. But a leap change had taken place since adoption. Some scholars considered medical education has taken a backseat in medical schools, others showed that it is lagging far behind others and the rest declared that it is in stagnation period.

Furthermore, criticizing and comparing the technology of smartphone and biosensors, that give the consumers, e.g. patients, the opportunity to control their health and lug power away from healthcare givers, faded and elapsed with the age of Paternalism.

Nonetheless, by 1980s, where applied Computer Assisted Learning (CAL) saved time in comparison to the more traditional in medical education, in 1990s, and due to rapid increase of knowledge and technologies, differing practice frameworks and pedagogical new understandings, medical schools dared to revise their curricula for more active learning and integrated medical education.

In closure of the last century, Health Information Technology (HIT) that generally refers to ‘computer applications for the practice of medicine’, arose to enhance life expectancy, quality of life, diagnostic and treatment options, as well as the efficiency and cost effectiveness of the healthcare systems.

‘To err is Human’

(Alexander Pope, "*Essay on Criticism, Part II, 1711*")

Within this new era, there is incessant innovation of technology with an astounding pace, particularly, in medicine. This technology simplifies certain aspects of life ascribable to its advantages and increases complexities due to difficulties in using devices associated with it. Usability, that is potentially hazardous, is a vital part and a core factor in human-computer-interaction process. Medical educators, healthcare givers and clients (patients) are supposed to be well versed in dealing with this technology through orientation by technology providers, training by field courses or long-term periods and environmental practice. These are called ‘human factors engineering’, ‘subsequent learning of theoretical contents’ and ‘implementation’, that incorporate the application of principles about human behaviours, abilities and limitations, to the design of tools, devices, environments, and training in order to optimize human performance and safety.

A review of articles was conducted by deploying an online literature search with Science Direct and Google Scholar, as well as other random resources search within Near East University grand library, using key phrases like medical education, technology, computer-assisted instruction or social media. Criteria of inclusion and exclusion for relevance were accustomed to involve the analytic dimensions and elements of the selected study articles. Details into a shared docs tables were displayed through systemic reviews, where itemized on the study purpose, population studied, outcomes measures, results, conclusions and limitations.

Significance of the Study

The study will clearly study the role of technology in medicine with emphasis on medical education and signifies that technology is behind the furtherance of medicine that appears in healthcare systems improvement, efficiency and cost-effectiveness. It inspires medical and health leaners, practitioners and instructors to pursue education visions, within its parameters, shares efforts and success.

The study helps to identify the importance of usability and the commentative impact on users, and would benefit health policy-makers, health care industry and stakeholders.

Aim of the study

The aim of the study is to summarize and synthesize the analysis of the selected articles into a compound study paper that moves within the circle of computer assisted medical education, covers identified dimensions and answers the raised queries, such as; stated research problem, technique and research methodology, tools for collection of data, subject and area of interest, device and application, context of user (Usability), articles distribution according to year of publication, articles distribution according to countries and sampling.

Methodology

Prior to analysis, the collected data was securitized carefully for mislaid data and outliers. The selected data was then analysed by using SPSS software. Still and all, this is a scholarly paper which derived from summative content analysis through a systemic review method (i.e. qualitative descriptive method) that combines quantitative and qualitative researches and database relevant to the area of the study paper. The sampling resources were literature reviews of pertinent interest.

Electronic databases (collected data) from ScienceDirect publications (Contemporary Clinical Trials Communication, n=20, Journal of Biomedical Informatics, n=14 and Computer in Human Behaviour, n=11), Research Gate (Springer, BMC Medical education) and other different resources of a total of fifty-one articles were included. Extra articles (n=4) were lastly added for invaluable contents, particularly in recalling history and the early application of computers in medicine and medical education too.

Study Sample

A collection of 55 articles had been selected out of 1200 articles under the heading of human-computer interaction in medical education in broad heading, sifted in guidance of the keywords stated in the abstract and within a period of three years (2016-2019). The articles had been critically analysed and summarized in a table (appendix) that covers the salient dimensions of technology domination that stated in the said articles.

Data Collection and Analysis

Since literature review is regarded as a data collection tool, it amasses information – such as activities, concepts, etc. – apt to the area of interest. The data (body of information) which collected from ensured and relevant articles, were attentively analysed in relation the raised queries that were announced previously, through descriptive research method and within the dimensions that were initially stated. The analysis criteria that applied was containing:

1. Distribution term of year of publication.
2. Scope of research paper.
3. Distribution term of country;
   - Studies per country
   - Country per year.
4. Data collection technique
5. Method of study
6. Sample of study.
   - Distribution of sample collection
7. Distribution of software application.

Through the stated criteria, database was formed on categories, codes and themes, and the results were analyzed in SPSS statistic application.

Findings

Findings across the statistical analysis are presumptive to support understanding of HIC notion in medicine and healthcare system alike. Phenomena of social learning, design of future learning platform for follow-up researchers, role of customer dynamics and customer experience in application of smart technologies, structural knowledge can be obtained through the adoption of generated lectures, the expertise(s) of a specific user and up to importance of social factors in encouraging participants to change.

They are summarized in the following tables:

There were notable findings from the six models in Table 1. The models suggested to understand requirements, generate designs that reach the requirements, and evaluate selected design. These commonalities among the models emphasizes designing computer systems that support people so that they can carry out their activities productively and safely, and understanding and creating software and other technology that people will want to use, will be able to use, and will find effective when used [37]. In other words, HCI process supports users in terms of achieving their goals successfully [37]. Although the process titles across the models vary, when looked at the descriptions and key purposes, the objective to achieve in each step were alike.

Table 1.
Results by Year

Year	Articles	%
2019	9	17.7
2018	10	19.6
2017	21	41.2
2016	11	21.5
Grand Total	20	100

As it can be seen Table 1, the number of articles dealing with Human-Computer Interaction in Medical Education in Journals obtained from Science Direct Data Base revealed that most of the studies were done in 2017 with a frequency of 21(41.2%) and 2016,2018 and 2019 with a frequency almost equal.

Table 2.
Distribution of the subject area within the scope of this research

Study Topics	Frequency	%
Broad Diagnostic and Systems	9	17.6
Medical Education	6	11.7
Patients Attitudes	3	5.8
Interactions of Medical factors	3	5.8
Develop skills	4	7.9

Table 2.
Continuation

Study Topics	Frequency	%
Patients physiology	2	3.9
Healthcare	6	11.7
Cognitive Techniques \ Medical informatics	9	17.6
Compare and study outcomes.	5	10
Human Augmented	2	4
Case Study	2	4
Grand Total	51	100 (rounded)

As can be seen in Table (2), with Human-Computer Interaction in Medical Education examines various subjects, mostly in the Broad Diagnostic and Self-triage Systems with the frequency of 9 (17.6%), Cognitive Techniques \ Medical informatics with the frequency of 9 (17.6%), and Student Attitudes, Patient Care with the frequency of 6 (11.7%).

Table 3.
Distribution of studies by countries

Country	Frequency	%
United States	5	50.9
France	1	2
Australia	6	11.7
United Kingdom	4	7.8
Germany	1	2
Norway	2	3.9
Netherlands	2	3.9
Portugal	1	2
China	2	3.9
Canada	1	2
Japan	1	2
Spain	2	3.9
Denmark	2	3.9
Grand Total	51	100 (rounded)

Table 4.
Distribution in Terms of Countries

Countries	2016	2017	2018	2019	TF
United States	8	10	4	4	26
France		1			1
Australia		4		2	6
U. K.		2	2		4
Germany	1				1

Table 4.
Continuation

Countries	**2016**	**2017**	**2018**	**2019**	**TF**
Countries	2016	2017	2018	2019	TF
Norway	1	1			2
Netherlands			1	1	2
Portugal		1			1
China		2			2
Canada	1				1
Japan				1	1
Spain			2		2
Denmark			1	1	2
Total Frequency	11	21	10	9	51

Table 3 and Table 4 on the distribution of articles in terms of countries revealed that most studies in Human-Computer Interaction in Medical Education were conducted in the United States at a rate of 26 (50.9%) in 2017. In 2017, with a repeat frequency of 21 (41.2%) of the selected studies.

Table 5.
Data Collection Techniques

Data Collection Techniques	**Frequency**	**%**
Matched-pair	2	4
A questionnaire	3	5.8
Experimental	9	17.6
Interview	2	4
Scale Development	9	17.6
Environment Design	5	9.8
Application Development	9	17.6
Case Study	2	4
Descriptive	1	2
Literature Review	1	2
Semi Experimental	3	5.8
Content Analysis	1	2
Comparative study	4	7.8

Table 5 revealed that 9 (17.6%) of the in Human-Computer Interaction in Medical Education were done through Experimental, Scale Development and Application Development. This finding revealed that the most used data collection technique was through Special metrics Articles designed for a particular purpose.

Table 6.
Distribution of Data Collection Method

Data Collection Method	Frequency	%
Qualitative Method	10	19.6
Quantitative Method	14	27.5
Mixed Method	27	52.9
Grand total	51	100 (rounded)

Table 6 revealed that the greater part of the studies in the scope of the research (n=51) was fulfilled through a mixed method of the studies, however, were done through a quantitative method, while 14 of the studies was through the use of qualitative method were preferred.

Table 6a.
Distribution of Sample Types

Sample	Frequency	%
Patients	15	29.4
Medical Professional	3	5.8
Students	10	19.6
Hospital (Surgeons, Interns and clinicians)	2	3.9
Special Case	5	9.9
Records Follow-up	2	3.9
Pathologists	3	5.8
Male Patients	4	7.8
Female Patients	2	3.9
Users	1	2
Classrooms	1	2
Households	1	2
Training	1	2
Participant of Short Duration	1	2
Grand total	51	100 (rounded)

Table 6b.
Distribution of Sample Collection

Class Interval	Frequency	%
10-Jan	7	13.7
20-Nov	5	9.8
21 - 40	6	11.9
41 - 100	15	29.4
101 - 200	5	9.8
201 - 500	5	9.8
501 - 1000	3	5.8
Over 1000	5	9.8
Grand total	51	100 (rounded)

Table 6a was the sample of the participants that were used in the studies within the scope. As analyzed, the sample on patients has the highest frequency of 15(29.4%) and the students with a frequency of 10(19.6%) each as shown in the table. It is noted in Table 6b that the sample with a class interval of (41 - 100) was at a frequency of 15 (29.4%). Samples at an interval of (1 - 10) were at a frequency of 7(13.7%) each as shown in the Table 6b.

Table 7.
Distribution of Applications (software and hardware)

Application	Frequency	%
Health Application (Erdusyk, Twitch, TSST, F-PST, FitMindKit, Gadget, REDCap, WBIS)	11	21.5
Computer-based simulation (games, Video, Strong4Life, coding, PAX)	6	11.7
Gestures Interactive (3D)	3	5.9
Program (Intervention, Risk Stratification, VPP)	5	9.9
Systems (EHR, Elgg)	4	7.8
A protocol (based framework for medical education)	7	13.7
Devices	5	9.9
Mobile Application	3	5.9
Reality Application (ARBio App, GeoAR App)	6	11.7
Department	1	2
Grand total	51	100 (rounded)

Table 7 was the sample of the participants that were used in the studies within the scope. As analyzed, the Application on Health Application (Erdusyk, Twitch, TSST, F-PST, FitMindKit, Gadget, REDCap, WBIS) has the highest frequency of 11(21.5%) each as shown in the table.

Finally, since the selected study articles were covering ‘medical education’ randomly, a major limitation arose of absence scale for assessment and correlation, where, again was controlled by subject research and publishing periods as well.

Discussion and Conclusion

A thorough review of the literature within the selected study articles disclosed advantages of technology in medicine for the subject areas. For examples; Erdusyk supported patients for self-triage, 3d hand-gesture in medical and health practitioners explore volumetric medical images (Irene Hernandez-Giron, et.al. (2019), the F-PST for potential trauma registry information, Kyoto-Kagaku patient simulator for training medical students and healthcare practitioners (Plooy Annaliese M et al. (2016), FA (Framework Analysis) and UPT in health informatics for diabetic patients and Oculus Rift and Samsung Gear VR devices as an immersive training application for anatomy in universities. These are examples of technology reflections (Soykan, E. & Uzunboylu, H. (2015), as hardware and software, on whole medicine.

Nevertheless, technology in medicine, as becoming a part of our lives, has advantages and disadvantages, which are vitally deliberated and thought-out, in order to minimize errors that arise from hackers, mistakes or malfunction of the hard or the software. However, more than 500,000 devices and equipment are used in medical and health fields for the sake of health and medical professional learners, practitioners and patients. Medical physicians believe that GoodRX and or Red Cross First Aid could keep their patients healthier, where IoMT (Internet of Medical Things) could prospectively better and surpass medications dispensed through patient's data analysis and patient's entire health profile (condition, care administered and medical history of diagnosis, treatment and further follow-up, etc.) and information.

In spite of many positive effects of technology in medicine, its disadvantages of patients' privacy, data breaching and hackers generate precaution and close supervision and inspection to achieve the intended purposes. Table 8, summarizes the pros and cons of some of technology media that are intensively applied in medical education.

Great part or sector in medical and health professional education depends on simulation, as it is known as an imitation or a production of computer model for purpose of learning, where simulator is the device that produces or attempts to represent characteristics of a particular occasion. Simulation for medical education, as it was firstly demonstrated in 1968 (American Heart Association Scientific Sessions by Dr Michael Gordon of the University of Miami Medical School), produces artificial representation to replicate clinical situations and scenarios in order to: improve medical and health learners and practitioners' competencies; improve patient's safety (no patient's risks); reduce health care costs; allow the acquisition of clinical skills through hands-on practice, and could be assigned into physical and iterative types through procedures or situations.

Within those reflections bursts the hidden value of those devices and applications;

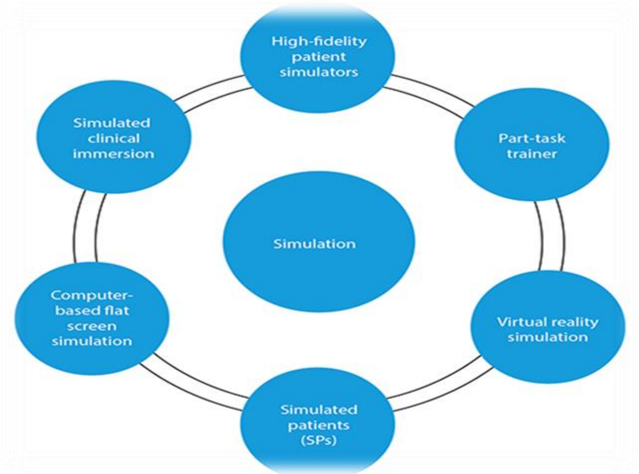

Figure 1. *Simulation modalities. (http://www.cmej.org.za/index.php/cmej/article/view/2697/2898)*

Within those reflections bursts the hidden value of those devices and applications; usability, where it is operationally defined, cognized and assimilated through criteria like learnability, easy to understand, consistency, efficiency, configurability, error tolerability and compatibility. Each of these criteria enables and grants product developers to assess usability from quality and quantity points. Error is a matter of grave concern and plausibility has no room alike. An iterative usability testing should be carried out through products development and covers the users that use or attempt to use those products. All these measures fall under calibration, accreditation and licensing. Experts agree "usability is best when used early and often, and not at the end when it is too late to make changes" (Redish & Dumas 1993, p.22).

The objective of this study was to state the crucial needs of technology in medicine and particularly, for medical education. Learners and practitioners (medical and health professionals) prefer technology-associated modalities that offer learning material that is interactive, reputable, simple, pragmatic, and coupled with relevant feedback.

Table 8.
Pros and Cons of Technology in Medical Education

Medium (Approach)	Pros (Advantages)	Cons (Disadvantages)
1. E-health, that is the transfer of health care and resources by electronics.	Provides an invited method for utilization of health resources (information, medicine, etc.).	Time consuming and Financial costs.
	Improvement of information transmission and circulation, for interchange and participation	Users technical knowledge.
	among educational institutions, health professionals,	Changes of workflow and loss of productivity.
	Healthcare providers and stakeholders.	Privacy and security that may lead data migration.
		Several liabilities (system break-down/ destruction and loss of data)
	Distance learning that overcomes scatter learners and practices.	Social isolation where is developed by companion study.
2. Web-based learning that depends on the nature of intervention and the intended setting (usability)	Scheduling flexibility that includes timings and location.	De-individualized instruction (determined instructions).
	Adapting of interminable resources.	High cost
	Learning individually (on one's pace of time).	Technical problems that may lead to hindering of learning.
	Facilitation of assessment and interpretation.	Poor technical design.
	Safety of patients	High cost
3. Simulation in medical education	Useful for learners and practitioners training (e.g. surgery)	Lack of fidelity
	Creation of multiple scenarios for different learners	Shortage of trained staff
	Preferable for drills, common and uncommon emergencies	Expense of maintenance
	Skill acquisition	
	Assessment and certification	
	Machine Learning (ML) has prospective influence and effect that utilize data sets (patient inputs vs outputs) in order to make prophesy and prognosis.	Financial limitation and restriction.

Table 8.
Continuation

Medium (Approach)	Pros (Advantages)	Cons (Disadvantages)
4. Big Data in healthcare industry (ML and DL)	Deep Learning (DL) that includes Personalized Recommendation Systems and Natural Language, improves comprehensive, efficient and sustainable education, helps and advocates students to more relevant contents.	Time consuming
		Space
		Privacy and security.
		Accuracy.
		Replacement of staff

Ethics

Technology in health and medical practice and education is not an aim or an intension, rather than a tool that applied to achieve an objective. Thus, the incorporation of medical ethics should be an obligatory component in medical education curriculum (World Medical Association, 1999), to adhere to clients' privacy, philosophical morals, laws and values.

Consideration of ethical issues and dimensions in coping with the fast advancement of technology in health and medical usage minimize unprofessional, fraudulent and disrespectful behaviours. They awaken self-awareness, eliminate unethical conducts and arouse consent signature to the fore of any clinical activity.

However, doing better for preserving life is a clear objective but unethical behaviour and misconduct create conflicts such like ignominy in disclosure of patient's medical records (patient's information to reliable parties) and shame (female foeticide and infanticide).

Recommendations

Carol Barnum (2008, Usability testing essentials: ready, set...test!) stated that 'When usability is inherent in the products we use, it is invisible. We do not think about it. But we know it is there.' Thus, the 'dark side' of technology, which is unseen from majority of academic's circle, creates demands, needs and desideratum for more studies on human (medical educators, health professional learners and practitioners and patients) interaction and system usability. Acquisition systematized, deeper understanding of its benefits and risks, structured and consistent means to work in usability assessment is important for providing authentication. Hence, there is necessity to equalize the over-reliance and overutilization of technology in medicine and medical education, where it becomes a mixture of art and science.

As medical and health fields are depending vitally on technology in their advancements and services' improvement, future researches are encouraged in precision and exactness of relevance, applicability and appositeness by selecting specific terms, phrases or even words as guidance for research vehicles.

Conjointly, there were limitations affected this paper represented into the sample of the study, i.e. content analysis study, which is governed by and depended on determined keywords from selected articles of particular journals. Some of these selected articles might reveal different findings, which is weakening the correlation in certain areas of the study. Thus, opportunities for further and refined studies in future are immense, particularly, with the speedy rhythm of information and communication media.

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