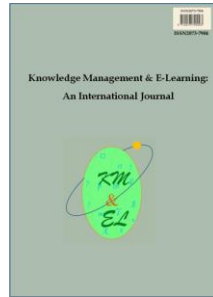


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# **Knowledge Management & E-Learning**

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## **Improving auscultatory proficiency using computer simulated heart sounds**

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## **Improving auscultatory proficiency using computer simulated heart sounds**

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**Abstract:** This study aimed to examine the effects of 'Heart Sounds', a web-based program on improving fifth-year medical students' auscultation skill in a medical school in Egypt. This program was designed for medical students to master cardiac auscultation skills in addition to their usual clinical medical courses. Pre- and post-tests were performed to assess students' auscultation skill improvement. Upon completing the training, students were required to complete a questionnaire to reflect on the learning experience they developed through 'Heart Sounds' program. Results from pre- and post-tests revealed a significant improvement in students' auscultation skills. In examining male and female students' pre- and post-test results, we found that both of male and female students had achieved a remarkable improvement in their auscultation skills. On the other hand, students stated clearly that the learning experience they had with 'Heart Sounds' program was different than any other traditional ways of teaching. They stressed that the program had significantly improved their auscultation skills and enhanced their self-confidence in their ability to practice those skills. It is also recommended that 'Heart Sounds' program learning experience should be extended by assessing students' practical improvement in real life situations.

**Keywords:** Auscultation skills; Computer simulation; Medical education

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Dr. Ayman khairy Mohamed Hassan, MD. PhD. he is a lecturer of cardiovascular medicine at Assiut University. After finishing both his PhD at Leiden University medical Centre (LUMC) then his doctoral exams at Assiut University, he started to improve the quality of medical education by applying e-learning courses for under-and post-graduate students. Also as an experienced interventional cardiologist he pushed the field forward by practicing difficult cases and applying a primary PCI project for the first time in Upper Egypt. He

is interested in health care reform in Egypt and was nominated as the vice director of Assiut University Hospitals and the head of a new health care quality unite.

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## 1. Introduction

While the health care field is moving toward embracing the notion of clinical best practices, there are considerably few studies discussing the structure, process and content of how to best educate health care providers. It would appear, in fact, that educational processes have changed very little over the years, and even emerging advances in technology often have become prisoners of academic norms and traditions. It is ironic that while many educators emphasize to clinicians the need to evaluate and align care-giving processes with the strongest evidence of effectiveness; they often fail to demonstrate or make a role model of a similar belief related to their own educational processes.

Classroom practices continue to be dominated by delivery of lectures by instructors in class. More than 30 years of research point to the limitations associated with unidirectional learning via in-class lectures, including lack of student attention and limited opportunities to develop essential skills (Bligh, 2000).

Literature highlights the need to rethink depending on classroom learning and describes pedagogical innovations that foster higher-order thinking, improved information analysis and learning skills, and more opportunities for interactive learning. These approaches represent an ongoing paradigmatic shift in education from teacher- or lecture-centered instructional strategies to learner-centered instruction such as e-learning (Barr & Tagg, 1995).

e-Learning is known for its flexibility in taking into account individual differences in the processing of information, which is functional, as students differ in the way they prefer types of visual or auditory information (Valcke & De Wever, 2006). By combining the strengths of computer instruction and face-to-face teaching, blended learning can ensure an environment that can produce improved student's outcomes and facilitate acquisition of competencies that may not otherwise be achieved (Garrison & Kanuka, 2004; Gray & Tobin, 2010; McLaughlin et al., 2014).

Proficiency in cardiac auscultation skill has been and still is an important skill in clinical medicine for all specialties. As freshly graduated doctors — general practitioners (GPs) — must master the skill of recognizing different heart sounds in less than a minute. Students often find it difficult to determine the timing and characterization of the heart sounds in this short time. Several studies discussed students lack of such skills among medical students (Vukanovic-Criley et al., 2006) as well as among clinicians (Mangione, 2001; March, Bedynek, & Chizner, 2005).

Egyptian medical education curriculum at Assiut University, undergraduate cardiology training is limited to a three-month period, which takes place during the fifth year of medical studies (the total duration of medical studies is 7 years). The schedule includes a combination of tutorials-case discussion and clinical practice from 8:00 am to 14:30 pm once a week for each student. During this period, students visit in rotation several sub-units in cardiovascular department, such as the echocardiography, the outpatient clinics, the catheterization laboratory and coronary intensive care unit.

So, basically cardiac auscultation has traditionally been taught as if it were an intellectual skill, with a didactic lecture followed by a brief demonstration of heart sounds directly on patients with more than 15 doctors for each patient. Cardiac auscultation has a unique property that differs from patient to patient and from moment to moment during examination. This approach has yielded disappointing results, with most clinicians able to recognize only about 40% of abnormal heart sounds. At Assiut University hospitals (AUH), the problem is much complicated because of the large number of students and difficulty to find a co-operative patient who accepts that all students have enough time to hear his heart sounds.

To facilitate learning of auscultation and improve its efficiency efforts have been directed since 1960s to development electronic devices to facilitate learning of such sophisticated skills. Mannequins, electronic stethoscopes, computer programs and simulators have since then been developed and marketed. The first mannequin made for teaching students heart auscultation was introduced in 1968 and named "Harvey" (Gordon, 1974). In 1987 a study on the use of Harvey on fourth-year medical students showed improved skills compared to a control group not using the device (Ewy et al., 1987).

Since that literature has supported the need for more effective teaching and learning strategies in the area of physical assessment. One study showed that medical students identified only 20% of 12 cardiac events correctly and the accuracy of residents was no better at 19% (Mangione, 2001). Another investigation showed that expect for cardiology fellows, there was no improvement in auscultation skills after the third-year of medical school among medical students, residents and faculty (Vukanovic-Criley et al., 2006). The need for improved assessment and training in core skills such as cardiac auscultation is emphasized by the transition towards a competence based model of medical education (Accreditation Council for Graduate Medical Education, 2010).

The general decline in physical examination skills is clearly indicated through measuring students' cardiac auscultation skills (Lok, Morgan, & Ranganathan, 1998). There is a mounting evidences that students are exposed to instructors who themselves have variable skills in auscultation: residents have alarmingly low identification rated of abnormal heart sounds, and even experienced cardiologists have low inter-observer agreement about certain cardiac auscultation findings (Lok, Morgan, & Ranganathan, 1998).

Uniform delivery of an auscultation curriculum in medical schools attempts to overcome the deficiencies of a curriculum taught by multiple instructors. In addition, heart sounds simulators, auscultation enhancement technology, audio-tapes, and other computer-based interventions have been implemented at different medical schools to refine students' auscultation skills (Issenberg et al., 2002).

From an educational perspective, an ideal curriculum for teaching auscultation skills would be to have each student evaluated a series of live patients with abnormal heart sounds in clinic of an expert cardiologist who would then take the time to review each case and instruct students individually. Given the numbers of students involved, the availability of patients and schedules of cardiologists, this curriculum is not feasible. Fortunately, advances in technology have provided an opportunity to create a simulation of this experience without the requirements of excessive faculty or patient time. With computer based programs all students can receive both the benefits of an outpatient experience and the teaching and feedback of an expert clinician (Stern et al., 2001).

Research in the field of e-learning has provided substantial evidences that this type of learning have a positive effect on students' enjoyment and interest in learning, leading to increases in their ability to control their learning. Becker (2000) cited at least four key benefits for using ICT in education: increase commitment to the learning task, increased independence and motivation for self-directed study, enhance self-esteem, and improved behavioral habits. Literature connecting e-learning with the learning process presents a multifarious view of ICT application and student learning (Cavanagh & Romanoski, 2004). The mode of participation of students in the learning process is typically varied. Students can work independently, in groups, or interact virtually. The cognitive processes constituting learning are also varied. These include constructivist activities such as memorization, problem-solving, and creativity. Further, the outcomes or products of e-learning tend to be multidimensional. It can affect the quality of learning products and the pace at which given tasks are completed.

Literature review reveals that simulation technology with deliberate practice (Ericsson, 2004) can be used to improve a variety of trainee skills. Examples include cardiac auscultation (Barrett et al., 2006; Issenberg et al., 2002), Advanced cardiac life support (ACLS) (Wayne, Butter, & Siddall, 2006) thoracentesis (Wayne, Barsuk, O'Leary, Fudala, & McGaghie, 2008), and central venous catheter insertion (Barsuk, McGaghie, Cohen, Balachandran, & Wayne, 2009). In addition to enhancing technical proficiency, some educational interventions have also been shown to transfer skill to the clinical environment and improve patient care and patient outcomes (Barsuk, Cohen, Feinglass, McGaghie, & Wayne, 2009). Horiszny (2001) proved that students' ability to correctly interpret simulated heart sounds is better among those who participate in face-to-face teaching sessions in conjunction with e-learning training, (blended learning), compared to those who attend traditional class only.

Recently blended learning, the mixture of e-learning and face-to-face learning, has been presented as a promising alternative learning approach to traditional methods of learning, as it is characterized as maximizing the advantages of traditional learning and e-learning (Wu, Tennyson, & Hsia, 2010). It is proved that blended learning allows for greater flexibility and responsiveness in the teaching and learning process (Lewin, Singh, Bateman, & Glover, 2009). The integration of e-learning has been shown to overcome the limitations of time and space, and reach a large number of students without increasing resources requirements (Gray & Tobin, 2010). Moreover, evidences from a wide range of disciplines supports the use of blended learning as it proved to be able to enhance students' critical-thinking skill; as it increases student engagement in the learning process (McLaughlin et al., 2014; Pierce & Fox, 2012).

However, it is strongly argued that blended learning is highly context-dependent and that the generalization of its effectiveness among different disciplines is quite challenging (Harris, Connolly, & Feeney, 2009). Thus a successful implementation of blended learning in one domain does not necessary mean that it will have the same value within another domain. Hence, the significance of the recent study stems from this argument, as we are trying to prove that the implementation of blended learning in the field of medical education in Egypt will be fruitful especially in training medical students to improve a very sophisticated skill as auscultation.

The present study aimed to collect empirical evidences to support the hypothesis that: Implementing blended learning in the form of intensive repetition of basic cardiac murmurs using a computer-based program, 'Heart Sounds', will enable fifth-year medical students to improvement their auscultation skills.

## **2. Method of the study**

To overcome difficulties fifth-year medical students encounter in learning and mastering auscultation skills, a group of cardiology specialists (Dr. Ayman Khairy Mohamed Hassan and colleagues) have developed a computer based program which they call 'Heart Sounds' program. The program is based on psychoacoustic research demonstrating that intensive repetition (400 to 600 times) is required for the human brain to master a new sound. This degree of repetition is necessary for the formation of an auditory template of each new sound. Once each new sound is mastered, it is reinforced each time you hear it in a patient. By using this learning principle, 'Heart Sounds' program is expected to produce a significant improvement in cardiac auscultation in a relatively short time. Basic heart sounds and its variability, basic systolic and diastolic murmurs for most common valvular lesions (ex: mitral stenosis & or regurgitation, Aortic stenosis & or regurgitation, ventricular & atrial septum defect and pulmonary stenosis & hypertension) are presented in a simple way in this web based program. A web test was designed to measure students' auscultation skills improvement. Students were asked to listen to different basic heart sounds and identify them through answering choose questions. Then after the program the students were tested again. Students' scores in the pre- and post-test were compared in order to prove the effectiveness of the program on fifth-year medical students' auscultation skills.

In the assessment questionnaire students were asked to assess their learning experience with 'Heart Sounds' program in five aspects: 1) Improvement in cardiac auscultation skills. 2) Improvement of field practice. 3) Increasing confidence in the obtained cardiac auscultation skills. 4) The effectiveness of the new learning technique compared to traditional methods. 5) Increasing of students' satisfaction with the new learning experience. Finally students were asked whether they will recommend using this program with other students or not.

### *2.1. Development and constructional work*

It started by an idea to put all basic auscultation skills for medical students in a web based system. It is well known that Upper Egypt is endemic for rheumatic heart disease (RHD) where up to 70% of daily practice in the outpatient clinic at AUH and 90% of students' education at cardiology department is on RHD patients. Basic heart sounds and its variability, basic systolic and diastolic murmurs for most common valvular lesions (ex: mitral stenosis & or regurgitation, Aortic stenosis & or regurgitation, ventricular & atrial septum defect and pulmonary stenosis & hypertension) are presented in a simple way in 'Heart Sounds' program.

So, in addition to their usual curriculum courses, fifth-year medical students are authorized to use the 'Heart Sounds' program to master cardiac auscultation skills. Each student is provided by a password to create an account for him/herself, through which they can access the program and use the computer simulator system. At the same time, a report of each student activities and involvement in the program will be provided. Computers with headphones were provided to all students at faculty of medicine, Assiut University.

Researchers launched 'Heart Sounds' program in November 2011 with a test phase, mainly depending on stimulating and encouraging students to learn and hear different heart sounds. The first 3 month round witnessed a low participation from students as only 40% of the targeted students registered for the program. Next term researchers managed to convince the head of the department to put only 4 marks on this program as an

obligatory system for all students, our success in the next groups was up to 98% rate of participation.

## 2.2. *The technical procedures*

The curriculum for fifth-year students at faculty of Medicine, Assiut University featured approximately 4 hour of deliberate practice of 12 major cardiac findings:

- 7 Basic heart sounds including (S3, S4, innocent murmur, mitral regurgitation, mitral stenosis, aortic regurgitation, aortic stenosis).
- 5 Complex heart sounds including (combined mitral regurgitation and stenosis, combined aortic regurgitation and stenosis, tricuspid regurgitation variation, pulmonary stenosis, continuous murmur of a patent ductus arteriosus).

The 12 findings were selected based on advice of our local educational committee. The intervention included a web based computer program that provide interactive self-study 'Heart Sounds Assiut University' program'; developed at the University of ASSIUT which features didactic instruction, deliberate practice, and self-assessment and comply with the national standards of e-learning (<http://www.mcit.gov.eg/Upcont/Documents/ELCC2010222143348.pdf>).

Each heart sound class contained 8 seconds of a heart sound recording, followed by the narrated identification of the sound. All students received a 1-time, multimedia lecture (PowerPoint) taught by 1 faculty member (Dr. A. K. M. Hassan), which reviewed the instructions of the heart sounds Assiut University program and how to use it. By the end of this introductory lecture, each student received a time limited username and password to log into web based program from anywhere, but as a standard all students can access this program at Assiut Faculty of Medicine, Education Center. Students are asked to use headphones to listen to the heart sounds and follow the instructions written at the top of the introduction page of the program. The volume of the heart sounds was fixed and students completed the class at their own pace and the program provides a report on the time spent with each class for each student through a unique feature call the PLOGS. This locally developed program also allow the students to directly communicate with the professors at cardiovascular department using a unique feature called FORUM, were all their questions are directly answered by the Prof. in charge via an email. Another feature which is online participation, each Sunday between 8-10 pm (Dr. A. K. M. Hassan) provide online medical guidance to all the students through the program. Also the IT personnel for any problem were available at the secretary department all working hours. Furthermore, the program provide online dedicated cardiology lectures as a power point presentations and pre-solved Multiple Choice Questions for students training and self-earning.

After approval of the ethical committee and board of directories at Faculty of Medicine Assiut University, fifth-year students were obligated to use this program by putting 4 marks on this e-learning program.

The computerized assessment was a set of 12 locally validated multiple choice questions including an audiovisual file of the heart sounds. Students chose the best among five possible responses. There was no time limit to complete this exercise and students could listen to the heart sounds as many times as they wished but within the cardiology round time frame (14 week). All students had to do the computerized assessment before the intervention (pretest) within the first 2 weeks of the round and again in last 2 weeks of the round after the education program (posttest). The same heart

sounds were used for pretest and posttest, although presentation order varied. However, for pre-test 3 trials are allowed for each student and the best results grade is the one used for each student. But for post-test final exam, only one attempt is allowed to answer each question.

### 2.3. Participants

A total of 980 students participated in the whole study distributed on six groups. Yet, only 764 students completed the pre- and post- tests, and 257 students successfully completed the questionnaire and they are distributed among six rounds as shown in Table 1.

**Table 1**  
Student participants

| Groups   | Round 1<br>23\10\2011 -<br>10/1/2012 | Round 2<br>15/2/2012-<br>21/3/2012 | Round 3<br>1\4\2012 –<br>1\7\2012 | Round 4<br>26\9\2012 –<br>15\12\2012 | Round 5<br>23\12\2012-<br>19/3/2013 | Round 6<br>1\4\2013 -<br>1\7\2013 |
|--|--------------------------------------|------------------------------------|-----------------------------------|--------------------------------------|-------------------------------------|-----------------------------------|
| Number of students registered in the program         | 187                                  | 190                                | 190                               | 138                                  | 138                                 | 137                               |
| Number of students completed the pre- and post- test | 154                                  | 109                                | 145                               | 145                                  | 95                                  | 116                               |
| Number of Students completed the questionnaire       | 0                                    | 0                                  | 70                                | 55                                   | 50                                  | 82                                |

### 3. Results

Statistical analysis using SPSS program was carried out to calculate the mean, standard deviation, statistical significance (sig.), and percentage of fifth-year medical students' scores in pre- and post-test.

**Table 2**  
Test scores of students' auscultation skills

|         | N.  | Mean of pre-test | Mean of post-test | Std. Deviation | Sig.  |
|---------|-----|------------------|-------------------|----------------|-------|
| Round 1 | 154 | 17.33            | 19.38             | 3.21           | 0.00* |
| Round 2 | 109 | 18.59            | 19.58             | 2.06           | 0.00* |
| Round 3 | 145 | 18.18            | 19.5              | 2.79           | 0.00* |
| Round 4 | 145 | 18.17            | 19.5              | 2.79           | 0.00* |
| Round 5 | 95  | 22.21            | 23.44             | 5.75           | 0.05* |
| Round 6 | 116 | 21.9             | 22.68             | 2.91           | 0.01* |



Results in Table 2 demonstrate that the performance of fifth-year medical students in post-test has improved significantly than their performance in the pre-test in all groups. The mean of post-test increased significantly in all groups than the mean of pre-test, therefore the value of (Sig.) is highly significant in all groups. This analysis suggests that medical students' experience with 'Heart Sounds' program has a positive impact on their auscultation skills as it appears in their performance in the post-test.

We also compared student performance in the pre- and post-test based on gender differences (see Table 3). We notice an overall improvement in the performance of both male and female fifth-year medical students in post-test. This marks that 'Heart Sounds' program has a significant positive influence on fifth-year medical students' auscultation skills.

**Table 3**

Test scores of students' auscultation skills based on gender differences

|         | Mean of male<br>pre-test | Mean of male<br>post-test | Mean of female<br>pre-test | Mean of female<br>post-test |
|---------|--------------------------|---------------------------|----------------------------|-----------------------------|
| Round 1 | 17.89                    | 19.12                     | 16.97                      | 19.17                       |
| Round 2 | 18.76                    | 19.57                     | 18.49                      | 19.53                       |
| Round 3 | 18.7                     | 19.65                     | 17.49                      | 19.29                       |
| Round 4 | 18.3                     | 19.65                     | 17.83                      | 19.29                       |
| Round 5 | 18.53                    | 19.55                     | 19.38                      | 19.68                       |
| Round 6 | 18.67                    | 19.82                     | 18.93                      | 19                          |

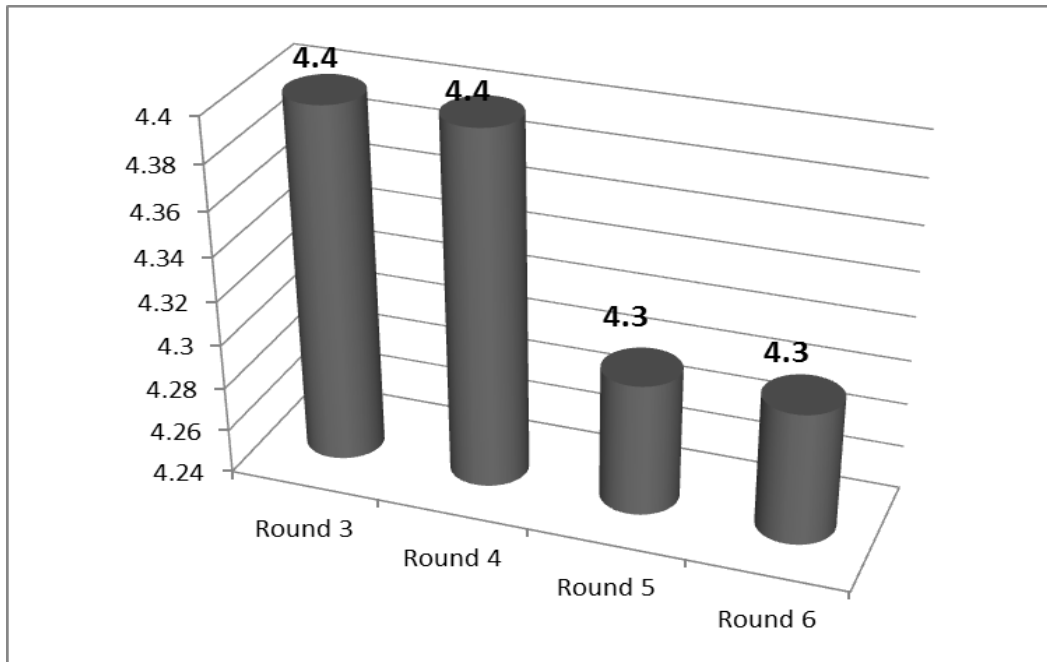
To complete the picture and support results driven from analysing students' performance in the pre- and post-test, students' perceptions of their experience with 'Heart Sounds' program were explored through examining their responses to the different items of the designed questionnaire. However, it must be elucidated that only four groups of students out of six had completed the questionnaire, as in the first two groups students had the choice to either fill the questionnaire or not. Then students were obliged to complete the questionnaire in order to finish their training and get the 4 marks.

A questionnaire was used administered to assess students' perceptions of their learning experience with 'Heart Sounds' program. A scale of 5 points were used (1 = strongly disagree, 5 = strongly agree). Fig. 1: Students' perception of the effect of 'Heart Sounds' program on their auscultation skills.

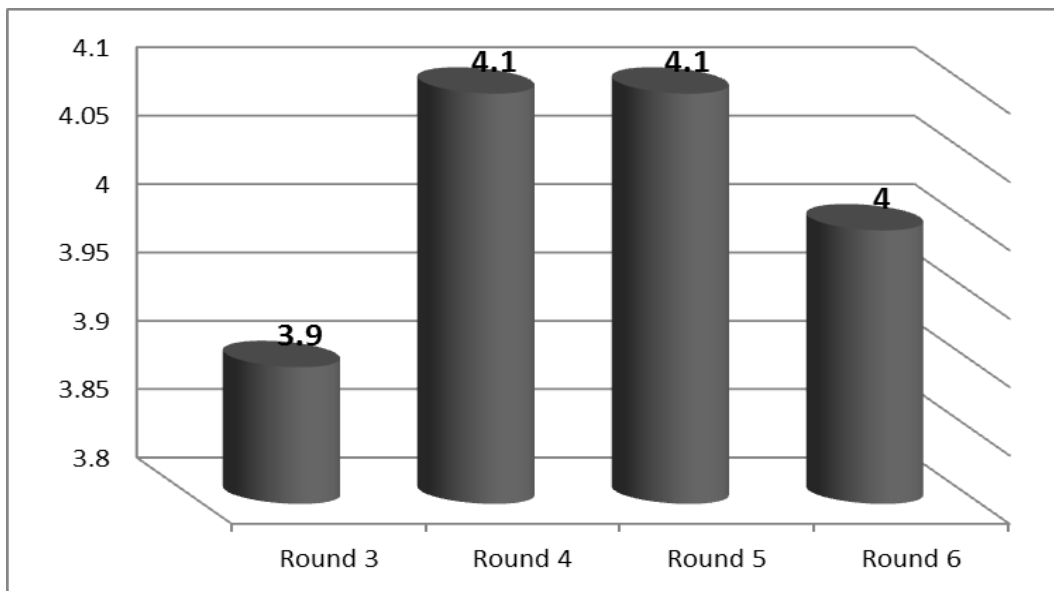
Fig. 1 reveals that all students in the four groups have constructed a very positive experience with 'Heart Sounds' program that blossomed in reaching into a consensus that the program has improved their auscultation skills.

Fig. 2 shows slight discrepancies among students' perception on the effect of 'Heart Sounds' program on self-confidence in their auscultation skills. However, students in all four groups have grown a significant consensus about the positive effect of the program on their self-confidence in their ability to practice auscultation skills.

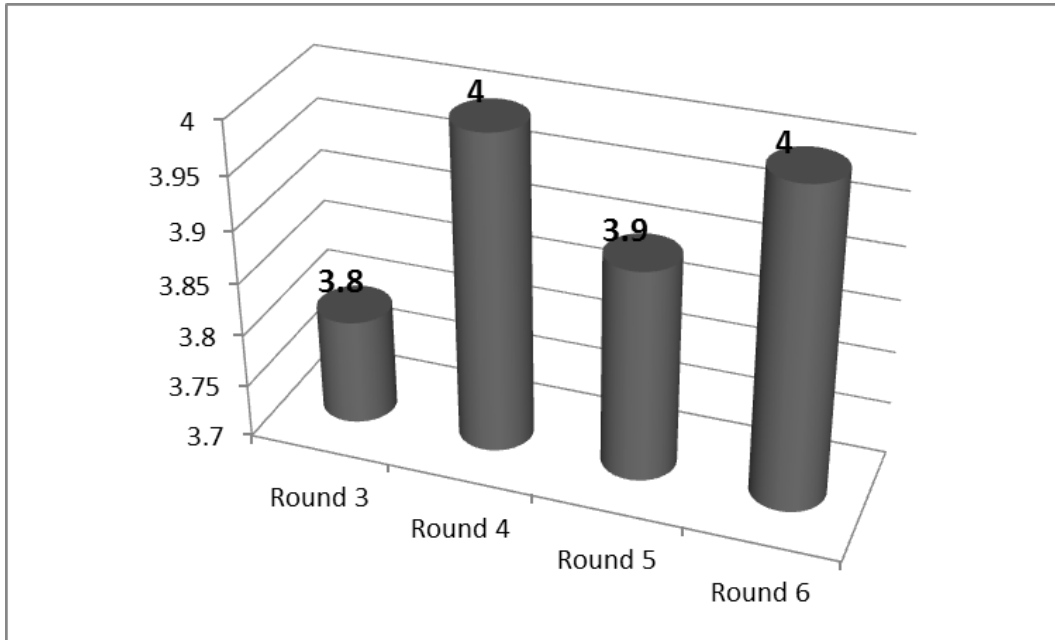
Fig. 3 reveals that students in the four groups have reached into a common belief that 'Heart Sounds' program has improved their field-practice.



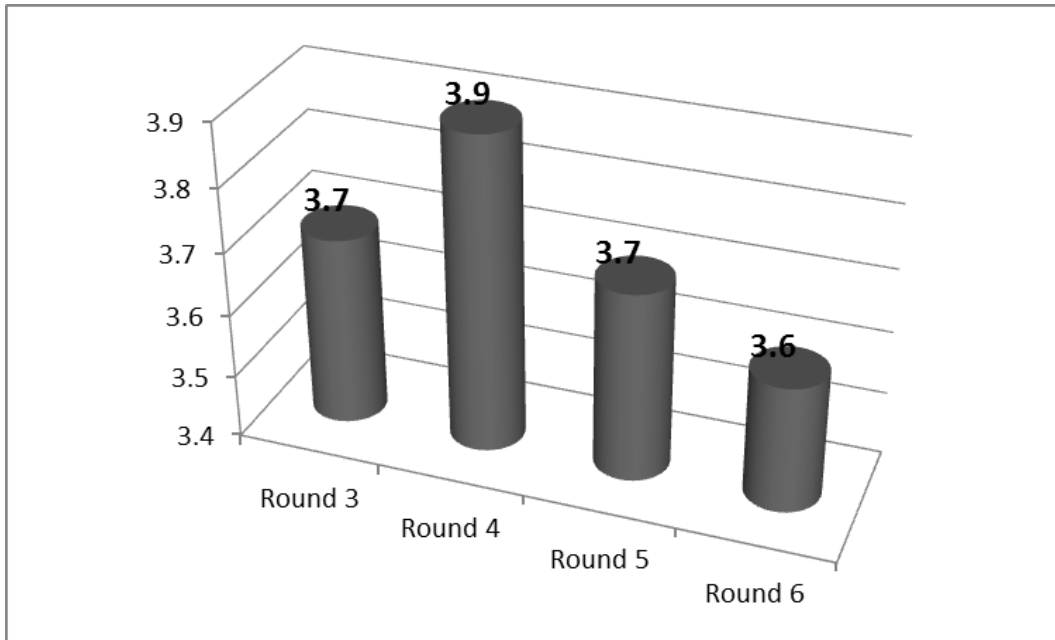
**Fig. 1.** Students' perception of the effect of 'Heart Sounds' program on improving their auscultation skills



**Fig. 2.** Students' perception of the effect of 'Heart Sounds' program on self-confidence in their auscultation skills

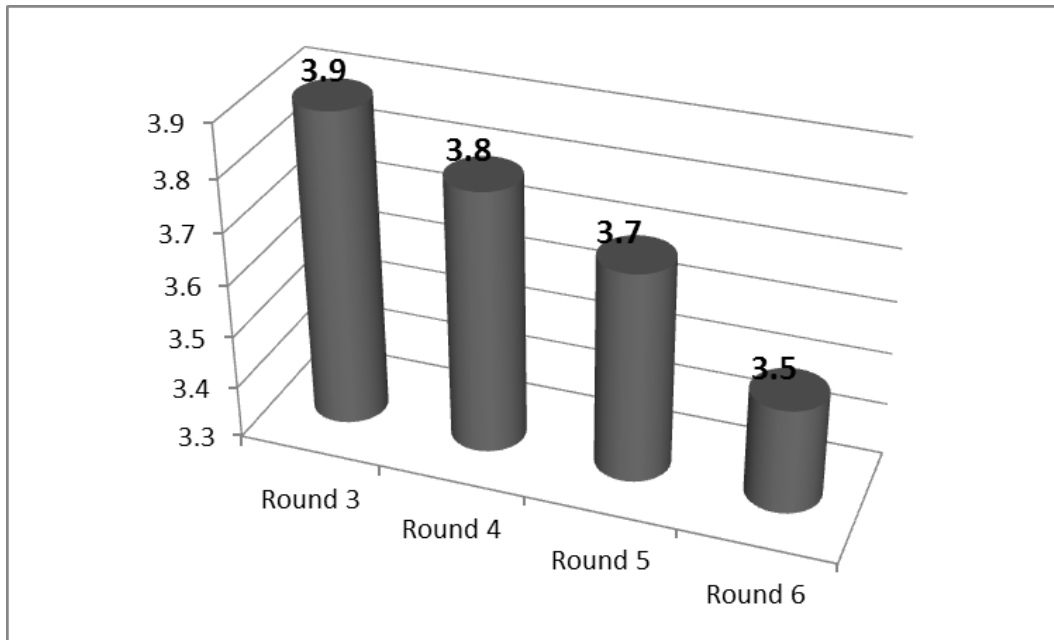


**Fig. 3.** Students' perception of the effect of 'Heart Sounds' program on their field practice



**Fig. 4.** Students' assessment of their learning experience with 'Heart Sounds' program

In Fig. 4 students while assessing their experience with 'Heart Sounds' program, they reached into a common belief that the learning experience they gained with the program is better than the one they gained with other traditional ways of teaching.



**Fig. 5.** Students' reflection on their satisfaction with the learning experience

Fig. 5 shows that students in all four groups hold a great appreciation to the learning opportunities 'Heart Sounds' program offered. Therefore, they expressed their satisfaction with learning experience they gained with the program.

#### 4. Discussion

In the current context, many researchers have criticized the poor auscultation skills regardless of training level, medical specialty or country of training (Mangione, 2001; Mangione & Nieman, 1997). Most of these studies are cross-sectional surveys that recommended development of educational strategies to address these auscultation deficiencies. Few studies have evaluated the effectiveness of such educational strategies. And none has involved students' evaluation of these teaching strategies.

In 2002 a group of researchers carried out a study in which student performance on a computer simulation to treat cardiac dysrhythmias (Advance Cardiac Life Support Simulator) was compared with the study of text-based materials. Initially the students in the text-based condition performed significantly better after the treatment period but one week later there was no longer a significant difference. The decline in knowledge gain was larger in the text-based condition. The authors explained the initial better learning performance (right or wrong answer questions) in the text-based condition by referring to the inexperience of students with learning in the ICT-based learning environments. Prior knowledge is a critical asset for students when studying complex knowledge. The researchers suggest therefore looking for a balanced mixture of both teaching approaches (Kim, Kim, Min, Yang, & Nam, 2002).

In another study the researchers explored the use of simulation software — with a computerized life-sized manikin — in the surgical education of students during their

clerkships. They concluded that the simulation software significantly improved skills. The researchers add in their research report an important remark on their conclusions. They refer to the fact that the approach was effective "in a clerkship that already emphasized...case-based learning" (Nackman, Bermann, & Hammoud, 2003). This remark points to the context in which ICT-based medical training approaches might be effective. It stresses the congruence between the varieties of teaching models being adopted.

In the current context, students participated in this study reached into a common consensus that the 'Heart Sounds' program has significantly improved the auscultation skills in a way increased their self-confidence in their ability to transcend those learned skills into field practice. This support the argument raised by different studies that during information-processing activities, students organize their knowledge to a further extent and link the new knowledge in an active way with knowledge already available in long-term memory. ICT applications that particularly foster this type of activity force students to use and reuse information that has been stored earlier in their long-term memory (Valcke & De Wever, 2006). It is obvious that students participated in the study have used and reused of information as they solved problems, answered questions, applied their knowledge to cases. This cognitive processing activity occurs in ICT-based learning environments when students apply and test their knowledge.

But despite the large potential of the very advanced computerized imagining approaches a balanced approach is needed. The study proved that all students in all four groups show a minor discrepancy in their evaluation of the learning experience they gained with the 'Heart Sounds' program when comparing it with other traditional ways of learning. In a large-scale study, involving over a thousand medical students learning anatomy, researchers studied whether ICT-based resources could replace real-life cadaver dissections. The results of this quasi-experimental study show that the proportion of students who received both treatments — traditional dissection and computer resources — was significantly larger than in the other conditions (Biasutto, Causa, & Criado del Río, 2006).

To avoid that, in addition to 'Heart Sounds' program, students in the current study attended lectures, received traditional bedside training, in addition to the teaching they received while using the 'Heart Sounds' program. Therefore, 'Heart Sounds' program appears to be a valuable supplement to conventional besides actual training. The program has just enabled students to develop auscultation assessment skills at their own convenience and pace, as they listened to authentic clinical sounds in a relaxed learning environment and provided with confidential and progressive feedback. This blended teaching method proved very effective as expressed by students who supported strongly the assumption that the program has improved their practical auscultation.

'Heart Sounds' program also allowed students to carefully examine their auscultation skills in a quiet environment, which rarely is present with real patients in a busy clinical practice. In this study students clearly stated that the learning experience they had with 'Heart Sounds' program is different than other traditional ways of teaching auscultation skills. This is also why all students strongly recommended exposing other medical students to the same learning experience. Consequently, it is becoming more evident that based on the results generated through this study, 'Heart Sounds' learning experience should be generalized with a recommendation to assess students' practical improvement in real life situations.

In conclusion, cardiac auscultation is a core clinical skill that all medical students need to master. Our finding show that a blended learning curriculum proved to be

effective in improving fifth-year medical students auscultation skills. In addition, results highlight that the use of this type of learning not only affect students' knowledge acquisition but also affect students' self-confidence in their ability to practice the learned skills. Therefore, the program was rated favorably by students. Use of blended learning techniques allows learners to meet and even exceed the predetermined teaching objectives and is valuable model to achieve and document competence in important clinical skills.

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### References

- Accreditation Council for Graduate Medical Education (ACGME). (2010). *ACGME outcome project*. Retrieved From <http://www.ucdenver.edu/academics/colleges/medicalschoo/department/pediatrics/meded/fellowships/Documents/ACGME%20Outcome%20Project.pdf>
- Barr, R. B., & Tagg, J. (1995). From teaching to learning - A new paradigm for undergraduate education. *Change*, 27(6), 12–26.
- Barrett, M. J., Kuzma, M. A., Seto, T. C., Richards, P., Mason, D., Barrett, D. M., & Gracely, E. J. (2006). The power of repetition in mastering cardiac auscultation. *The American Journal of Medicine*, 119(1), 73–75.
- Barsuk, J. H., Cohen, E. R., Feinglass, J., McGaghie, W. C., & Wayne, D. B. (2009). Use of simulation-based education to reduce catheter-related bloodstream infections. *Archives of Internal Medicine*, 169(15), 1420–1423.
- Barsuk, J. H., McGaghie, W. C., Cohen, E. R., Balachandran, J. S., & Wayne, D. B. (2009). Use of simulation-based mastery learning to improve the quality of central venous catheter placement in a medical intensive care unit. *Journal of Hospital Medicine*, 4(7), 397–403.
- Becker, H. J. (2000). Pedagogical motivations for pupil computer use that lead to student engagement. *Educational Technology*, 40(5), 5–17.
- Biasutto, S. N., Caussa, L. I., & Criado del Río, L. E. (2006). Teaching anatomy: Cadavers vs. computers? *Annals of Anatomy*, 188(2), 187–190.
- Bligh, D. A. (2000). *What's the use of lectures?* San Francisco, CA: Jossey-Bass.
- Cavanagh, R. F., & Romanoski, J. (2004). *Application of the Rasch model to develop a measure of classroom information and communication technology learning culture*. Paper presented at the 2nd International Conference on Measurement in Health, Education, Psychology and Marketing: Developments with Rasch and Unfolding Models. Murdoch, Western Australia.
- Ericsson, K. A. (2004). Deliberate practice and the acquisition and maintenance of expert performance in medicine and related domains. *Academic Medicine*, 79(10), S70–S81.
- Ewy, G. A., Felner, J. M., Juul, D., Mayer, J. W., Sajid, A. W., & Waugh, R. A. (1987). Test of a cardiology patient simulator with students in fourth-year electives. *Journal of Medical Education*, 62(9), 738–743.

- Garrison, D. R., & Kanuka, H. (2004). Blended learning: Uncovering its transformative potential in higher education. *The Internet and Higher Education*, 7(2), 95–105.
- Gordon, M. S. (1974). Development of an animated manikin to teach cardiovascular disease. *The American Journal of Cardiology*, 34(3), 350–355.
- Gray, K., & Tobin, J. (2010). Introducing an online community into a clinical education setting: A pilot study of student and staff engagement and outcomes using blended learning. *BMC Medical Education*, 10: 6.
- Harris, P., Connolly, J., & Feeney, L. (2009). Blended learning: Overview and recommendations for successful implementation. *Industrial and Commercial Training*, 41(3), 155–163.
- Horiszny, J. A. (2001). Teaching cardiac auscultation using simulated heart sounds and small-group discussion. *Family Medicine*, 33(1), 39–44.
- Issenberg, S. B., McGaghie, W. C., Gordon, D. L., Symes, S., Petrusa, E. R., Hart, I. R., & Harden, R. M. (2002). Effectiveness of a cardiology review course for internal medicine residents using simulation technology and deliberate practice. *Teaching and Learning in Medicine*, 14(4), 223–228.
- Kim, J. H., Kim, W. O., Min, K. T., Yang, J. Y., & Nam, Y. T. (2002). Learning by computer simulation does not lead to better test performance than textbook study in the diagnosis and treatment of dysrhythmias. *Journal of Clinical Anesthesia*, 14(5), 395–400.
- Lewin, L. O., Singh, M., Bateman, B. L., & Glover, P. B. (2009). Improving education in primary care: Development of an online curriculum using the blended learning model. *BMC Medical Education*, 9: 33. doi: 10.1186/1472-6920-9-33
- Lok, C. E., Morgan, C. D., & Ranganathan, N. (1998). The accuracy and inter-observer agreement in detecting the 'gallop sounds' by cardiac auscultation. *Chest*, 114(5), 1283–1288.
- Mangione, S. (2001). Cardiac auscultatory skills of physicians-in-training: A comparison of three English-speaking countries. *The American Journal of Medicine*, 110(3), 210–216.
- Mangione, S., & Nieman, L. Z. (1997). Cardiac auscultatory skills of internal medicine and family practice trainees: A comparison of diagnostic proficiency. *The Journal of the American Medical Association (JAMA)*, 278(9), 717–722.
- March, S. K., Bedynek, J. L., & Chizner, M. A. (2005). Teaching cardiac auscultation: Effectiveness of a patient-centered teaching conference on improving cardiac auscultatory skills. *Mayo Clinic Proceedings*, 80(11), 1443–1448.
- McLaughlin, J. E., Roth, M. T., Glatt, D. M., Gharkholonarehe, N., Davidson, C. A., Griffin, L. M., Esserman, D. A., & Mumper, R. J. (2014). The flipped classroom: A course design to foster learning and engagement in health professions education. *Academic Medicine*, 89(2), 236–243.
- Nackman, G. B., Bermann, M., & Hammoud, J. (2003). Effective use of human simulators in surgical education. *Journal of Surgical Research*, 115(2), 214–218.
- Pierce, R., & Fox, J. (2012). Vodcasts and active-learning exercises in a “flipped classroom” model of a renal pharmacotherapy module. *American Journal of Pharmaceutical Education*, 76(10): 196.
- Stern, D. T., Mangrulkar, R. S., Gruppen, L. D., Lang, A. L., Grum, C. M., & Judge, R. D. (2001). Using a multimedia tool to improve cardiac auscultation knowledge and skills. *Journal of General Internal Medicine* 16(11), 763–769
- Valcke, M., & De Wever, B. (2006). Information and communication technologies in higher education: Evidence-based practices in medical education. *Medical Teacher*, 28(1), 40–48.
- Vukanovic-Criley, J. M., Criley, S., Warde, C. M., Boker, J. R., Guevara-Matheus, L., Churchill, W. H., Nelson, W. P., & Criley, J. M. (2006). Competency in cardiac

- examination skills in medical students, trainees, physicians, and faculty: A multicenter study. *Archives of Internal Medicine*, 166(6), 610–616.
- Wayne, D. B., Barsuk, J. H., O’Leary, K. J., Fudala, M. J., & McGaghie, W. C. (2008). Mastery learning of thoracentesis skills by internal medicine residents using simulation technology and deliberate practice. *Journal of Hospital Medicine*, 3(1), 48–54.
- Wayne, D. B., Butter, J., & Siddall, V. J. (2006). Mastery learning of advanced cardiac life support skills by internal medicine residents using simulation technology and deliberate practice. *Journal of General Internal Medicine* 21(3), 251–256.
- Wu, J. H., Tennyson, R. D., & Hsia, T. L. (2010). A study of student satisfaction in a blended e-learning system environment. *Computers & Education*, 55, 155–164.