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## Acoustic Labyrinth: Validation of a game – based heart auscultation educational tool

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### Abstract

The aim of the study was to validate a prototype of a game-based educational tool for improving auscultation skills. The tool was presented to 12 medical school students studying at a foundation university. The data collection tools of the study were: Cardiac sound identification form, educational tool evaluation form and auscultation survey form. Key findings of the study were: 1—Each medical student increased their identification skills and retention was possible. 2—The most incorrectly identified heart sound was the most correctly identified heart sound after using the tool. 3—Medical students sided with the tool for it is flexible, quicker method of learning and getting feedback, can be used anytime, anywhere without interruption of daily life. 4—Since students felt skillful and epic, in real-World tackling problems, on the mission; saving lives, and competitive, they repeated the content otherwise they would not. 5—The tool created a hype and motivation for further learning. 6—Tool was effective on the users with possible restricted acoustic capability which could imply findings might also be used for improving listening skills and musical ear.

Keywords: Stethoscope skills, heart auscultation training, mobile learning, game-based learning, retention.

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## 1. Introduction

Irregular heartbeats and murmurs are only recognised by cardiologists, who constitute 5% of physicians (Magnione, Nieman, Gracely & Kaye, 1993). Auscultation is the action of listening to sounds from the heart, lungs or other organs, typically with a stethoscope, as a part of medical diagnosis. Even with improving high technology, auscultation, one of the main elements of medical education, sustains its significance as a valuable skill, as it is helpful for physicians to progress their treatment with their patients' voices. Physicians agree that auscultation remains important even in the face of developing technology (Roy, Sargent, Gray, Hoyt, Allen & Fleming 2002). In the last 20 years, studies have been made in various countries demonstrating that less than 40% of the medical students, trainees, even interns who continue their academic education can identify irregular sounds coming from the heart (Marcus, 1999). The poor identification of skills has been related to the lack of trainers with related skill (Mackie, 2011) and the followings have been detected: (i) Auscultation skills of medical students and interns are poor (Mangione, 1998; Mangione and Nieman, 1997; Roy et al. 2002; Vukanovic-Criley et al., 2006) (ii) The use of stethoscope in medical education is not effective, (iii) the ability to identify irregular heart sounds is difficult to gain and (iv) auscultation skills cannot be taught in medical schools (Mangione, 2001). As a result of this lack of skill (Mackie, 2011), the innocent heart sound cannot be distinguished. Seventy percent of patients with normal auscultation findings are referred to expensive research procedures (Fogel, 1960), and patients with abnormal cardiac signs cannot be diagnosed for many years until the disease becomes unbeatable (Fogel, 1960), (Wong, Baker & Warren, 2005).

The deficiencies of meeting the specific needs of auscultation training, weakens the auscultation skills of medical students and interns. Such deficiencies can be summed up as: (1) Not paying sufficient attention to the auscultation teaching, (2) Not changing teaching methods in last 50 years, (3) The ineffectiveness of the existing teaching methods, and the lack of information related to it, (4) The inability of medical trainers to train users of stethoscope, (5) Lack of understanding the fact that auscultation teaching is not a skill but needs to be developed effectively, (6) Not using modern protocols to teach auditory skills by Medical schools and (7) Not measuring auscultation skills often.

Currently, the medical education community has not adopted a common method of teaching auscultation. The currently available auscultation training tools with similar nature, iAuscultate, iMurmur2, Stethoscope Expert, iStethoscope Pro, Auscultation, Auscultation Premier, Litmann Learning Institute, Heart Murmur Sim in Second Life, can be expressed as voice analysis software which separates different voices and detect silence and speech in an acoustic signal. The content that needs to be learned by the students coupled with a technical voice analyzing tool, is not directly motivating to students (Prensky, 2003).

Auscultation training needs to be revised both for its importance for medical education and for the above-mentioned deficiencies. There is a need to go beyond traditional approaches by introducing new effective learning tools and environments to the curriculum (Kanthan & Senger, 2011) such as digital game-based learning. Digital game-based learning is used both for its learning effectiveness and motivational appeal of a computer game, designed according to curricular objectives and subject matter in education (Papastergiou, 2009). Created for learning purposes characterised by learning that occurs by interaction of the player with the mechanics of the game, game-based learning appreciated for improving focus, personal motivation and problem-solving skills.

The aim of this research study was to validate the game-based heart auscultation educational training tool for both technical and pedagogical aspects to improve auscultation skills. This study is comprised two phases. The first three processes of the design and development research model, which is identifying the problem, describing the objectives and designing and developing the

prototype, was completed at the first phase of the study in France and China. The last three processes were completed in the scope of this study, at the second phase. This study, which focuses on to phase two, is comprised testing the prototype, evaluating the testing results, and communicating the testing results.

The significance of this study was due to demonstrate ability of a game-based educational tool to keep its users engaged on a content that is found extremely hard to perceive, actively attempting to reach goals and determined to overcome their failures day by day. It was expected that the new method of auscultation learning could allow the creation of a template in the mind to be recorded to long-term memory via intense repetition with periodic intervals. Due to being portable, personal, accessible, independent of time and space, could access very large audiences quickly through smartphones and tablets.

Also, a similar study in the game environment has not been detected in the literature. Literature that contained studies comparing different teaching methods was not sufficient. Moreover, there was no well-designed academic research evaluates the benefits of games for medical education. In this context, we think that a scientific approach is necessary for new generation games to become more effective tools that support current education (Wang, DeMaria, Goldberg & Katz, 2016).

## **2. Method**

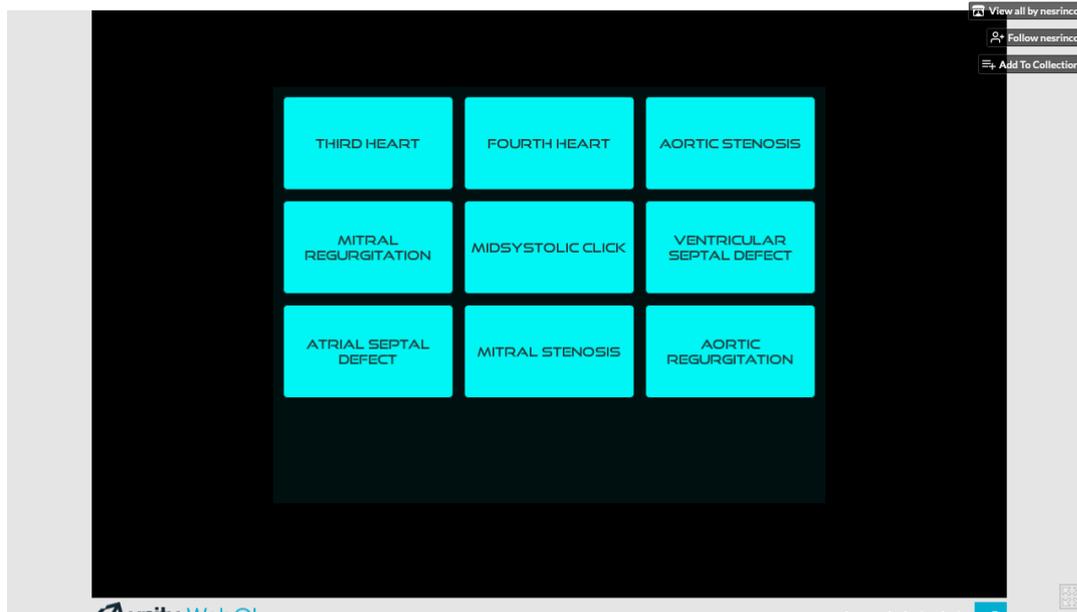
### *2.1. Research design*

Design and Development Research (DBR) methodology (Richey & Klein, 2007) was used in this study. The framework of the DBR model is consisted of six steps: (1) Identifying the problem, (2) Describing the objectives, (3) Designing and developing the prototype, (4) Testing the prototype, (5) Evaluating the testing results and (6) Communicating the testing results. While the first three steps of the DBR model was completed at the first phase, the last three steps were completed at the second phase in the scope of this study.

(1) Identifying the problem: It was determined that the existing auscultation training did not meet the requirements of medical school students, and the support of the educators was insufficient, based on literature review and opinions of the medical experts in France/Paris. Also, literature on the most common pathological heart sounds was examined in France/Paris under the guidance of a medical expert. Senior cardiovascular diseases specialist was consulted for the confirmation of the problem motivating the research.

(2) Description of the objective: Objective of the solution to the problem was determined. Aiming to increase the accuracy rate of diagnosis, the instructional design had been done as follows: Periodic, intermittent and intense repetition of the data to create a template for pathologic hearts sounds in user's long-term memory.

(3) Design and development of a prototype: Before designing a prototype, existing auscultation teaching methods as well as existing auscultation teaching tools on web and their solutions have been analysed in terms of their advantages and disadvantages. Opinions of two experts from two faculties who have been working at a private university for almost 20 years in the fields of Game design and Education Technologies, have been taken. The experts stated that the educational design of the game-based educational tool was in line with the teaching principles of the educational design. Prototype of game-based educational tool that offers a new learning method for auscultation was designed primarily based on the pedagogic teachings Gagne's teaching actions, ARCS Model and MDA Framework of game design.



This game can support anyone identifying eight abnormal sounds coming from the heart in an effortless way, when played enough.

In the prototype of the game-based educational tool, the user tries to find a way out of a maze. In the attempt to find the exit, they follow one of the common irregular heart sounds. In order to get out of the maze they have to listen to the sound 500 times. During the game user listen to the choice of heart sound characteristic in the sequence of "Listen, Test, Learn". After choosing the right sound they can proceed with the next level.

(4) Testing the prototype: The game-based educational tool was first evaluated in France/Paris. The game-based educational tool was deemed worthy of further development and taken to Tsinghua University (China / Shenzhen). The modification of the game with the Chinese team was made here. Second evaluation of the tool was made in China, presenting games from to general public and medical students in a cultural center with 10,000 visitors per day with the support of Tsinghua University. At this stage, an Intuitive Evaluation was carried out which included demographic information of the participants, opinions about the game, and suggestions for improvement. The tool was developed into three gradually increasing levels of difficulty. Finally, third evaluation was made in Turkey/Istanbul. It was observed at the 1st, 2nd and 3rd evaluation stages that the game based educational tool could increase the focus and listening skills of its users and be effective in learning and retaining basic concepts in long-term memory also in other disciplines other than medicine. Upon positive feedbacks by the target group, finally, data collection tools were designed to collect data from medical students in this study.

## 2.2. Participants

The participants of the study were students who continued their academic education and were predominantly third grade students with two being first graders of Acibadem Medical Faculty. They had strong personal characteristics of general medical faculty students such as being highly responsible and motivated, positive attitude towards learning activities, and having patience as well as reasoning abilities. It was observed that apart from general characteristics of a medical student, the

participants of the study had strong attention and memory, very fast, had zero tolerance to mistakes, perfectionist personal characteristics but not all had high level of hearing ability and relatively insensitive to difference in sounds, as would be four percent of general population.

### 2.3. Data collection and analysis

Cardiac sound identification form. This form consists of eight questions on eight heart sounds (Normal heart sound, Third Heart Sound, Fourth Heart Sound, Aortic Stenosis, Midsistolic Click, Ventricular Septal Defect, Mitral Regurgitation, Atrial Septal Defect, Aortic Regurgitation). The eight irregular heart sounds were asked in a Right-Wrong Test type, which is considered highly objective and extensively valid test type. These sounds were the original heart sounds provided by the expert in the Medical School in France. Questions to be used in the study was prepared by taking a sample of a study (Nguyen et al. 2015) that includes multiple-choice test with a low-cost approach for the competence assessment of medical students. It was presented to the participants before and after the test play. The ability of the participants to identify heart sounds was tested based only on hearing. Test Participant could play the sound by clicking the link in the question and by evaluating if the irregular heart sound belonged to the given heart disease, answer choosing between either right or wrong.

Educational tool evaluation form. This form (Wrench, 2001) Pre-prepared questions were asked in the form of free flow about the game-based educational tool (Content, Learning Effectiveness, Accessibility, Game Dynamics and Usability dimensions). As Likert-type items; the answers were expressed between the Strongly Agree and Strongly Disagree options. The learning theories and their strategies and methods such as; the material to be learned and guidance, revealing the performance behavior and feedback from Gagne’s Nine teaching actions, facilitating self-growth and confidence, giving learners control method of ARCS Model, game dynamics from MDA framework, which were implemented into the game, were tested by the use of tool.

Auscultation survey form. This form (Owen & Wong, 2015) was consisted of three right or wrong questions and one semi-structured open-end question, which is the fourth question inquiring about current auscultation training of the participants. On the fourth question, participants are encouraged to express their thoughts freely about their auscultation trainings. The aim of gathering the relevant data was to determine if current auscultation training in a medical faculty is needed to be supported with a tool in general and their current auscultation training. Pre-prepared questions were asked in the form of free flow and the answers were expressed between the Strongly Agree and Strongly Disagree options.

Regardless of their class and achievement status being a medical student was enough criterion to participate in the study. The participants of the study were predominantly third grade medical school students, who received their auscultation training recently with two being first graders of a foundation university. After collecting participants’ pre-test play data on their ability to identify eight irregular heartbeats and one normal beat of the heart, the tool was presented to the participants six times in three days which enabled spaced and around five hundred times repetition of the nine heart sounds. And on the fourth day, the same Cardiac Sounds Identification Form was presented to the participants as a post-test to determine and measure to what extent their current knowledge on nine heart sounds got improved; and the Auscultation Survey Form was given to the participants to gather data about their ongoing auscultation training. And finally, semi-structured interview questions were presented to the participants via Educational Tool Evaluation Form.

In the analysis of the information obtained from the forms; qualitative comparison analysis was used to measure the relationships between variables during the two reporting periods. In the analysis of semi-structured interview data obtained with the educational tool evaluation and auscultation research forms; descriptive analysis method of the qualitative research was used to provide different opinions of the participants. The study was concluded with the finding of pedagogical and technical validity of the prototype of the tool.

### 3. Results

#### 3.1. The data obtained from heart sounds identification form

Before starting the test plays, 12 participants were asked nine questions on heart sounds which made 108 questions in total. Out of 108 questions, 63 were answered correctly before the test play. Auscultation skills on identifying heart sounds of test participants on initial evaluation was roughly over 40 percent. After using the educational tool for three subsequent days, the right answers increased from 63 to 90, while the expert level was 108. Table 1 and Table 2 presents the data collected during the study, demonstrating the least and the most increased identification skills. The least increase was two heart sounds; one participant’s three heart sounds identification before test play increased two more reaching to five after test play. The most increase was five heart sounds; one participant who increased identification skills from four to nine and reached to expert level. The tables also demonstrate that least identified heart sound was the most correctly identified sound after the test play. Also, according to tables, normal heartbeat which could not be identified by two participants before test play could also not be identified by two participants but after the test play, but not same participants. One of the first graders, who did not have any auscultation training previously, could identify three sounds before the test play, which was the least among the others. Increasing four more, the first grader could identify seven heart sounds after the test play.

While each participant made a progress and increased their identification skills on heart sounds ranging between at one and five and, four participants reached to expert level. Among the participants who reached to expert level was one first grader who had no previous auscultation training. As can be observed from both tables, the tool improved identification skills.

**Table 1. Right Answers to Each Heart Sound - Before Test play**

	P 1	P 2	P 3	P 4	P 5	P 6	P 7	P 8	P 9	P 10	P 11	P 12
Atrial Septal Defect Sound			X		X		X	X		X	X	
Third Heart Sound	X	X										
Fourth Heart Sound		X	X	X	X	X				X		
Aortic Stenosis Heart Sound		X	X							X	X	
Midsystolic Click Heart Sound	X	X		X	X	X			X			X
Ventricular Septal Defect Heart Sound	X	X		X	X		X		X		X	X
Normal Heart Sound	X	X	X	X	X	X	X		X	X	X	
Aortic Regurgitation Heart Sound	X	X	X		X	X	X	X	X	X	X	
Mitral Regurgitation	X	X	X		X	X	X	X	X		X	X

TOTAL	6	8	6	4	7	5	5	3	5	5	6	3
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Note. The letter P is the abbreviation of the Word “participant”.

**Table 2. Right Answers to Each Heart Sound - After Test play**

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11	P12
Atrial Septal Defect Sound	X	X	X	X	X	X	X	X		X	X	
Third Heart Sound	X	X		X	X	X	X	X	X	X	X	X
Fourth Heart Sound	X	X		X	X		X		X	X	X	
Aortic Stenosis Heart Sound	X	X	X	X	X	X		X	X		X	X
Midsystolic Click Heart Sound	X	X	X	X	X		X		X	X		X
Ventricular Septal Defect Heart Sound	X	X	X	X	X	X	X		X		X	X
Normal Heart Sound	X	X	X	X	X		X		X	X	X	X
Aortic Regurgitation Heart Sound	X	X	X	X	X	X	X	X		X	X	X
Mitral Regurgitation	X	X	X	X	X	X	X	X	X	X		X
TOTAL	9	9	7	9	9	6	8	5	7	7	7	7

Note. The letter P is the abbreviation of the Word “participant”.

### 3.2. The data obtained from educational tool evaluation form

#### 4. Table 3. Educational Tool Evaluation Frequency Data

	Strongly Disagree	Somewhat Disagree	Neither Agree nor Disagree	Somewhat Agree	Strongly Agree
<b>Content rating</b>					
This game-based educational tool would work with existing auscultation content.					9
The game-based educational tool has a clear learning objective of teaching eight irregular heart sounds.					9
Content comprised of eight irregular heart sounds can advance as the user (learner) advances.				2	7
The game-based educational tool is appropriate for all users of stethoscope.				3	6
The game-based educational tool has appropriate use of sound to simulate real human heart.				2	7
The objective that must be followed during the game, are clearly stated.				1	8
<b>Learning effectiveness rating</b>					
I find the use of game-based educational tool enhancing the learning process.				2	7
My sound identifying acquisition has increased because of game-based heart auscultation tool.				2	7
My motivation has been enhanced by the use of game-based heart					9

auscultation tool inside and outside the classroom.				
The game based educational tool has stimulated my enthusiasm for further learning.				9
Overall, I believe using game-based educational tool in learning heart auscultation is effective.				9
<b>Accessibility rating</b>				
Difficulty setting of educational tools is suitable for all levels of auscultation experience of users.			3	6
The game that the educational tool presents is usable in any environment of the user.			1	8
The game-based educational tool is more flexible method of learning as it can be done anytime, anywhere.			1	8
The game-based educational tool is a quicker method of getting feedback in learning.				9
The game-based educational tool can be used for learning due to availability of mobile phones with a larger number of students.				9
The game-based educational tool provides user an immediate summary of performance.				9
<b>Game dynamics rating</b>				
I lost track of time when I used the game-based educational tool.	1	1	2	5
My thoughts went fast when I used the game-based educational tool.	1	1	2	5
The game feels real.		1	4	4
I really got into the game.	1		1	7
I played the game longer than I meant to.	1		1	7
Playing the game-based educational tool made me feel calm.	1	1	3	4
I felt I was learning when I used the game-based educational tool.	1			8
I felt skillful when I used the game-based educational tool.			3	6
I felt stimulated (motivated) while playing the game.			2	7
<b>Usability rating</b>				
It is easy for users to start the game and navigate through it, to completion.			2	7
It is easy for users to figure out the actions to get to the next task.			1	8
It is easy to get familiar with the game-based tool and learn how to use it.				9
Users can do their tasks during the game without unnecessary effort.		1		8
The game-based tool reacts fast to user inputs (selections).	1		1	7
No need for instructor to assist users to play the game-based tool.			1	8
Using the game-based tool requires no computer knowledge.		1	4	5
It does not require users to reference manuals on how to use the game-based tool.		1	1	7
Length (time) of the game is appropriate for users.			2	7
Instructions that is presented before the game can be skipped if already known.			2	7
Information given about irregular hearts before starting the game, is appropriate for users.			4	5

Educational Tool Evaluation Form presents the data collected after the test plays, demonstrating the evaluation of participants on the tool in five categories. These categories were: Content, learning effectiveness, accessibility, game dynamics and usability. On the content that is presented with the tool all participants approved that the tool had a clear learning object and that would work with existing auscultation content. On learning effectiveness of the tool, participants were very much contented of the ability of the tool for possessing effective learning method which increases sound identification acquisition, motivation for further learning. As for accessibility of the tool, participants sided with its' usability in any environment of the user, a more flexible, quicker method of learning and getting feedback, as it can be done anytime, anywhere and anyone due to availability of mobile phones with large number of students. Although the tool was used more than meant to and participants got really into the game, felt skillful and on the mission and they were learning and motivated while playing; participants slightly disputed the game dynamics of the tool. And lastly, for usability of the tool although all agreed that length of time and information given about irregular heart

sounds were appropriate for users. Some participants contradicted on their rating for using the tool without any assistance. The evaluations of the participants can be seen in Table 3.

### **3.3.The data obtained from auscultation survey**

According to data that is obtained from Auscultation Survey on the efficiency of their current auscultation training of the participants; all participants were highly aware of the importance of the auscultation training expressing that stethoscope is a crucial tool both for making a correct diagnosis and also for doctor-patient connection was much more enhanced when it involved auscultation as well as providing equal health care to everyone. Aligned with the literature, even with the highest quality education at the participant medical school, auscultation training was still neglected because of deficiencies and difficulties of meeting the specific needs of auscultation training based on the fact that auscultation training was presented only given once with no feedback. Although medical students thought that their education system in their medical faculty “was much better than the other medical schools, and although they posed a heart sound simulation device, it was not practical. They felt they didn’t have access to auscultation trainings, they think their auscultation training level was very low” and felt that they were not learning and get training on auscultation effectively.

## **4.Discussion**

Aligned with the literature, the finding of even with the highest quality education at Medical school, auscultation training was still neglected because of deficiencies and difficulties of meeting the specific needs of auscultation training was expected nevertheless, the finding that the auscultation skills of medical students were over 40 percent, contrary to literature, was a surprising fact at the study. The findings that the tool created a hype and motivation for further learning; the feedback function, repetition, one to one learning setting were very much liked and made feel confident and skillful on the way to becoming a doctor were confirmed learning effectiveness of Gagne’s nine teaching actions, ARCS Model and self-determination theory.

One other result of the study was that even though as a prototype, tool was lacking fun factor and game visuals and art, medical students felt epic and in the real World tackling problems and on the mission; saving lives and feeling skillful was directly in correlation with Prensky’s (2003) findings of “Educational games which are explicitly designed to teach about a specific sub-skill, is becoming mainstream, it is being realized that digital games are not the enemy, but the best opportunity we have to engage our learners in real learning.

The statements of medical students during the study which pointed out that they felt playful as well as competitive and therefore repeated the content that was presented by the tool; it was evident for them that they would not repeat in any other circumstances supports Mackie (2011) on his finding of “Since medical education has shown a tendency to change its shells with increased reality-based active learning practices for the last 15 years, it is now more possible to develop a new learning method for auscultation training and related skills.

Although not surprising but a noteworthy finding was on testing the effectiveness of tool, which is basically an audio game, with restricted acoustic capability of users. Restricted acoustic capability is defined as tone deaf and it is estimated that only between two and five percent of the population is medically tone deaf - and there are varying degrees and types of tone deafness.

Although a very motivated medical student, the participant who had made the least identification, P8, could only recognize three heart sounds and not identify normal heart beat in the first test play: After the test play, though increased the number of heart sounds two more and could recognize five heart sounds, still could not differ normal heart beat and was the participant who had made least

identification but the fact that P8 was the least identifying participant might be due to a slight tone deaf, which is relatively insensitive to differences in musical pitch.

And the last worthy finding was on the Third Heart Sound, which was the least identified sound before the test plays. The Third heart Sound was the most correctly identified sound after the test plays, which imply the validity of the tool. Other possibilities of the reason of success on the Third Heart Sound is could be due to previous learning factor or motivational trigger factor.

As a previous learning on reading and writing direction sequence for Turkish and English using participants writing starts with the first word at the top left and moves rightward and then downward and lists are from top-to-bottom of the page. Spatial representations for sequences take left as the beginning, proceeding toward the right, might have influence the participants' tendency to choose the first heart sound, which is the Third Heart Sound in the order of the heart sounds to be played. The participants who played the game more than meant to having a success on the Third Heart Sound. Although, each participant had to play each heart sound once during the test play, there is a possibility that playing the game more than meant to with the influence of the hype that was created by the game and tending to choose the Third heart Sound might have influence participants' success of learning Third Heart sound. Another possibility is that it was known by the medical student that Third Heart Sound tests the auscultatory skills of the examiner because it is often the most difficult heart sound to hear. The sound does not radiate widely and is audible only over a small area of the chest wall. The usual frequency (pitch) of the sound is near the lowest level that the human ear can detect (Silverman, 1990). The fact that Third Heart Sound tests the auscultatory skills of the examiner might trigger competitive and perfectionist character of medical students; thus, aiming the success on the Third Heart Sound.

## 5. Conclusion and Recommendations

Although, auscultation skills on identifying heart sounds of participants of the test on initial evaluation was over 40 percent contrary to literature primarily because of pre-learning inclination and perfectionist, competitive, zero tolerance to mistakes character of the participants, the concept of the most commonly seen heart diseases, was regarded very much needed since it created a connection to their knowledge, and advanced skills. In accordance with the aim of the study, correct identification rate of stethoscope users was identified, and the tool was validated based on the facts that each participant had made a progress, most incorrectly identified heart sound was the most correctly identified heart sound after using the tool and retention was possible. Auscultation provides fast, cheap and easy assessment of a patient, with no further invasive tests. It is essential to a physician to differ what is pathologic and what is not. Auscultation training needs to be revised and supported with the learning tools of the new era for its importance for medical education.

The game-based tool improved skills on heart auscultation, therefore, it is valid and its possible implications in other areas of study might be for improving musical ear and listening skills of anyone in need, such as music students, attention deficit disorder patients. As for the future work, the answers given by the medical students at the interviews as well as data gathered from evaluation forms demonstrates that second and, if needed third iteration studies of the prototype of tool should be made considering the following: (i) Repetitive learning method should be supported with fun factor, where it was missing in the prototype of the tool. To fulfill this lack, fun actor can be added by organizing tournaments among the users in addition to a leaderboard. (ii) Even with the users who don't have acoustic capability, the tool can be used but then it would be challenging, and learning process can be affected. Nevertheless, this difficulty can be overcome with more repetitions as well as other presenting practical ways of decoding the rhythms of each irregular heart sounds. (iii) The game

should be developed by adding graphics so that heart sounds should be supported also visually. (iv) Establishing a heart sound library with more than five or six heart sounds for each type of anomaly is strongly advised. The medical teaching community should also notice that with its one to one setting of learning, its repetitive model of teaching and immediate feedback factor; tool, presented a very much liked effective learning method on a subject that is found extremely hard by medical students.

Furthermore, the medical teaching community must be aware that game dynamics of the tool made medical students feel skilful and on the mission with an epic purpose of saving lives and feeling that coming one step closer to be a doctor. Although a prototype and missing fun factor and some missing qualifications at its usability, users of the tool kept on playing the game because they felt they were in a playful and competitive environment, which comply with medical students' character. To do that, the game-based educational tool should be developed to fill existing gap of auscultation training by teaching how the sounds are produced and how they change under different conditions and thus teach how to hear and identify sounds. A heart sound library with couple of heart sounds for each type of anomaly should be established. Practical ways of decoding the rhythms of each irregular heart sounds should be developed. Heart sounds should be supported also visually. Feasibility studies should be made for new tools development based on the same principles to support level of attention for the children with ADHD and enhancing listening skills and hearing sensibility of users as well as enhancing music ear in music discipline. Derived from the conclusions of the study, following are the recommendations for the medical teaching community:

1. The medical teaching community must pay attention to their students' need as it was widely expressed that the content consisted of eight irregular heartbeats is very much needed to be supportive and make connection to theoretical knowledge by medical students.
2. Moreover, the medical teaching community for auscultation should be tuned in to their medical students' enjoyment of the tool's accessibility such as making it easy to use it on the go without any interruption from their daily life, which is loaded with heavy curriculum and little time.
3. The medical teaching community should also perceive that auscultation teaching is not a skill but needs to be developed effectively. Therefore, they should pay sufficient attention to auscultation teaching and supporting it with digital game-based learning tools of the new era.
4. The medical teaching community should revise auscultation training to improve listening/identification ability on how to hear.
5. The medical teaching community should improve auscultation skill by what causes that sound and how it is produced.
6. The medical teaching community should relate clinical knowledge and sound knowledge by teaching the way how to auscultate.
7. The medical teaching community should present real heart sounds every week at lab at a cardiology internship to establish patient – doctor relationship.
8. The medical teaching community should measure auscultation skills often.

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