

# Appraising Smartphone APPs as a Tool for Practical Teaching in Audiology

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Pure Tone Audiometry (PTA) is an essential investigation used in evaluating the degree and the character of hearing loss. However, due to busy clinic time and overflow of patients, the PTA teaching is not optimized during clinical sessions. Accordingly, the students' experience of PTA is not optimized. To overcome this problem, the researchers encouraged the students to use the smartphone's application (APPs) that simulate PTA to support the teaching and learning process of audiology. Fifty-seven medical students in their fourth-year in University Malaysia Sabah (UMS) contributed to this study. They used that APPs to screen the hearing status in a random sample of a population ( $N = 277$ ) in the workplace. The students managed to analyze PTA. A third of students performed the tests correctly. APPs showed high effectiveness as a diagnostic tool which supported their skills in solving the clinical problem. They managed to confirm the diagnosis of presbycusis (hearing impairment due to aging) in patients aged 60 and above. APPs as a screening tool supported students' skills in performing PTA testing (learning by doing). They identified abnormal PTA in 51.9% among those cases who did not have any complaint of hearing loss. The APPs results confirmed the complaint of the hearing loss in 42.6 % of cases. APPs was also helpful in identifying non-manifested conditions in 40.4% of cases. The availability and reliability of smartphone's APPs can overcome the problems of limited exposures and the expensive simulators. Eventually, it will enhance the medical students' competency.

*Keywords:* Pure Tone Audiometry, smartphone, APPs-learning by doing, problem-solving, screening

## Introduction

Pure Tone Audiometry (PTA) is an essential investigation used in evaluating the degree and the type of hearing loss. Having excellent PTA knowledge and skills is crucial to achieving an accurate clinical diagnosis for those patients who complain of hearing impairment. The conventional methods for teaching/learning PTA

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among medical students are the lectures and practical sessions in dedicated clinics. Traditionally, this training takes place at the hospital which gives the students an opportunity to get immediate feedback from an experienced clinician (Lieberth & Martin, 2005). However, the busy clinical schedule, the overflow of patients and the short period of the course, and absence of hands-on practice limit the students' chance for discovering learning in own autonomy (Bradshaw & Lowensteinn, 2011).

### **Literature Review**

There are many issues contribute to the competency of the learner. These factors are the education environment and the learning tools. According to Cantillon and Wood (2010), learners do best when they are immersed in an environment that supports and promotes active and deep learning. Learning by doing gives the students the opportunity to gain experiences in mastering psychomotor skills, verbalizing, reasoning, and assessing their learning (Bleakly, Bligh, & Browne, 2011). Therefore, this study took place at the patients' offices, homes, or learners' hostel to give the students the opportunity to reach out a larger sample of cases and to learn deeply.

Recently, the high fidelity simulators (mannequin-based and full virtual reality) and computer patient (virtual world) are recommended as teaching-learning tools. These high-tech models are recommended for training on performing the subjective tests like PTA (Cooper & Taqueti, 2004; Heitz, Dunser, Christoph-Bartneck, Grady, & Moran, 2014). However, these simulators are expensive and unavailable in many countries. The evolution of the smartphone industry and the explosion in medical information became an alternative for these expensive facilities (Bradshaw & Lowensteinn, 2011). In 2016, nearly 1.5 billion smartphones sold worldwide (Statista Technology and Telecommunication, n.d.; Robinson, Cronin, Ibrahim, Jinks, Molitor, & Newman, 2013). Accordingly, the researchers recommended using smartphones as a tool for enhancing the education process.

Concurrently, more and more smartphone-based smartphone's applications (APPs) are developed to be user-friendly and accessible to students. A high proportion of medical students are using it daily in their self-learning (Payne, Wharrad, & Watts, 2012; Wallace, Clark, & White, 2012; O'Connor, Byrne, Butt, Offiah, Lydon, & McInerney, 2014; Gavali, Khismatrao, Gavali, & Patil, 2017). The evolved applications and open-resources activities help the students to consolidate the learning they are doing from the available resources (Race, 2015).

The portability and increasing power of smartphones allow access to medical knowledge through medical websites and to download medical applications (Payne et al., 2012; O'Cornnor et al., 2014). Several studies have investigated the use of audiometry software, both those which stand-alone and the Website based applications, and found good results (Wilson, Hill, Hughes, Sher, & Laplante-Levesque, 2010). However, literature did not address the use of smartphones as a teaching aid in audiology and did not explain its pedagogical impact on students' competence. Besides, it did not evaluate the reliability of these APPs as a tool in screening hearing in the community.

Therefore, four folded aspects will be addressed in this study. Firstly, did APPs enhance students' cognitive skills in analyzing PTA and solving the clinical problems? Secondly, what is the impact of APPs on the students' psychomotor skills in performing PTA? Thirdly, did the APPs show clinical reliability while screening the hearing among the community? Lastly but not least, did APPs motivate the students to study and understand the concepts of audiology?

### Methodology

First of all, we trained the students to use the downloaded APPs in performing PTA testing and interpreting its results. Each student was asked to examine seven cases. One of the most basic inclusion criteria for the random sample included the age, which started at age of 21 years and opened to all senior people.

For each case, the student was eligible to take informed consent and to examine the subject's ear clinically before performing PTA examination using the APPs. Eventually, the submitted report included a snapshot of the PTA together with the clinical sheet data. Each learner responded to a structured feedback about own experience in using the APPs.

In the next stage, the researchers appraised each report to evaluate the students' competency in analyzing, interpreting PTA results, and using it in solving the clinical problems. The researchers compared the recorded PTA pattern and the clinical sheets to study the concordance of results. This analysis gave an objective evaluation of the APPs' role. Also, the researchers analyzed the feedback reports to identify the subjective impression of students about APPs as a learning tool.

### Results

The study continued over an academic year and included the fourth-year medical program ( $N = 57$ ). They screened a random sample of the population ( $N = 277$ ). The eldest case was 81-year-old, and the mean age for the examined group was 38 years.

#### The Impact of APPs on the Cognitive Domain

The students analyzed the PTA appropriately in 17.5% of encountered cases who had the complaint of hearing loss. In the category of patients, who had complaints like tinnitus, discharge without clinical hearing impairment, and the students to analyze the PTA results accurately in 28% of cases.

In the third category of cases, who had the risk factors for hearing impairment, the students correctly analyzed 30% of the patients ( $N = 66$ ). Overall, the students analyzed PTA results correctly in 30% of cases, but they inappropriately commented on 10% of the cases. The rest of the cases required no analysis as the PTA presented normal patterns (see Figure 1).

Table 1

#### *Analysis of Students' Performance in Problem-Solving Using APPs*

Category of clinical problem	Student performance in problem-solving		
	Satisfactory synthesis (%)	Unsatisfactory synthesis (%)	No. synthesis required (%)
Cases with a complaint of hearing loss	60.3	11.1	28.6
Cases without hearing loss	22.4	14.8	62.5
Cases with another Otological complaint	49.3	10.7	40.0
Cases without any Otological complaint	24.4	15.4	60.2
History of risk factors	37.3	14.5	48.2
No History of any risk factors	27.1	13.9	57.2
Overall	31.4	14.1	54.5

The students' competency in solving the clinical problems of hearing impairment by using APPs is shown in Table 1. For every single case, we correlated the analyzed report, to the examination sheet, and finally, to the

student's provisional diagnosis.

Figure 2 shows that in 30% of all over cases, APPs results supported the students to solve the clinical problems. However, 14.1% of the cases were not finally solved and required further investigations. In this random sample of a population, 54.4% of the reports determined were healthy subjects with classic PTA pattern.

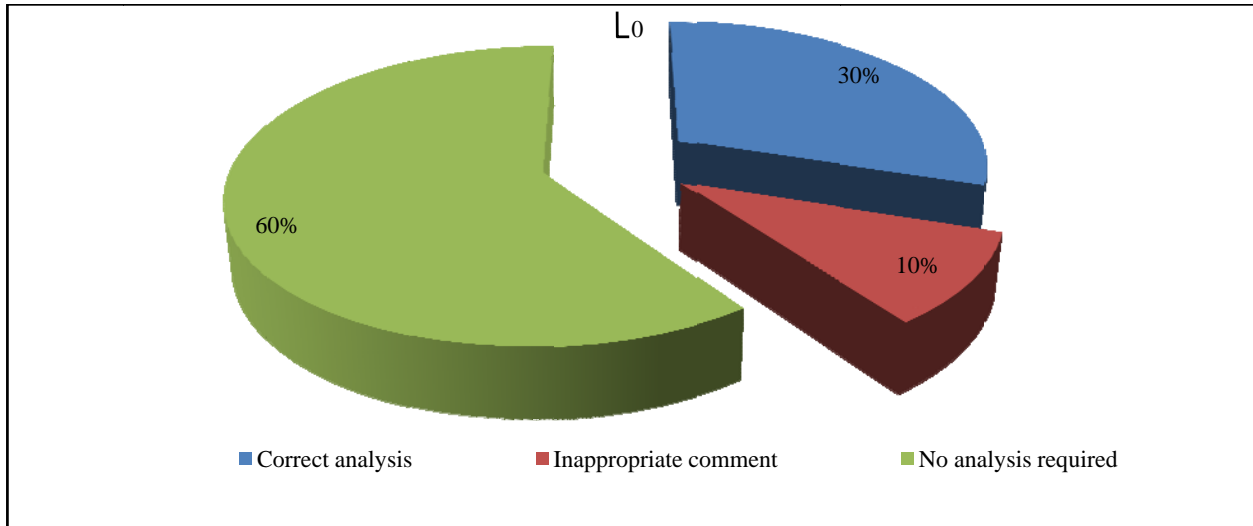


Figure 1. Students' performance in analyzing PTA.

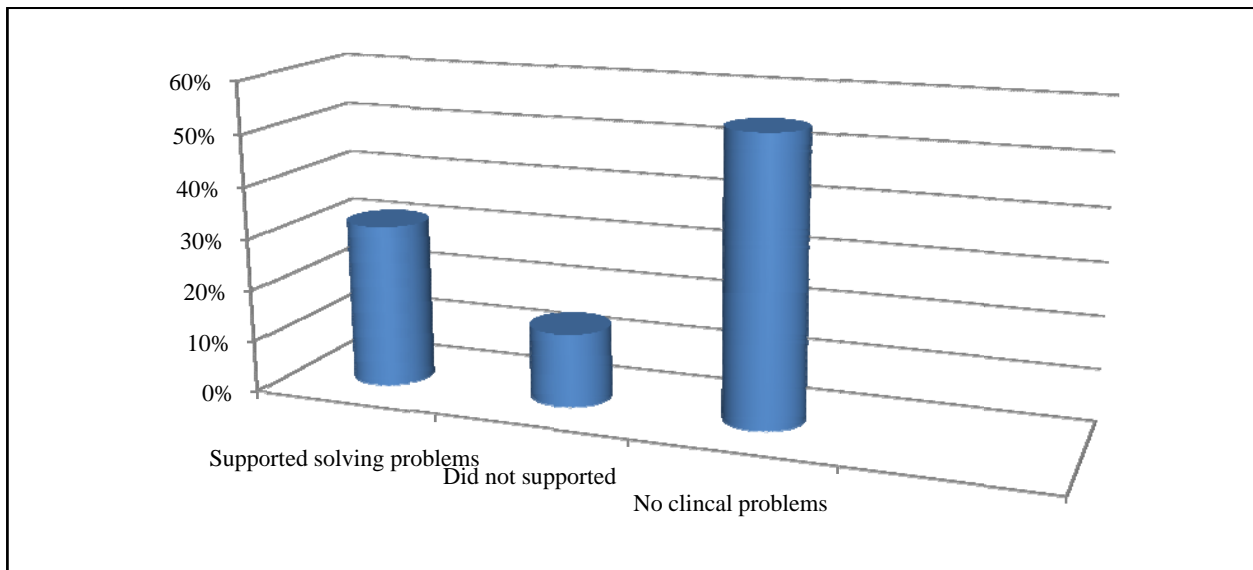


Figure 2. Analysis of Apps support in solving the clinical problem.

**The Impact of APPs on the Psychomotor Skills in Performing PTA**

The impact of APPs on the psychomotor skills in performing PTA is studied by comparing the pattern of PTA with the complaint in each case (see Figure 3). The pattern of a hearing loss was concordant in 98.4% among those who had hearing impairment complaints ( $N = 62$  cases). Overall, the tested sample, the pattern of a hearing was concordant with the clinical status in 42.6% ( $N = 118$ ). New details about hearing level detected in 40.4% ( $N = 112$ ) case out of all cases.

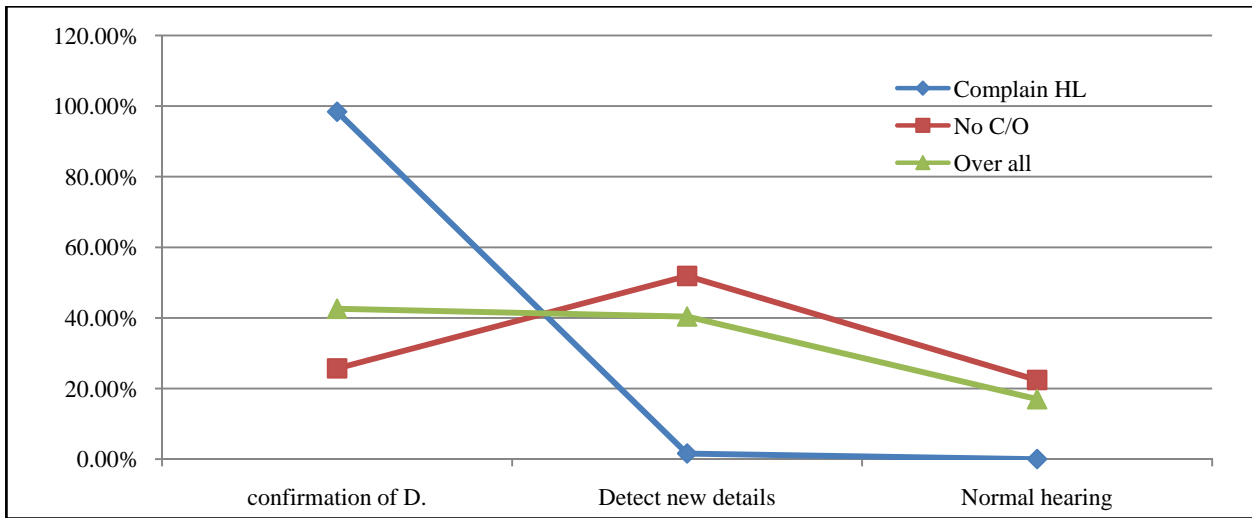


Figure 3. Mastering of PTA testing is proved as the PTA patterns matched the clinical status of different categories of patients.

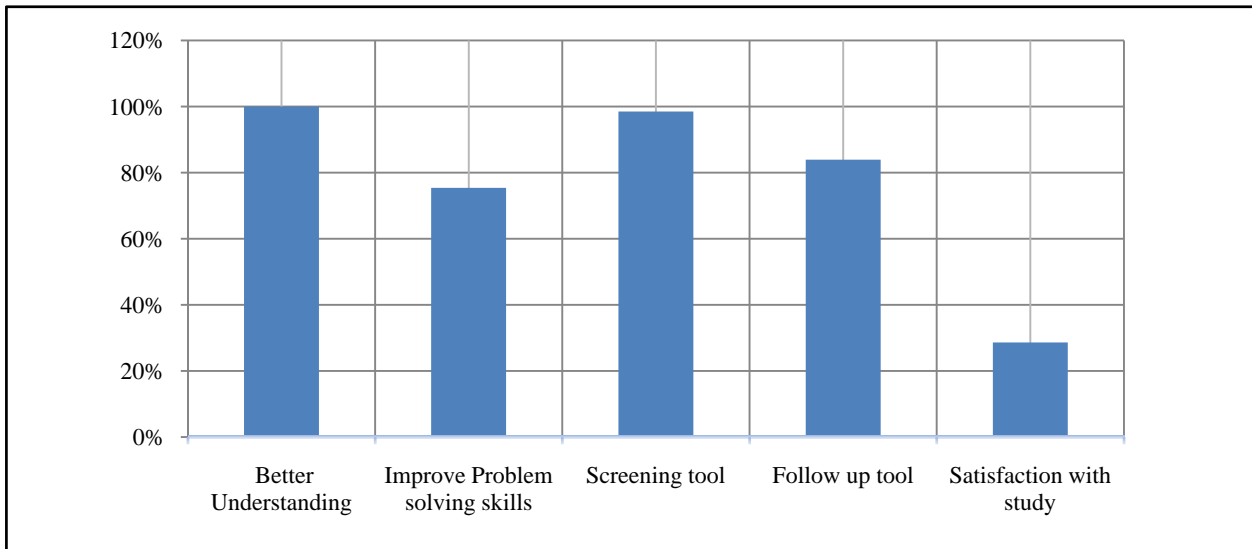


Figure 4. Analysis of students' feedback regarding APPs as educational and screening tool.

**The Clinical Reliability of the APPs**

The clinical reliability of the APPs is evaluated by correlating the clinical data collected by the students to the performed PTA. As shown in Figure 3, the PTA pattern of a hearing loss was concordant with the hearing impairment complaints in 98.4%. In addition, new details about the hearing pattern were detected in 1.6% of this group and in 51.9% of those who presented with different otological issues rather than hearing impairment.

In the category of elderly patients aged 60 and above, the APPs graphs confirmed the complaint of hearing loss in 37.5% of cases which is presbycusis (hearing impairment due to aging).

**The Students' Feedback on the APPs as an Educational Aid**

The students' feedback on the APPs as an educational aid is summarized in Figure 4. All students expressed that APPs helped them to get a clear understanding of PTA principles (Question 1). The majority of responders (75%) found it a helpful tool in solving the clinical problems they faced during the survey.

There is a high degree of concordance among the clinical reports and students' feedback. Table 2 shows the aspects of comparison which are the helpfulness of APPs in the understanding of PTA, assisting clinical problem solving, and finally, improving psychomotor skills by performing a clinical survey.

Table 2

*Comparison Between the Objective and Subjective Evaluation of APPs as an Educational Aid*

	Clinical reports analysis by researchers (Objective study )	Students' feedback (Subjective study, Figure 4)	Answer "Yes" (%)
Educational aid as a training platform	Overall 30% of cases had been satisfactory analyzed PTA (Figure 1).	Q 1. Are Apps helpful in understanding PTA?	100
	Overall, 30% of cases, APPs results satisfactory to solve the clinical problems (Table 1 and Figure 2).	Q 4. Does APPs support the diagnosis (help in problem-solving)?	75.4
Clinical value—a clinical tool	APPs as a diagnostic tool: APPs detected new findings in half of this category (Figure 3).	Q 2. Do APPs help in detecting new cases?	96.5
	APPs confirmed hearing loss complaint in 98.4% detected new details in 40.4% (Figure 3).	Q 7. Do you think helpful as a (screening tool)?	98.2

### Discussion

In this research, we addressed using smartphone APPs to improve teaching-learning of audiology course among the fourth year medical students. Satisfactorily, each student managed to examine seven cases in everyday places. That overcame the problem of short exposure time to the patients in the hospital setting. Also, the availability of downloaded APPs overcame the problem of unaffordability of expensive simulators in the teaching institute. This sort of clinical training enhanced the learning environment and encouraged deep learning (Cantillon & Wood, 2010).

The four folded aims of this study had been fulfilled after evaluating the clinical sheets and feedback forms.

Firstly, the APPs helped in improving the cognitive skills of the learners as they managed to describe and analyze a third of the cases in different surveyed categories as shown in Table 1. Also, APPs supported the students' skills in problem-solving for different clinical conditions by providing PTA data on the spot. This observation is concordance with the students' feedback on the fourth question, as three-quarters of students expressed that APPs supported their problem-solving skills (see Table 2).

Secondly, APPs promoted the students' psychomotor skills as they performed PTA on their own, which is a high grade of competence according to Miller's skills triangle (Harden, 2009). The evidence of improving this skill is proved by the compatibility between the PTA patterns and the clinical status (see Table 1 and Figure 2).

This result answers the third question about the clinical reliability of APPs as a standard teaching aid. This reliability of APPs makes it a valuable educational tool and a gadget for screening hearing impairment cases in remote areas.

The fourth objective of this study was to identify if APPs enhanced and motivated audiology study. The vast majority of students reported that APPs was beneficial in enhancing the learning process, only a quarter of students were satisfied with the research process (see Figure 4). We think that the workload and the busy schedule of students discouraged them from enjoying the extra research (Cantillon & Wood, 2010).

### Limitation

The relatively short time of posting and crowded schedule of students affected their performance in implementing the survey. It also limited the variety of clinical cases.

## Conclusion

The smartphone APPs is an excellent alternative platform for teaching-learning PTA for medical students. APPs affordability overcomes the problem of unavailability of the simulators and short period of face-to-face training. Generally speaking, the effectiveness of any APPs as an educational aid depends on its offline availability to be used any time anywhere. The reliability of the chosen APPs is crucial to avoid any misleading teaching. On the other hand, it is important to consider students workload and time frame to guarantee the proper implantation of this educational aid.

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