Smartphones as detector the speed of sound: A classroom explanation and demonstration

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Abstract. This paper presents how smartphones determine the speed of sound (C) with a classroom explanation and demonstration to design a variety of lab instruments. Smartphone sensors such as mics and speakers were used as experimental tools by students for calculating the value of speed of sound. Mathematics is used to describe physics principles using only the mean of repetitive experimental results. After conducting an experiment with 43 students, majoring in general science, faculty of education and educational innovation, Kalasin University, the students report the value of the speed of sound nearly to theoretical values with a percentage difference of less than 0.1%, equipment used in everyday life in the classroom, equipment that is cheap, along with a simple calculation of speed of sound, is an advantage of this experiment.

1. Introduction

In the realm of teaching sound waves in general physics, learners are enquired to participate in the practical laboratory of a resonance tube apparatus. Learners will able to understand of wavelength λ, the frequency of the sound wave f, and proficiency of computation in the speed of sound C. Regarding the Traditional resonance labs, have normally basic equipment which is involving a scale-mounted closed-end tube with adjustable pistons or fluids, speakers, and a variable-frequency amplifier, a tuning forks replace a sound source, a thermometer, and a microphone to measure the sound intensity level in decibels. According to Lab-based learning, learners gained positive performances in both scientific reasoning skill and practical skills [1-2]. Nevertheless, laboratories require exclusive lab instruments which is costly to cooperate with a research laboratory. The worthy instruments can generate the accuracy of the operating parameters on the resonance tube device.

In the aspect of the experimental laboratory, the resonance tube apparatus device used basic tools such as plastic bottles and common measuring instruments in the classroom [3]. Also, the smartphones performed as the detector equipment instead of trial laboratory session [4]. We found that the resonance tube apparatus device proved precisely accurate when compared to the related study [5-7] In addition, the standardized device can be applied to general science classrooms to enhance learners' interest in using costless equipment. The purpose aims to enhance and encourage learners' scientific reasoning abilities and practical skills. The study tends to propose a suitable method for applying syringe barrel replacement to the substitution of a closed tube. The microphones' sensors within smartphones are used to measure sound-intensity levels by application of The Decibel X (ios) Sound Meter (Android). Likewise, the speaker of the smartphone is mainly used as the sound source that can adjust the sound

frequency with the application f Generator (ios) Frequency Generator (Android). The results in a resonance tube revealed that it can be implemented in a general science classroom.

2. Experimental methods

2.1. Research objectives

To develop scientific reasoning skills and practical skills from the study of sound-speed detector.

2.2. Participants

The participants of the study were 43 undergraduate students, Bachelor of Education (General Science), Faculty of Education and Educational Innovation, Kalasin University. The applicants of the study who study general sciences course were being classified into 10 groups since the beginning of the semester.

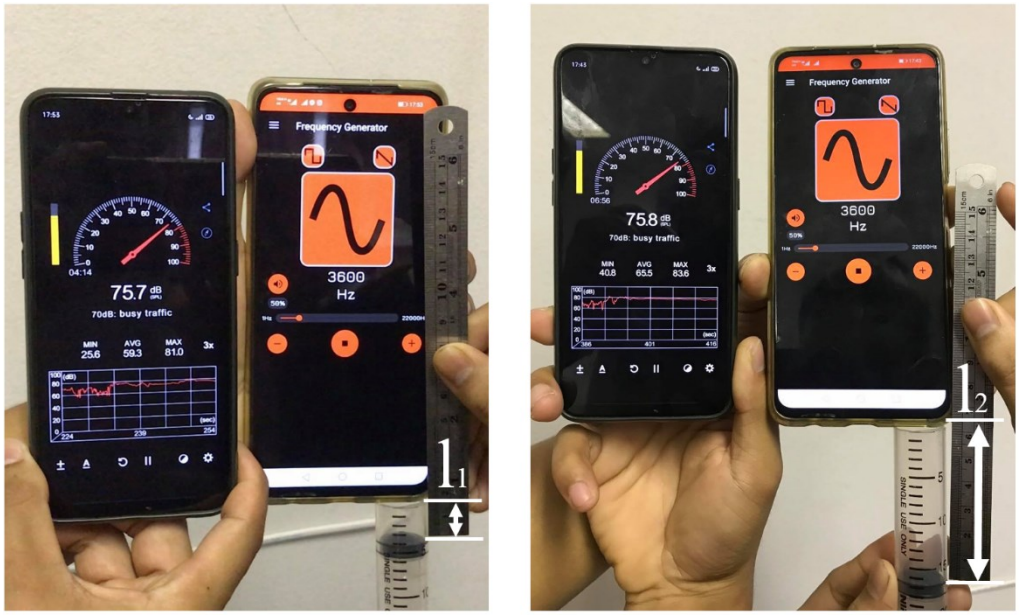
2.3. Experimental setup

Each of the groups were prepared the following equipments:

- The replacement of truncated syringe and syringe plunger use to interchange the substitution of a closed tube and the adaptable pistons respectively.
- The initial smartphones (speaker) use for generating the variable-frequency from sound source application.
- The second smartphones (microphone) use for measuring sound-intensity levels in decibels from sound measure application. The quiet classroom is needed for the experiment.
- In this research, a ruler was used as the equipment for measuring the length.
- Thermometer which is used for measuring the temperature of the room.

2.4. Recording of different lengths of syringe barrel from two nearby positions that measured the highest sound-intensity level

The participants organized the equipment which was included a truncated syringe and two smartphones (or tablets). Regarding different functions, smartphone was used for generating the frequency from sound source. Whereas, the other smartphone was used for measuring sound-intensity levels respectively. Meanwhile, participants prepared a thermometer in order to measure the room's temperature. The position of the smartphone was placed close to the mouthpiece of the syringe. The students pulled down the syringe plunger to locate the highest sound intensity level at the first position l_1, as shown in figure 1 (a). Owning to the sound waves moved along to the syringe barrel to encounter the piston, it was reflected by the standing wave amplitude. Then became zero at the surface of the piston. This point was called node where the sound waves reflected from the piston surface. At the same time, the sound wave reflected from the piston was phased shift by 180°. The reflection of either incoming waves or reflect waves was caused to generate a standing wave at the tip of the syringe barrel. In accordance, resonance conditions are met at the open end of the tube, the maximum amplitude of the standing sound wave was called anti-node. Similarly, students pulled down the syringe plunger to locate the position with the highest sound intensity in the second position l_2, as shown in figure 1 (b).



(a) (b)

Figure 1. (a) the first resonance position (b) the second resonance position.

2.5. Data analysis

From the study of general physics classroom, students have gained understandable precisely relationship of wavelength λ, the frequency of the sound wave f and speed of sound C according to the equation:

$$C = f\lambda \tag{1}$$

Regarding, the resonance condition, the anti-node at the open end of the tube has the maximum amplitude of a standing sound wave. The distance between the positions of the anti-node (Δl) is related to the sound wavelength of the sound source correspondingly, according to the equation:

$$\Delta l = (1/2)\lambda \tag{2}$$

Where Δl is the position between 1/4 wavelength position and 3/4 wavelength position. In other words, Δl is 1/2 wavelength. Consequently, equations (1) and (2), the speed of sound wave is defined by [3]

$$C = 2f\ (l_1 - l_2) \tag{3}$$

where l_1 and l_2 are the length of the syringe barrel for the first and second resonance respectively. When consider to the theory of the speed of sound upon the temperature, the speed of sound C is equal to the square root of the ratio of specific heats $\gamma = 1.4$ for air at STP, the gas constant $R = 8.314\ J/(mol \cdot K)$ for air, the molecular mass of gas $M = 29 \cdot 10^{-3}\ kg/mol$ and the temperature $T = 273.15 + °C$ [8] according to the equation:

$$C = sqrt[\gamma RT / M] \tag{4}$$

Here, T must be specified on an absolute scale.

3. Results

3.1. Student's scientific reasoning skills and student's practical skills

Students in each group were requested to analyze and comment on the likely range of temperature in the science classroom in Thailand. The experiment demonstrated that the greatest temperatures were commonly ranged from approximately 24-38 °C based on the regional area and the personal facilities used of the air conditioner in a greater number of classrooms learning. From the scientific learning

collaboration, all groups calculate the feasible speed of sound based on equation (4) theoretical. As presented in the illustration in table 1 includes the feasible speed of sound which was estimated range 344-353 m/s.

Table 1. The relationship of the speed of sound waves and range of temperature.

Temperatures (°C)	38	36	34	32	30	28	26	24
speed of sound (m/s)	352.9652	351.829	350.6891	349.5455	348.3981	347.247	346.092	344.9331

By the particular results, the explicit area of the temperature was ranged at approximately 24-38 °C. Most students were capable to calculate the applicable sound frequency for the experiment which was corresponded to the length of the syringe barrel. The results from students' opinions determined the frequency of the sound wave f in the range of 3-4 kHz. Because of the length of the largest syringe barrel, approximately 0.075 meters necessity be greater than the 3/4 wavelength that is the second resonant position. The reason is that the length of the largest syringe barrel, approximately 0.075 meters, must be greater than 3/4 wavelength where the second resonant position was taking place.

3.2. The result of the experiment of speed of sound

The result of the experiment of the speed of sound indicated that all students distributed the frequency of the sound waves to each group in the experiment session. The results of the experiment shown in table 2.

Table 2. The relationship of the velocity of sound, was calculated from the measurement results from frequency indicated 5 different frequency values from each group with 26 °C room temperature.

Group No.	Frequency (Hz)	Δl_{avg} (cm)	Speed of sound (m/s)
1 and 6	4,000	4.325	346.00
2 and 7	3,900	4.450	347.10
3 and 8	3,800	4.550	345.80
4 and 9	3,700	4.700	347.80
5 and 10	3,600	4.800	345.60
Speed of sound average			346.46

4. Discussion and conclusion

From the students' perspective of the relationship of parameters index of the equipment resonant experimental. Some positive pieces of evidence revealed that students gained the methodical study. To begin with the study, students examined the possible temperature values which were normally 24-38 °C for the general science classroom. Also, students analyzed and simulated the appropriate frequency within the Excel program that equivalent to the length of the syringe barrel, resulting in the frequency of the study in the range 3-4 kHz. In the following step, students were participated in calculating the speed of sound from the theoretical value according to equation (4) is 346.092 m/s. Later, students measured Δl of the syringe barrel in each frequency band and calculated the speed of sound value is 346.460 m/s. The computation indicated that the results differed from the theoretical value of 0.1%. Similar to development of scientific reasoning skills and student's practical skills [1-2] defined as those developed through the application of scientific principles, observation, manipulation and demonstration.

According to the results, the researcher and co-workers found that the scores of the Student's scientific reasoning skills and practical skills were 97% and 98% respectively. The consistency of the results was taken by consideration and students' experiment cooperation. Within the condition, if values of Δl accurate and measure temperature scale deeply on a more detailed scale. The results will be able to calculate the speed of sound exactly accurately. By the effective procedure and condition, students were classified into a group to find out and experiment with parameter index. In the aspects of enhancing

students' performance both scientific reasoning skills and practical skills, the instructor performed as the facilitator in the class such as setting conditions for the use of ready devices, encourage students by asking, analyzing, and discussing during the experiment. Moreover, small-group discussion can develop students in practical skills, and cooperative working [9]. All approaches aim to facilitate learners to understand the content and be able to implement a common device with the smartphone. In this experiment, the devices can be used as additional tools for other experiments either or demonstrate tools for learning in the scientific internship classroom teaching as well.

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