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Analysis of Sound Frequency on Guzheng Using Advanced Spectrum Analyzer Pro

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ABSTRACT
Physics learning about sound frequency will be more effective if equipped with practicum activities. This practicum activity can be done by linking it with a cultural because cultural values have the potential to be implemented in physics learning, such as musical instruments for sound frequency. As for the culture used in this research is the Guzheng. This research aims to analyzed of the Guzheng sound frequency, the comparison of the sound frequency to the prime tones, and the comparison of the sound frequency to the octave tones. The research type that was used is based on laboratory experiment with the aids of Advanced Spectrum Analyzer Pro application which is already installed in the smartphone to measure the sound frequency of 21 strings of Guzheng. The result of the analyzed showed that the longer of string so the sound frequency produced is the lower. As for of simple linear regression test showed that the sound frequency is linearly distributed to the prime tones and to the octave tones. The result of research can be applied in physics learning by conducting practicum activities and utilizing technology by the Advanced Spectrum Analyzer Pro application to measure the sound frequency both on musical instruments and on other objects that can make a sound.

INTRODUCTION

Physics is an experimental science that is used to discover the principles and patterns that relate to natural phenomena. This pattern of relations between theories is known as theoretical physics [1]. In addition, physics is not only studied through mastering collection of knowledge in the form of facts, principles, or concepts but also in the form of a discovery process obtained by knowing about phenomema nature systematically [2]. On of the studies of physics which is part of human life is sound. Sound is a series of waves that propagate from a source of vibration as a result changes in sound density and pressure [3]. Sound can be heard caused by the vibration of an object as a sound source which vibrates the surrounding air and propagate through the medium of air so that it reaches the ear. Sound that can be heard by humans are in the 20 Hz to 20 kHz [4] [5]. One of the

intermediaries for sound propagation is through musical instruments. Each musical instrument can make a sound and if it played in an integrated manner it will create a harmonious tones, one of it is the Guzheng from Chinese ethnic in Singkawang. The Guzheng can be used as a physics learning tool.

The method which is used of learning in school still emphasizes students on the aspect of receiving information which is the result of student activity being less in digging up information. This is because the teacher is the only source of learning and students only listen to the explanations given by the teacher, it causing students to not be able to ask and answer critically about physics concepts [6]. This is reinforced by a statement made by Rosdianto through a survey conducted of schools in Singkawang, it is known that around 33% of schools do less than twice of practicum activities per semester and about 65% of schools do not carried out practicum activities throughout the semester [7].

The existence of practicum activities can make students have an active role in physics learning. Practicum is a learning activity through understanding theory and practice that actively involves student. According to zainuddin said that through practicum activities students can practice skills, can apply and integrate their knowledge and skills, prove something scientifically, and can appreciate the knowledge and skills of inquiry [8]. Rustaman said that through practicum activities can provide learning experiences with a scientific approach to students because practicum learning teaches students to formulate problems, design experiments, use practicum tools, take measurements, interpret data acquisition, and make reports [9]. Therefore, which this research expected that students can be an active role in physics learning activities and can grow students' critical thinking skills so that physics learning becomes more meaningful learning. This can be done by linking physics learning with local culture.

As an embodiment, it can be started by studying the potential of any culture that can be used as a medium in learning physics. Culture and learning are two things that can't be separated because culture makes a big contribution to the learning process [10]. Local culture-based learning is the creation of a learning process by providing a learning experience that integrates local culture as part of the learning process [11]. The integration of a culture into learning is one of the strategies in developing students' thinking skills with a contextual approach that links the concepts to everyday life situations, this is can make students able to make connections between the knowledge they have and their application in life [12]. Local culture-based learning can provide a different learning experience for students. Students can understand the learning concepts and also get to know the local culture of their area. In line with development of technology, it is hoped that local culture will also be increasingly recognized by the younger generation, this can be done through innovative learning in schools. Innovative learning is needed in education so that local culture can be used as part of the learning process [13].

Based on the result of observation, it is found that the Guzheng is related to the concept of physics, but until now there hasn't research that explores the concept of physics on the Guzheng. Therefore, it is necessary to study futher the concepts of physics in the form of sound frequency on Guzheng.

The Guzheng is a traditional musical instrument that has a convex rectangular shape and is made of wood, there are spreads 21 strings which are toned to a pentatonic tone consisting of do, re, mi, sol, and la tone, then in the middle of the strings are placed grip that can be shifted to increase or decrease the tone frequency [14]. The strings have the repetition of the tones of the fives tone which are called octave. A tone has a frequency that is twice as large as the same tone in the next octave or has a frequency twice less than the same tone in the previous octave [15]. These tones are sounds that have a certain frequency. In accordance with Marsenne's Law said the factors that affect the sound frequency of a string are the length, the tension, and the density of the string [16].

The used of musical instruments in physics learning can motivated students to learn physics, such as the research by Wahyu et al which studied the effect of learning physics by integrating the music on students' enthusiasm and understanding of sound concept, the result is the teacher has succeeded in

increasinng students' understanding to participating in learning [17]. The learning method used has succeeded in increasing students' understanding pf sound physics and making lessons more interesting, fun, easy to remember, easy to understand, more motivating, and more memorable. The research by Anwar et al which investigated and analyzed the phenomena of the D_{mayor} chord on a guitar instrument, the result is that the D_{mayor} chord are composed by D3, A2, D4, dan Fis tone. This is because they all contain harmonic frequencies that match the sound frequency of the D_{mayor} chord [18]. The research by Hartanti & Astuti which measured the intensity of the sound produced by Angklung using Sound Level Meter software, the result is that the higher the frequency so the sound intensity produced is the greater [19]. The research by Trisnowati which determined the frequency of various Gong instruments, the result is that the larger of the Gong's diameter so the fundamental frequency produced is the smaller [20]. The research by Purwiyantini et al which investigated the frequency characteristics of the Rebana, the result is that the lower of the Rebana's frequency regularly as well as the sound intensity, that the larger of the Rebana's diameter so the sound intensity is decreasing regularly [21]. Futhermore, the research by Nurul & Mitrayana which analyzed the frequency of Gender Barung Laras Slendro, the result is that there are differences in the frequency of each part, that the smaller the resonator column so the sound frequency produced is the higher [22].

Based on the results of the research by these researchers, there is no research has been do on the Guzheng. Therefore, this research focus on analyzed the sound frequency contained in the 21 strings of the Guzheng. The measurement of sound frequency on Guzheng used the Advanced Spectrum Analyzer Pro application. The Advanced Spectrum Analyzer Pro apllication is a powerful real-time audio (RTA) tool for visualizing and analyzing signals from smartphone device microphones in the frequency domain [23]. The selected application in this research has gone through various considerations, namely (1) this application is available for free, so anyone can install this application; (2) this application is an application installed on a smartphone, considering that almost all students have their own smartphones, but not every student has a laptop/computer, so this is not an obstacle for students in learning; (3) there is no research that uses this application in research the sound frequency of Guzheng; and (4) this application is an application that is easy to obtain, easy to use, and easy to maintain.

This research aims to analyzed of the Guzheng sound frequency of each string, the comparison of the sound frequency to the prime tones, and the comparison of the sound frequency to the octave tones. With this research, students are expected to be able to take advantage of technology in the form of the Advanced Spectrum Analyzer Pro application to conducted practicums related to sound frequency in physics learning, so that the learning that occurred is more meaningful. In addition, with this research, students are expected to be able to help preserve the Guzheng which is one of the Chinese cultural heritages in Singkawang so that it remains known by the public.

METHOD

The type of research used in this research is laboratory research, used a tool in the form of the Advanced Spectrum Analyzer Pro application that is already installed on a smartphone to measured the sound frequency of the 21 strings on Guzheng. The independent variable is the 21 strings of the Guzheng, and the dependent variable is the sound frequency.

The data is taken by plucking the strings one by one so that each string produced sound and then the sound frequency is measured. The sound frequency measurement used the Advanced Spectrum Analyzer Pro application that is already installed on the smartphone. Each string is plucked 5 times in an experiment, then these data are calculated the average value and standard deviation. Figure 1 is a schematic of sound frequency measurement on Guzheng with Advanced Spectrum Analyzer Pro application.

Fig 1. *Design of Sound Frequency Measurement on Guzheng with Advanced Spectrum Analyzer Pro Application*

After obtained the value of the sound frequency on the 21 strings, then the data was analyzed. The data were analyzed using a simple linear regression test to test the comparison of sound frequency to prime tones, and comparison of sound frequency to octave tones. This regression test will display a graph of the sound frequency with the length of the strings whether linear or not.

RESULTS AND DISCUSSIONS

The Sound Frequency of Each String on the Guzheng
Based on the measurement of the sound frequency on each string, the average sound frequency data is obtained which is presented in Table 1.

Based on Table 1, the length of the strings is getting longer while the value of the sound frequency is getting smaller. The 1st string is the shortest string which has a length of (110 ± 0,05) cm where this string produced the highest sound frequency of 562 Hz. Meanwhile, the 21st string is the longest string which has a length of (136,1 ± 0,05) cm where this string produced the lowest sound frequency of 93 Hz.

Table 1. The Result of Measured the Sound Frequency of Each String

String	String Length (cm)	Tone	Average (Hz)
1	110 ± 0,05	C_5	562
2	110,3 ± 0,05	A_4	469
3	110,6 ± 0,05	G_4	431 ± 9,4
4	110,9 ± 0,05	F_4	413 ± 9,4
5	111,2 ± 0,05	D_4	328
6	111,8 ± 0,05	C_4	328
7	112,5 ± 0,05	A_3	281 ± 0,2
8	113,6 ± 0,05	G_3	281 ± 0,2
9	114,9 ± 0,05	F_3	244 ± 9,2
10	116,5 ± 0,05	D_3	243 ± 9,63
11	119,2 ± 0,05	C_3	188
12	122,2 ± 0,05	A_2	187 ± 0,24
13	125,6 ± 0,05	G_2	187 ± 0,2
14	128,8 ± 0,05	F_2	187
15	131,3 ± 0,05	D_2	186 ± 1,4
16	132,8 ± 0,05	C_2	140 ± 0,24
17	134,1 ± 0,05	A_1	140
18	135 ± 0,05	G_1	131 ± 9,2
19	135,5 ± 0,05	F_1	122 ± 11
20	135,9 ± 0,05	D_1	94
21	136,1 ± 0,05	C_1	93

Based on the data above, it showed that the longer the strings so the sound frequency produced is the lower, and the shorter the strings so the sound frequency produced is the higher. So it is proven that the length of the string is inversely proportional to the sound frequency on the Guzheng. This is reinforced by the theory of Berg which said that the sound frequency of the strings is inversely proportional to the length of the strings. It is also reinforced by the statement that the high and low of the tone depends on the length of the strings obtained when the strings are pressed and measured from the bottom string grip [16]. A string that has a shorter size means that the result tone is higher and vice versa [18].

The Comparison of the Sound Frequency to the Prime Tone on the Guzheng

In the Guzheng there are five basic tones, namely C, D, F, G, and A tone. Each tone have 4 strings, there tones can be grouped become prime tones. The tone group is then made in the form of a simple linear regression test graph using Microsoft Excel. The result of prime tones data processed are showed in Figure 2 to 6.

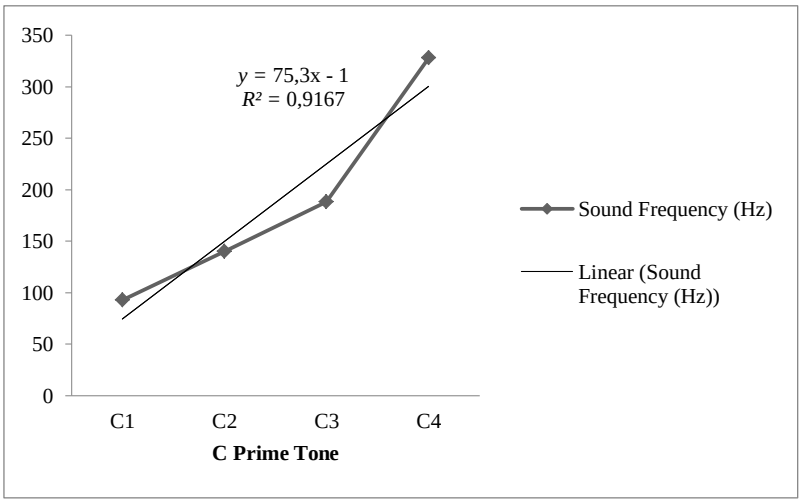

Fig 2. *The Graph Result of the Simple Linear Regression Test on the C Prime Tone*

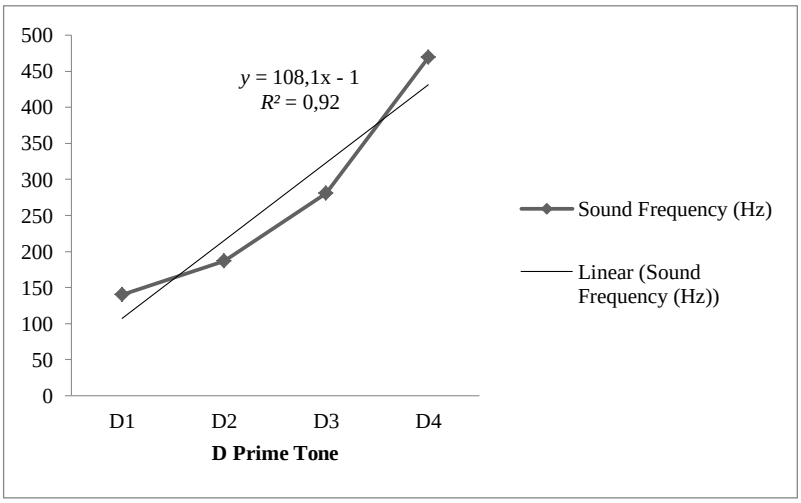

Fig 3. *The Graph Result of the Simple Linear Regression Test on the D Prime Tone*

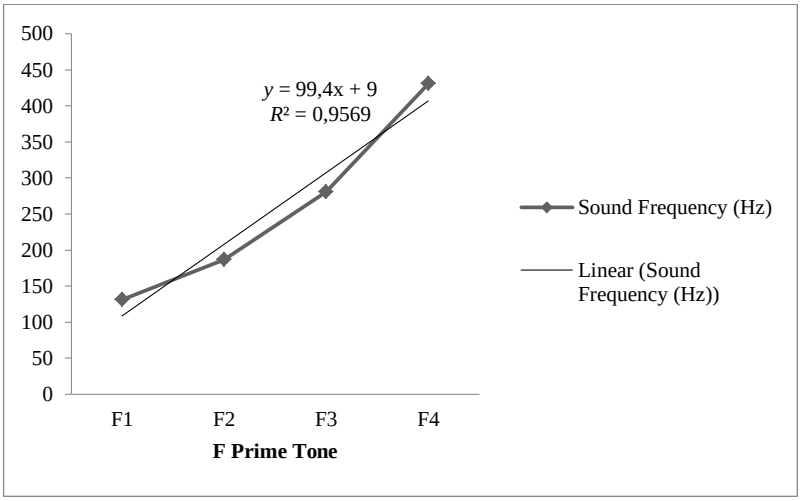

Fig 4. *The Graph Result of the Simple Linear Regression Test on the F Prime Tone*

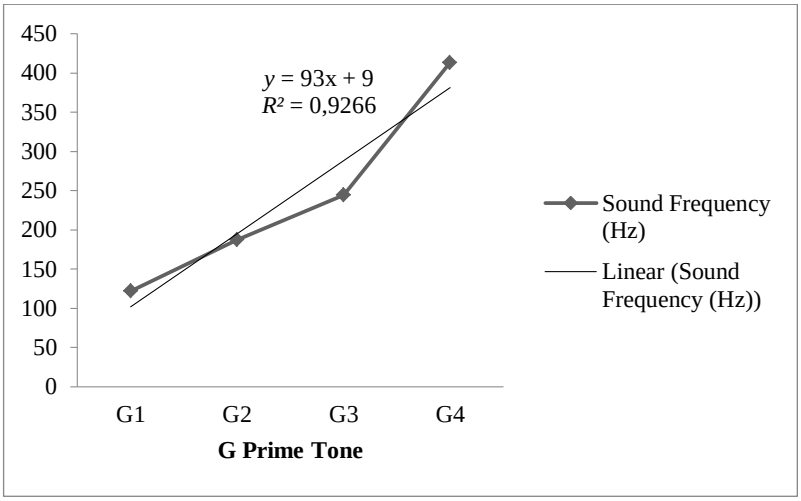

Fig 5. *The Graph Result of the Simple Linear Regression Test on the G Prime Tone*

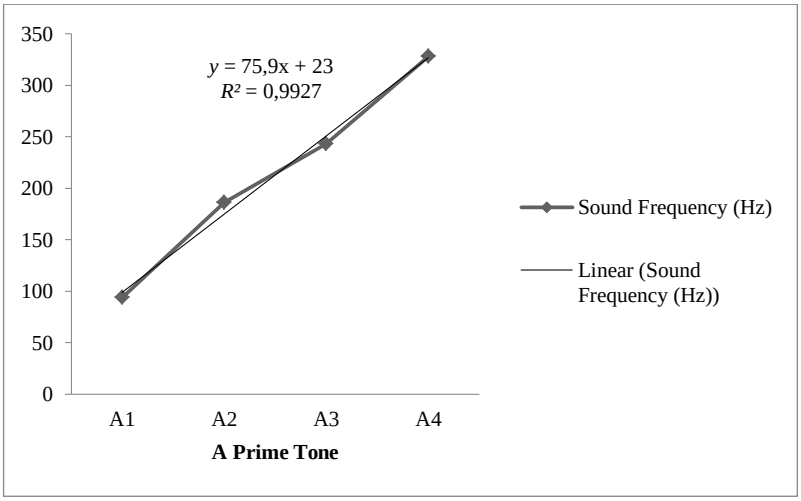

Fig 6. *The Graph Result of the Simple Linear Regression Test on the A Prime Tone*

The analyzed result of the simple linear regression test is showed that R^2 for each prime tone, namely the C prime tone with a value of R^2 = 0.9167, the D prime tone with a value of R^2 = 0.92, the F prime tone with a value of R^2 = 0.9569, the G prime tone with a value of R^2 = 0.9266, and the A prime tone with a value of R^2 = 0.9927. The R^2 value data showed that the analyzed result of the simple linear regression test on prime tones have a linear relation, so this indicated that the sound frequency in prime tones is linearly distributed, namely occurrence of an increase in the sound frequency along with the increase in the tone. So it can be stated that the increase in the sound frequency of the prime tones is in accordance with Marsenne's Law.

Next is the calculating of the comparison of the sound frequency on the prime tones. The comparison of the sound frequency on the prime tones is simplified so that the comparison of the sound frequency is obtained which is presented in Table 2 to 6.

Table 2. The Comparison Result of the Sound Frequency on the C Prime Tone

Prime Tone	**C_1**		**C_2**		**C_3**		**C_4**
Comparison	1.16	:	1.75	:	2.35	:	4.1

Table 3. The Comparison Result of the Sound Frequency on the D Prime Tone

Prime Tone	**D_1**		**D_2**		**D_3**		**D_4**
Comparison	1.75	:	2.34	:	3.51	:	5.86

Table 4. The Comparison Result of the Sound Frequency on the F Prime Tone

Prime Tone	**F_1**		**F_2**		**F_3**		**F_4**
Comparison	1.64	:	2.34	:	3.51	:	5.39

Table 5. The Comparison Result of the Sound Frequency on the G Prime Tone

Prime Tone	**G_1**		**G_2**		**G_3**		**G_4**
Comparison	1.53	:	2.34	:	3.05	:	5.16

Table 6. The Comparison Result of the Sound Frequency on the A Prime Tone

Prime Tone	**A_1**		**A_2**		**A_3**		**A_4**
Comparison	1.18	:	2.33	:	3.04	:	4.1

Based on Table 2 to 6, the comparison of the sound frequency on the C prime tone, D prime tone, F prime tone, G prime tone, and A prime tone showed the number that gradually increases the sound frequency, the meaning that the sound frequency in prime tones have a linear increase. This is showed that the comparison of sound frequency in prime tones is linearly distributed. Therefore, this research showed a linear relation between the strings of the prime tones. This is also reinforced by the music theory in accordance with the statement of the ancient Yunani's philosopher, Giancoli stated that the comparison of tones is the C, D, E, F, G, A, B, and C' tone have sound frequencies of 262 Hz, 294 Hz, 330 Hz, 349 Hz, 392 Hz, 440 Hz, 494 Hz, and 525 Hz [24].

Based on the order of the tones, in this research the form on prime tones is in each prime tone the sound frequency is increases according to the sequence. The C basic tone has the lowest sound frequency, the sound frequency increases to the E, F, G, A basic tone, and the highest sound frequency is at the B basic tone. The sound frequency of the Guzheng is in one tone level, the C basic tone has the lowest sound frequency, then the sound frequency increases in the D, F, G basic tone, and A basic

tone has the highest sound frequency. Therefore, the result of analyzed data is obtained that the relation between sound frequency and prime tones is linearly distributed. This means that these tones have a proportional increase in the sound frequency according to the basic tone level.

The Comparison of the Sound Frequency to the Octave Tone on the Guzheng

In the Guzheng there are five basic tones, namely C, D, F, G, and A, these tones have repetition so that they can be grouped into actave tones. The graph of the relation between the octave tones and the sound frequency is depicted in Figure 7 to 10.

The analyzed result of the simple linear regression test is showed that R^2 for each octave tone, namely the 1st octave tone with a value of $R^2 = 0.9278$, the 2nd octave tone with a value of $R^2 = 0.516$, the 3rd octave tone with a value of $R^2 = 0.8625$, and the 4th octave tone with a value of $R^2 = 0.9226$. The R^2 value data showed that the analyzed result of the simple linear regression test on octave tones have a linear relation, so this indicated that the sound frequency in octave tones is linearly distributed, namely occurrence of an increase in the sound frequency along with the increase in the tone. However, the 2nd and 3rd octave tone have the smaller R^2 value than other, this is happen due to external factors, namely the string tuning factor for the basic tone of the Guzheng may not be right, so the result of the sound frequency have a slight change from the basic tone.

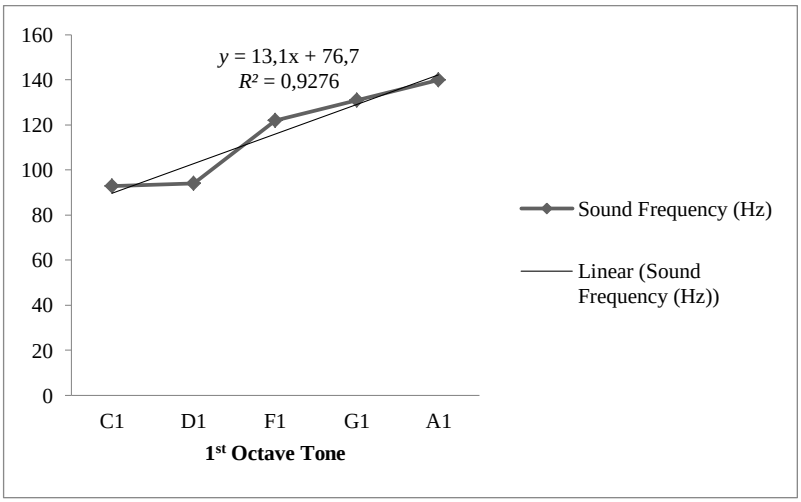

Fig 7. *The Graph Result of the Simple Linear Regression Test on the 1st Octave Tone*

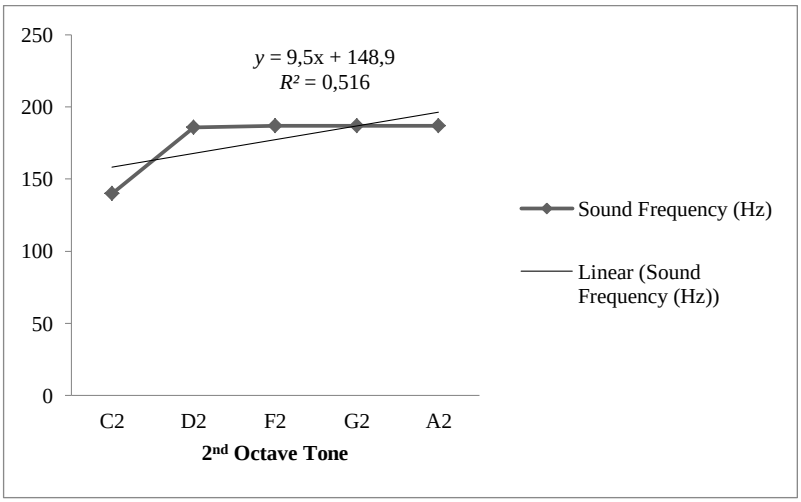

Fig 8. *The Graph Result of the Simple Linear Regression Test on the 2nd Octave Tone*

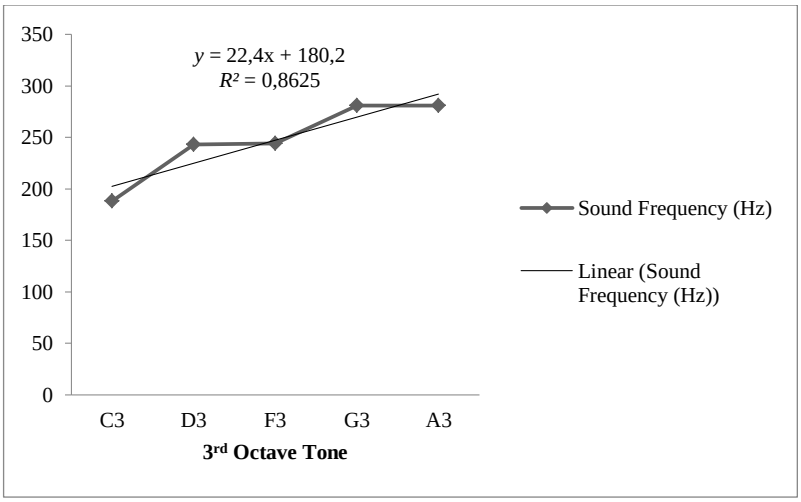

Fig 9. *The Graph Result of the Simple Linear Regression Test on the 3rd Octave Tone*

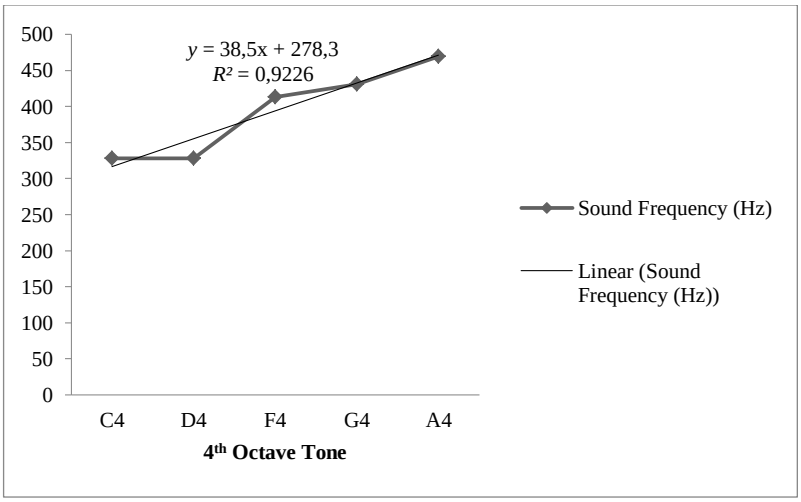

Fig 10. *The Graph Result of the Simple Linear Regression Test on the 4th Octave Tone*

Next is the calculating of the comparison of the sound frequency on the octave tones. The comparison of the sound frequency on the octave tones is simplified so that the comparison of the sound frequency is obtained which is presented in Table 7 to 10.

Table 7. The Comparison Result of the Sound Frequency on the 1st Octave Tone

Octave Tone	C_1		D_1		F_1		G_1		A_1
Comparison	1.16	:	1.18	:	1.53	:	1.64	:	1.75

Table 8. The Comparison Result of the Sound Frequency on the 1st Octave Tone

Octave Tone	C_2		D_2		F_2		G_2		A_2
Comparison	1.75	:	2.33	:	2.34	:	2.34	:	2.34

Table 9. The Comparison Result of the Sound Frequency on the 1st Octave Tone

Octave Tone	C_3		D_3		F_3		G_3		A_3
Comparison	2.35	:	3.04	:	3.05	:	3.51	:	3.51

Table 10. The Comparison Result of the Sound Frequency on the 1st Octave Tone

Octave Tone	C_4		D_4		F_4		G_4		A_4
Comparison	4.1	:	4.1	:	5.16	:	5.39	:	5.86

Based on Table 7 to 10, the comparison of the sound frequency on 1st octave tone, 2nd octave tone, 3rd octave tone, and 4th octave tone showed the number that gradually increases the sound frequency, the meaning that the sound frequency in octave tones have a linear increase. This showed that the comparison of sound frequency in octave tones is linearly distributed. Therefore, this research showed a linear relation between the strings of the octave tones. This is also reinforced by the music theory in accordance with the statement of the ancient Yunani's philosopher, Giancoli which stated that the comparison of tones is the C, D, E, F, G, A, B, and C' tone have sound frequencies of 262 Hz, 294 Hz, 330 Hz, 349 Hz, 392 Hz, 440 Hz, 494 Hz, and 525 Hz [24].

Based on the order of the tones, in this research the form on octave tones is in each octave tone the sound frequency is increases according to the level. In the statement above, it can be seen that C tone has a sound frequency of 256 Hz, the C' tone has a sound frequency of 524 Hz. This proves that the octave tone level has a higher sound frequency than the previous octave tone level. 1st octave tone has the lowest sound frequency, then increases to 2nd, 3rd, and 4th octave tone has the highest sound frequency. Therefore, the result of data analyzed obtained that the relation between sound frequency and octave tones is linearly distributed. This means that these tones have a proportional increase in the sound frequency according to the increase in level tones.

The succeeded of this reseaech showed that practicum activities are one of the solutions in physics learning so that learning become more meaningful and students can be actively involved in learning. This is reinforced by statement of Sudrajat which stated that learning process must be carried out interactively, inspiring, fun, challenging, motivating students to participate actively and providing sufficient space for creativity, and students independence in line with talents, interests, physical development, and psychology of students [25]. In addition, interactive and fun learning will make it easier for students to understand concepts in physics learning and can be an alternative for continuous physics learning [26] [27]. The practicum activities can also train the students to learn collaboratively so that smart students can become tutors for other students. The collaborative learning with peer tutors in practicum activities has an important role in the learning process because it can develop critical and rational thinking in students, can foster cooperation between students, and students can learn to respect each other [28]. In addition, practicum activities in physics learning can also make learning that occurs more effective. This is because physics learning that is carried out through practicum can train various skills that can provide direct experience for students in building and designing their own knowledge [29]. Therefore, will no longer feel bored and bored in learning of physics. Students will become more active, interactive, and collaborative during learning activities and the knowledge conveyed by the teacher is more evenly distributed and comprehensive for all students.

CONCLUSION AND SUGGESTION

Based on the analyzed on the Guzheng, it is can be concluded that the sound frequency of the each string showed that there is an affect of the length of the string on the sound frequency where the longer the string so the sound frequency is the lower, and vise verse. This showed that the length of the strings in inversely proportional to the sound frequency on the Guzheng. The prime tones make the sound frequency with a linear graph. The relation between prime tones and sound frequency is directly proportional where the higher of the basic tone level, the higher of the sound frequency. This showed that the comparison of the sound frequency to the prime tones on the Guzheng is linearly distributed. The octave tones also make sound frequency with a linear graph. The relation between octave tones and sound frequency is directly proportional where the higher of the octave tone level, the higher of the sound frequency. This showed that the comparison of the sound frequency to the octave tones on the Guzheng is linearly distributed. This research is a research related to strings, so it is advisable to pay attention to the tuning of the basic tone of each string so that is matches the sound frequency of the basic tone and try to measure the sound in a place that is closed from outside noise interference.

REFERENCES

[1] Young, H., & Freedman, R. A. (2001). *Fisika Universitas Jilid 2 Edisi Kesepuluh*. Jakarta: Erlangga.

[2] Zulfiani. (2009). *Ilmu Pengetahuan Alam*. Jakarta: Ditjen Pendidikan Islam Departemen Agama Republik Indonesia.

[3] Soeripto. (2008). *Higiene Industri*. Jakarta: Balai Penerbit FKUI.

[4] Yasid, A., & Yushardi, Y. (2017). Pengaruh Frekuensi Gelombang Bunyi Terhadap Perilaku Lalat Rumah (Musca Domestica). *Jurnal Pembelajaran Fisika*, *5*(2): 190-196.

[5] Soedojo. (2004). *Fisika Dasar*. Yogyakarta: CV Andi Offset.

[6] Malik, A., Oktaviani, V., Handayani, W., & Chusni, M. M. (2017). Penerapan model process oriented guided inquiry learning (POGIL) untuk meningkatkan keterampilan berpikir kritis peserta didik. *Jurnal Penelitian & Pengembangan Pendidikan Fisika*, *3*(2): 127-136.

[7] Rosdianto, H. (2018). Rancang bangun alat praktikum gerak jatuh bebas dengan stopwatch otomatis sederhana. *JIPF (Jurnal Ilmu Pendidikan Fisika)*, *3*(1): 20-23.

[8] Nisa, U. M. (2017). Metode Praktikum untuk Meningkatkan Pemahaman dan Hasil Belajar Siswa Kelas V MI YPPI 1945 Babat pada Materi Zat Tunggal dan Campuran. In *Proceeding Biology Education Conference: Biology, Science, Enviromental, and Learning* (Vol. 15, No. 1, pp. 62-68).

[9] Candra, R., & Hidayati, D. (2020). Penerapan Praktikum dalam Meningkatkan Keterampilan Proses dan Kerja Peserta Didik di Laboratorium IPA. *Edugama: Jurnal Kependidikan dan Sosial Keagamaan*, *6*(1): 26-37.

[10] Kuswana, W. S. (2013). *Taksonomi Berpikir*. Bandung: PT Remaja Rosdakarya.

[11] Pieter, J. (2017). Pembelajaran ipa berbasis kearifan lokal sebagai solusi pengajaran ipa di daerah pedalaman provinsi papua. *On line at https://www.researchgate.net*, 1-11.

[12] Wisudawati, A. W., Sulistyowati, E. (2014). *Metodologi Pembelajaran IPA*. Jakarta: Bumi Aksara.

[13] Suastra, I. W. (2010). Model Pembelajaran Sains Berbasis Budaya Lokal Untuk Mengembangkan Potensi Dasar Sains dan Nilai Kearifan Lokal di SMP. *Jurnal Pendidikan dan Pengajaran*, *43*(1).

[14] Zou, L. (2005). *What is Guzheng*. https://guzhengmaster.com/what-is-guzheng.

[15] Kurnia, A. (2011). *Penala nada alat musik menggunakan alihragam fourier*. Semarang; Universitas Diponegoro.

[16] Berg, R. E. (2018). *Sound Physics*. https://www.britannica/science/sound-physics.

[17] Waluyo, K. A., Noviandini, D., & Sudjito, D. N. (2016). "Konser Fisika": Pembelajaran Fisika Dengan Mengintegrasikan Seni Musik Menggunakan Gitar Akustik, Zelscope, Dan Lagu Fisika

Pada Materi Bunyi. *UPEJ Unnes Physics Education Journal*, *5*(1).
[18] Anwar, K., Isnaini, M., & Utami, L. S. (2014). Analisis Akord Dmayor Pada Alat Musik Gitar Acoustik. *Jurnal Fisika Idonesia*, *18*(54): 77-81.
[19] Hartanti, R. S., & Astuti, B. (2017). Analysis of Angklung Sound Intensity as a Acoustic Instrument. *Journal Of Natural Sciences And Mathematics Research*, *2*(1): 122-126.
[20] Trisnowati, E. (2017). Analisis Frekuensi Pada Gong Laras Slendro. *Indonesian Journal of Science and Education*, *1*(1): 30-35.
[21] Purwiyantini, Y., Aji, M. P., & Sulhadi, S. (2016, October). Analisis Akustik Alat Musik Rebana. In *Prosiding Seminar Nasional Fisika (E-Journal)* (Vol. 5, pp. SNF2016-CIP).
[22] Nuzul, S. N., & Mitrayana, M. Pengukuran Frekuensi Gender Barung Laras Slendro Menggunakan Perangkat Lunak SpectraPlus. *Jurnal Fisika Indonesia*, *20*(1): 14-18.
[23] Czaplejewics, W. (2017). *Advanced Spectrum Analyzer Pro*. https://play.google.com/store/apps.
[24] Ishafit, I., Anwar, K., & Toifur, M. (2008, January). Pengukuran Frekuensi Tangga Nada Instrumen Musik Dengan Sistem Microcomputer Based Laboratory. In *Prosiding Seminar Nasional Sains dan Pendidikan Sains* (pp. D2-1). Fakultas Sains dan Matematka Universitas Kristen Satya Wacana.
[25] Sudrajat. (2009). *Pengertian Pendekatan, Strategi, Metode, Teknik dan Model Pembelajaran*. Bandung: Sinar Baru Algensindo.
[26] [26] Rosdianto, H., & Murdani, E. (2017). Implementasi Model Pembelajaran Poe (Predict Observe Explain) Untuk Meningkatkan Pemahaman Konsep Siswa Pada Materi Hukum Newton. *Jurnal Pendidikan Fisika*, *6*(1): 55–58.
[27] Murdani, E., & Sumarli, S. (2019, February). Student learning by experiment method for analyzing the dynamic electrical circuit and its application in daily life. In *Journal of Physics: Conference Series* (Vol. 1153, No. 1, p. 012119). IOP Publishing.
[28] Sumarli, S., Nugroho, S. E., & Yulianti, I. (2018). Keefektifan Model Pembelajaran Creative Problem Solving Berpendekatan Inquiry terhadap Keterampilan Proses Sains Siswa. *Physics Communication*, *2*(1): 63-69.
[29] Sumarli, S., & Murdani, E. (2014). Model pembelajaran kolaboratif dengan tutor sebaya pada pokok bahasan rangkaian seri-paralel hambatan listrik. *Jurnal Riset dan Kajian Pendidikan Fisika*, *1*(2): 42.