
Enabling Students to Learn scientific methods through Spreadsheet

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Abstract: Spreadsheet programs are enormously flexible, familiar, and relatively easy to use. Commonly, spreadsheets are used in business, technique, and education. Spreadsheets are widely used in various disciplines of education to simulate phenomena in order to solve problems. In traditional simulation using spreadsheet, the students asked to change certain parameters to visualize a mathematical relationship to get the concept. Consequently, students become passive in the learning process in classroom. Whereas, in science, the students just not only need to understand the concept, they also expected to know how to get the concept. It is argued in this paper that spreadsheets could also be used to enable students to learn scientific methods, including: the importance of model building, the relationships among variables in a model or models, and how to use a model to predict outcomes. By using a constructivist approach, students asked to make a supposition and test it using spreadsheet. The students could be required to investigate an open-ended problem with the help of hand out. Based on this research, it can be concluded that students motivated to participate in the class. Besides that, students can learn more in depth used scientific methods.

Keywords: spreadsheets, learn, scientific.

1 INTRODUCTION

Science learning should use the scientific method which generally includes a series of activities of collecting data through observation, process data, analysis and formulation and test hypotheses. Therefore, the teacher should: Foster a sense of wonder, encourage observation, push for analysis and require communication. Aiken (2013) argues that the most effective way to teach science is to have students learn the practices of a professional scientist. students should be trained in various skills of scientists such as defining the problem, model building, planning and conducting investigations, analyzing and interpreting data, using mathematical and computational thinking and constructing explanations and designing solutions with convincing reasons. Spreadsheets have frequently been used in mathematics classes to calculate quantitative relationships in various chemistry and physics classes. Brown et al (2006) argue that using spreadsheet to help students generate and test hypotheses is an effective learning strategy.

Halat and Peker (2011) argue that by using spreadsheet, the students can answer a variety of questions based on one problem and see the relationships among the variables as number change. In computation learning with spreadsheet, it should be contextual so the students can understand what they learn, the problems from the concept, the application of the concepts, and the way to solve the problems (Abramovich and Leonov,2009; Galina et al ,2010).

The use of spreadsheet to solve a problem requires higher thinking, for example in analyzing a problem to make a decision. In such condition, students must make a microworld to generate and test the hypotheses. In this term, spreadsheet is known as mindstool that shows the use of technolog Constructivist approaches to help students construct their own knowledge rather than having the teacher interpret the microworld. So, the use of computers to support learning, students should learn with the computer, not learn from the computer (Jonassen: 1998)

Baker (2003) argues that the use of spreadsheets can help the students between 10-11 years old to understand the concept of beat by using a simple mathematical equation (a periodic function). To use of simulation techniques in the classroom, students only need to operate the scrollbars that allow students to interact socially and to develop the understanding and representation of a concept by selecting the appropriate graph, then interpret the graph. Karakirik (2015) argues that the use of spreadsheets with macros and open-ended question enables students to make a hypothesis and test the hypothesis using a computer.

For physics, scientific approach cannot always be done procedurally. Many physics concepts are difficult to practice because of the difficulty of the tool, the difficulty of observation and the dangers that can arise if practiced directly. In this condition, instructional media especially those based ICT can be used by teachers to help students in observing, associating, questioning, and experimenting.

The use of spreadsheets should be able to help students learn the scientific method. The students should learn using computer, instead of learning from the computer. Therefore, to use spreadsheets in physics learning, students need to test the hypothesis by creating their own mathematical simulation in a microworld with the help of the activities that have been prepared by teacher (open-ended problem). In this article we'll show how to use a spreadsheet to help the students in learning the scientific method.

2 LITERATURE REVIEW

Beat is the periodic variation in amplitude at a given point due to the superposition of two waves having slightly different frequencies. When the two waves are observed at the point of superposition, they are periodically in and out of phase. That is, there is a *temporal* (time) alternation between constructive and destructive interference. For example, if two tuning forks of slightly different frequencies are struck, one hears a sound of periodically varying amplitude. The number of amplitude maxima one hears per second, or the *beat frequency*, equals the difference in frequency between the two sources. If two sound waves of equal amplitude travels through a medium with slightly different frequencies f_1 and f_2 . The equations to represent

the wave functions for these two waves at a point $x = 0$ are

$$y_1 = A \cos 2\pi f_1 t \quad \dots(1)$$

$$y_2 = A \cos 2\pi f_2 t \quad \dots(2)$$

Using the superposition principle, the resultant wave function is

$$y = y_1 + y_2 = A (\cos 2\pi f_1 t + \cos 2\pi f_2 t) \quad \dots(3)$$

The trigonometric identity

$$\cos P + \cos Q = 2 \cos \frac{P-Q}{2} \cos \frac{P+Q}{2}$$

The expression for y can be written as

$$y = \left[2 A \cos 2\pi \left(\frac{f_1 - f_2}{2} \right) t \right] \cos 2\pi \left(\frac{f_1 + f_2}{2} \right) t \quad \dots(4)$$

From equation (4), it can be concluded that the resultant sound for a listener standing at any given point has an effective frequency equal to the average frequency $\bar{f} = \frac{f_1 + f_2}{2}$ and an amplitude given by the expression in the square brackets:

$$2 A \cos 2\pi \left(\frac{f_1 - f_2}{2} \right) t.$$

That is, the amplitude and therefore the intensity of the resultant sound vary in time. A maximum in the amplitude of the resultant sound wave is detected whenever

$$\cos 2\pi \left(\frac{f_1 - f_2}{2} \right) t = \pm 1$$

This means there are *two* maxima in each period of the resultant wave. Because the amplitude varies with frequency as $(f_1 - f_2)/2$, the number of beats per second, or the beat frequency f_{beat} , is twice this value.

Based on the equation (1) to (4), the beat phenomenon can be explained by a mathematical approach. To determine the solution of the equation (3) as in equation (4), it takes quite difficult mathematical ability, and not every student is able to solve the equation correctly. In order to explain equation (4), the students need high abstraction ability. In this paper, we argued that with the help of a spreadsheet, students not need to solve the equation (3) to describe beat phenomenon. In accordance with the scientific method, students are shown the beat phenomena by striking two tuning forks with slightly different frequencies simultaneously. The students were asked to explain what they heard. By using open-ended questions, students were asked to solve the problem with the following activities:

- 1) Identify the problem: students were asked to identify the beat phenomenon and the parameter of beat phenomenon.
- 2) Make a hypothesis: students were asked to make a mathematical model the beat phenomenon then generate the hypothesis.
- 3) Conduct the experiment: the students were asked to write the mathematical model in the spreadsheet, then writing the parameters and fill the desired parameters value, Making table calculations and creating graphs.
- 4) Analyze the data: students were asked to change the value of the parameter and then observing the effect to another parameter.
- 5) Make conclusion: students were asked to make conclusion.

The beat phenomenon is depicted more by table 1, table 2, graph 1, and graph 2.

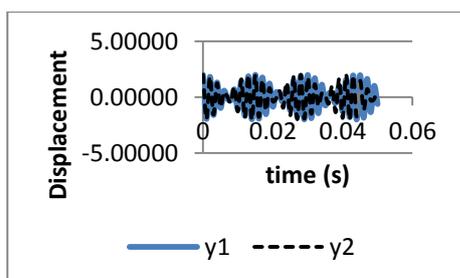
Table 1 Parameters the beat phenomenon

Parameter	Value	Unit
A1		unit
A2		unit
f_1		Hz
f_2		Hz
to		
Δt		S

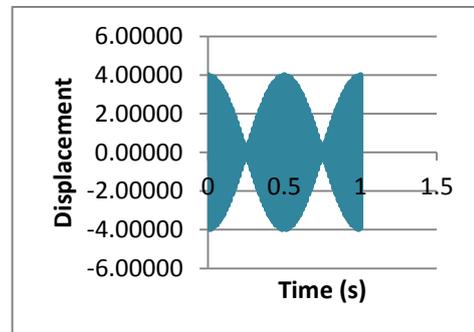
In this article, the beat phenomenon occurred at amplitude are 2 unit, $f_1=534$ Hz and $f_2 = 536$ Hz

Table 2 Displacement each wave and the superposition

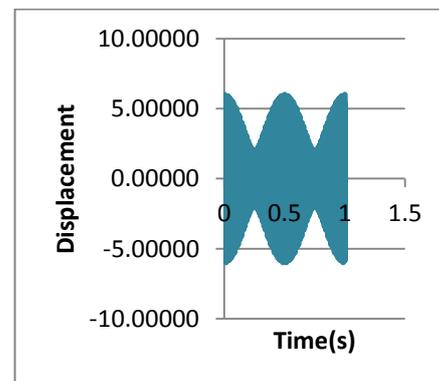
T	y1	y2	y1+y2
0	2.00000	2.00000	4.00000
0.001	-1.95454	-1.94905	-3.90359
0.002	1.82021	1.79881	3.61902
0.003	-1.60313	-1.55692	-3.16006
...



Graph 1. Displacement versus time two waves with a frequency of 534 Hz and 536 Hz with amplitude of 2 units within time $t = 0.05$ s



Graph 2. Displacement versus time of superposition two waves with a frequencies of 534 Hz and 536 Hz with amplitude 2 units within time $t = 1$ s



Graph 3. Displacement versus time of superposition two waves with frequencies 534 Hz and 536 Hz and amplitude 2 and 4 unit

3. STUDENTS'S FEEDBACK

In the class, the learning process is started by showing the beat phenomenon by striking two tuning fork of slightly different frequencies to help students identify the beat phenomenon and build the mathematical model. Some students were able to find the resultant by using the superposition principle, but they have not been able to explain the concept correctly. By using spreadsheet simulation, it is showed that only by using equation (1), (2) and (3) the students were able to describe the beat phenomenon without using equation (4). With the parameters shown in table 1, simulated data in table 2 and the graph, the students can investigate the effect of parameter changes to other parameters. In contrast to the simulation

made by baker (2003) which only shows beat phenomenon, we argued that if students have studied mechanical waves, by supporting spreadsheet simulation, they will be able to investigate the effect of the variation of amplitude and frequency in beat phenomenon.

Based on the interview to the student, we argue that if students can create their own spreadsheet simulation, their spirit to explore the simulation to test the hypothesis increases. Some students said that "I was surprised, it was not as complicated as I thought, the spreadsheet is helpful to solve physics problems only using a simple mathematical calculation". The other student said that "In my mind, the scientific method is difficult because it must be done in a laboratory, with the help of spreadsheet, it helps me to investigate the effect of changing the value of a parameter to another parameter, my motivation to learn increases, and my concept about physics increases too." The results of the interview is in line with Blecha (2013), the use of spreadsheet simulation has been providing alternative way to help students learn the scientific method as the model building, the relationship between variables in the model, and use the model to answer the hypothesis.

4. CONCLUSION

Spreadsheets are said to have the potential of solving almost any problem involving numbers or formulas, and are very powerful for manipulating the data repetitively. Just using a basic mathematical function and using standard spreadsheet functions and guide containing open-ended questions, students are able to develop simulations and solve problems through spreadsheets. We argued, spreadsheet as an alternative way to help students learn the scientific method, especially in model building, the relationship between variables in the model, and using the model to answer the hypothesis. In addition, using spreadsheet will increase motivation and participation of students and the meaning of the students will also increase.

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