

Researchable Question

How does integrating sonification into a lesson about Joint and Combined Variation influence student comprehension?

Hypothesis

Integrating sonification into a lesson about Joint and Combined Variation will improve student comprehension, especially for students that are auditory learners.

Purpose

My project aims to improve STEM education by using sonification as a tool to improve student understanding. Joint and Combined Variation is a topic where applying sonification is natural because the subject describes relationships between many variables which are difficult to exemplify visually. In addition, the impact of integrating sonification into education has not been widely examined, nor has the influence of sonification in lessons on auditory learners who may benefit the most from sonifications due to their learning style.

Learning Styles

- There are multiple different learning style models, but one of the most important ones is the Visual-Auditory-Kinesthetic learning styles model, which is based on student response and interpretation of external stimuli [1].
- Visual learners learn best through visual stimuli.
- Auditory learners learn best through the sounds they hear.
- Kinesthetic learners learn best through exploring the world around them.

What Is Sonification?

- Sonification is the process of representing data using sound, often for the purposes of interpreting the data [2].
 - Sonification is often used to provide audio feedback in cases when alternatives or enhancements to visual feedback are desired or can be more helpful [2].
- Audification involves directly mapping a data stream to pressure versus time graphs.
- Parameter mapping is more complex and involves the mapping of data to certain auditory dimensions such as timbre, volume, pitch, duration, and time.
- Model-based sonification attempts to control properties of sound that are associated with physical properties.
- Bonebright et al. found that sonified graphs which mapped two dimensional data to time and fundamental frequency (pitch) could be matched to their visual counterparts with fair accuracy by students with no background in sonification [3].
 - There have not been many actual applications in education.
- Sonification Sandbox is a java-based program with parameter-mapping capabilities built for non-professional use.

Materials

- Sonification Software – Sonification Sandbox
- Excel 365 was used to generate data and Power Point was for the lesson
- Video software – Flashback Express and VSDC Free Video Editor
- VAK Learning Styles Survey from businessballs.com [4]
- Google Forms web application
- Touchscreen laptop with an external monitor and a stylus
- Standard headphone and microphone headset
- Post-Test, Pre-Test, Background Survey (made by me)

Making the Lesson

I created a presentation in Power Point 365 which includes a sonification of an example relationship with joint or combined variation. Then I recorded myself presenting it using screen-recording software (Flashback Express) and a standard microphone headset. My laptop has touchscreen capabilities which allowed me to write on the screen as I present. For editing software I used VSDC Free Video Editor. I also made a copy of the lesson that did not include sonification, which served as a “standard” lesson.

Testing

In order to test the lessons I will send them to middle school and high school students. I will send a Google Form that contains a background survey, a learning styles survey, a pre-test, either the lesson with sonification or the lesson without sonification, and a post-test. I will then put data based on improvement in a database along with data on background and learning style. The pre-test and post-test used in the study are shown below.

Results

Though I currently have no results from testing yet, some of the materials to be used in the form are shown below.

The variables I will consider are before and after test scores which give improvement, and how improvement varies over different groups which have seen the two different variants of the lessons, have different learning styles, or have different experience levels.

Sources of Error could come from the lessons being too different to be comparable, but I addressed this by making the lessons almost identical except for a little additional content in the sonification lesson.

Data Analysis

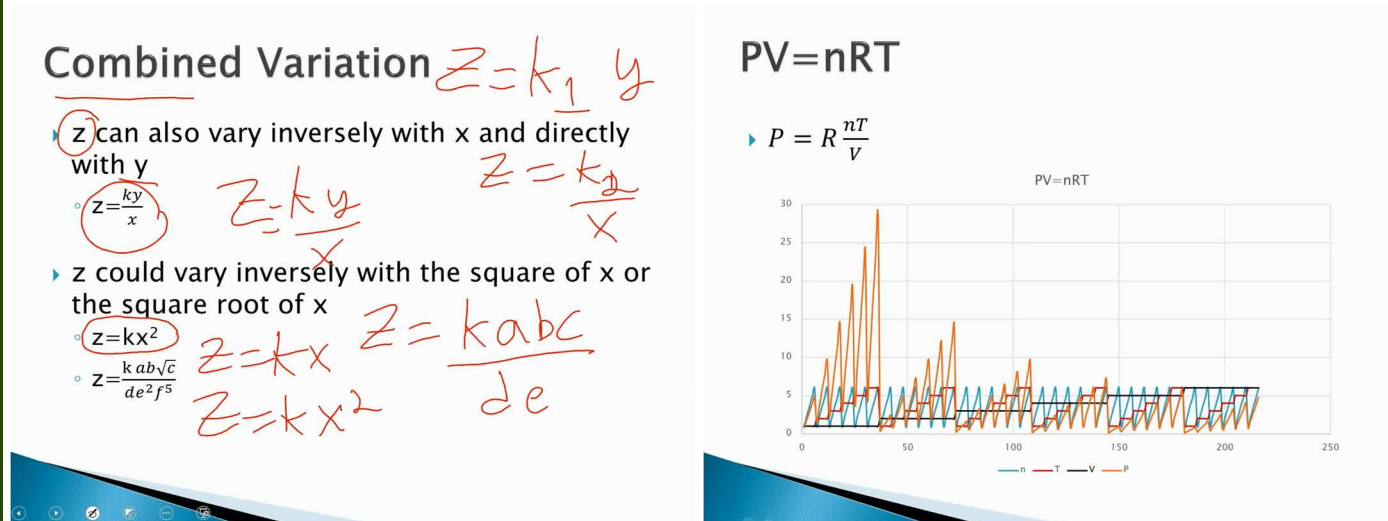
I will analyze improvement between participants that take the form with the sonification lesson and without the sonification lesson to find the influence of sonification on student comprehension. I will also check to see how the influence of sonification changes if I restrict the population to only visual learners, only auditory learners, or only kinesthetic learners, or if I restrict the population to students with the same or similar backgrounds to see how background affects the influence of sonification. This way I could determine whether a musical background is helpful or required to benefit from sonification and which how learning style affects the effectiveness of sonification in improving education.

Future Work

First I must finish the current stages of my project, and to do this I need to do a lot of testing and analyzing of data, as outlined in the sections above. Once I finish all the current stages of my project, I will try adding different sonifications to see what kind of sonification is most helpful for students. I could also vary different combinations of visuals and sonifications to try and find a method that is helpful for a wide range of learners.

Lesson

Figure 1. Lesson Screenshots



These are two screenshots of a sample slide from my lesson and a graph used for the lesson.

Timeline

Figure 3. Timeline

Month	October				November					December				January					February	
Week	1	2	3	4	5/1	2	3	4	5	1	2	3	4	1	2	3	4	5	1	2
Saturday	6	13	20	27	3	10	17	24	1	8	15	22	29	5	12	19	26	2	9	16
	Project Proposal			Paper Work Started 23		Paper Work Complete 12					December Fair 11 (tue)	Vacation						End Data Collection 31 (thu)		February Fair 13 (Wed)
	Background Research		Safe Paper Work		Record, Edit, Finalize Lesson		Addendum		Analyze Data						Buffer		Practice			
			Lesson Without Sonification		Add Sonification		Lesson with Forms together		Finalize Form		Collect Data									
					Test Sonification Program		Find People to Survey		STEM Paper and Poster											
							Visual Version of Lesson				Make changes to lesson if necessary									

This is the general timeline for my project, represented as a Gantt chart.

Survey and Test

Figure 2. Survey and Test

QUESTIONSRESPONSES

Background

Form description

How often do you listen to music?

12345

Never☐ ☐ ☐ ☐ ☐ All the time

Do you play/have you played at least one musical instrument?

☐ Never

☐ In the past, casually

☐ In the past, seriously

☐ Currently, casually

☐ Currently, seriously

Do you sing/have you sung?

☐ Never

☐ For fun

☐ Formally (individually)

☐ Formally (in a group and/or individually)

Have you learned music theory?

☐ None/Never

☐ A little/Not in a serious setting

☐ Yes, in a serious setting

What grade are you in?

☐ Freshman

☐ Sophomore

☐ Junior

☐ Senior or above

☐ 8th grade

☐ 7th grade

Pre-Test

Note: These problems present purely fictional scenarios. Please try your best but do not reference any external materials, including other sections of this form. Data collected is anonymous, so it does not matter how well you do as long as you try your best.

1. Billy and his friends work at the button factory, and the number of buttons Billy makes is directly proportional to the number of hours he works. If Billy makes 10 buttons in 2 hours, how many buttons does he make in 5 hours?

☐ 50 buttons

☐ 25 buttons

☐ 2 buttons

☐ 10 buttons

2. Shelly and her friends work at the shoe factory, and the number of workers making buttons is inversely proportional to the number of hours they work. If 2 workers work for 8 hours to complete a day's work, how long does it take 4 workers to complete a day's work?

☐ 16 hours

☐ 6 hours

☐ 4 hours

☐ 8 hours

3. Molly and her friends work at the marble factory, and the number of marbles produced varies jointly as the number of workers and the number of hours they work. If 2 workers make 48 marbles in 6 hours, how many marbles to 3 workers make in 8 hours?

☐ 96 marbles

☐ 11 marbles

☐ 64 marbles

☐ 384 marbles

4. The motivation of Bob to make snowballs is directly proportional with the number of cubic units of snow within a 1 mile radius of him and inversely proportional with the number of people within a 1 mile radius (they are potential rivals). If Bob has a motivation of 200 when there are 80 cubic units of snow and there are 4 people nearby, how many people are nearby if Bob has a motivation 90 with 81 cubic units of snow in the vicinity?

☐ 10 people

☐ 9 people

☐ 8 people

☐ 7 people

Above is a screenshot of a section of the background survey and a screenshot of a part of the pre-test. The post-test is very similar to the pre-test.

Joint and Combined Variation

- Describe relationships between many variables that each vary directly and inversely with each other.
- Since there are 3 or more variables involved, visual graphs are often not ideal for presenting joint and combined variation.
 - Sonification could be used for a more intuitive depiction of joint and combined variation.

Hear The Voices

Of The Graphs:

Integrating Sonification

Into A Lesson On

Joint and Combined

Variation

References

- [1] Deeb, B., & Hassan, Z. B. (2011). Towards Designing Elearning Materials based on Multi Learners Styles. *International Journal of Computer Applications*, 26(3), 7-10. doi:10.5120/3086-4225
- [2] Hermann, T., Hunt, A., & Neuhoff, J. G. (2011). *The Sonification Handbook*. Berlin: Logos Verlag.
- [3] Bonebright, T. L., Nees, M. A., Connerley, T. T., & McCain, G. R. (2001). Testing the effectiveness of sonified graphs for education: A programmatic research project. Georgia Institute of Technology.
- [4] Chislett, V. (n.d.). VAK learning styles test. Retrieved November 24, 2018, from <https://www.businessballs.com/self-awareness/vak-learning-styles/>