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K8 MEMES: K-8 Maritime Education Modules to Engage Students

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Prepared by:

Gary S. Prinz, PhD, PE (Project PI)

Department of Civil Engineering,
University of Arkansas, Fayetteville,
4190 Bell Engineering Center,
Fayetteville AR, 72701

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University of Arkansas
4190 Bell Engineering Center
Fayetteville, AR 72701
479-575-6021

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Introduction

This education development project focused on creating entertainingly engaging (entergaging), informative, and STEM-promoting "plug-and-play" curriculum learning modules for K-8 educators, using maritime transportation and infrastructure related topics to teach STEM concepts. Coupling music memory, fun STEM theories, and innovative experiential demonstrations into entertaining video learning modules, the project focused on opening the door for student excitement in learning of science topics and helping develop a new virtual learning paradigm that: 1) excites curiosity, 2) expands alternative cognitive processes, and 3) promotes future engagement in the STEM areas.

Scientific concepts and topics are exciting, interesting, and extremely powerful; however, our teaching and explaining of the subjects can often fail to express these described qualities. Research shows that learning a difficult subject takes persistence and dedication, both of which increase as self-interest in the subject increases [1]. Unfortunately, typical scientific communication for disseminating knowledge involves a "lecture" approach wherein the learning student can get bored and uninterested in the topic merely due its presentation. While some researchers have attempted to increase student interest using new-age tools ("virtual reality" [2], etc.), "actual reality" can already be amazing enough to inspire interest if portrayed to students in its proper context. The late Nobel Prize winning physicist Richard Feynman recognized the separation between the interesting scientific subjects and how they are portrayed in society when he said: "*Is no one inspired by our present picture of the universe? Our poets do not write about it; our artists do not try to portray this remarkable thing. The value of science remains unsung by singers: you are reduced to hearing not a song or poem, but an evening lecture about it. This is not yet a scientific age"* [3]. Examples of successful television shows produced with the goal of educating in an entertaining way do exist (i.e. Bill Nye The Science Guy, The Magic School bus, Cosmos, etc.), and lessons learned from such programs may help inform future developments in self-guided online video learning.

As our engineering challenges grow in complexity, understanding of scientific concepts at a fundamental level will be required, and a responsibility to ignite interest in scientific topics will fall on early k-8 STEM education. While consequences of the 2020 global pandemic have highlighted the need for flexible education platforms capable of promoting self-learning during "online/virtual" delivery mechanisms, these platforms often fall short in the promotion of STEM fields at the K-8 level. Put bluntly, existing online/virtual learning curricula are boring and can make STEM topics unappealing during the foundational education years. Educators need STEM-promoting learning modules that aren't boring, that can capture attention, relay information, inspire interest, and evaluate understanding in a virtual learning environment with increased distractions. A past survey during the Department of Civil Engineering Freshman Engineering Orientation found that most students identified their interest in engineering at the elementary grade level. The current project describes the development of educational tools (video learning modules) produced in a manner that promotes engagement while teaching fundamental STEM topics in an entertaining way (driving interest). The video learning modules created in this project are specifically tailored to merge with existing K-8 curricula at various grade levels, incorporate maritime transportation themes, and have the potential to influence future participation in the STEM fields.

This education development project created entertaining, informative, and STEM-promoting learning modules for K-8 educators, using maritime transportation and infrastructure related topics to teach important STEM concepts. Coupling music memory, engaging STEM theories, and innovative experiential demonstrations into entertaining video learning modules, the project developed a new virtual learning paradigm that: 1) excites curiosity, 2) engages alternative cognitive processes in elementary aged children, and 3) promotes future engagement in the STEM areas. A total of three entertaining video learning modules were produced within the scope of this project. Individual learning modules include interesting examples and exciting problems related to maritime transportation infrastructure (lock gate functions, material fatigue, and material elastic behavior).

The following sections describe the developed learning modules and their implementation in a case-study at the elementary grade level.

K-8 Learning Modules

The learning modules were designed specifically for keeping students interest locked on the screen while delivering factual fundamentals related to science/engineering topics. As an example, the Hooke's Law teaching module was broken down into an Experiential Learning segment followed by a concept-reinforcing Music/Singalong Segment; while the other learning modules focused mainly on the music/singalong informative format (with hands on experiments designed for classroom instruction). The following sections provide examples of the different learning segments from the video modules.

Student Entergagement through Experiential Learning Segment (Hooke's Law)

To excite and entertain students regarding the topic of study, popular culture references (i.e. *The Insight Zone,* rather than the popular TV series *The Twilight Zone*, etc.) were used alongside factual descriptions of STEM topics to promote engagement. Additionally, informative experiments were developed to highlight STEM concepts, while being presented in an enthusiastic way as to maintain engagement. Figure 1 shows a snapshot of the Hooke's Law module introduction filmed in the style of the early black-and-white *Twilight Zone* introductions, while Figure 2 shows a clip from a video experiment on the different behaviors of springs when arranged in parallel and series. Additional clips to keep the students engaged and informed involved a public service announcement (PSA) commercial cutaway discussing structural engineering, springs, and architecture (see Figure 3). The entergaging learning module also included a segment in the style of the nature show "The Crocodile Hunter," wherein an excitable naturalist is hunting springs and gets excited about their elastic behavior (see Figure 4).

Figure 1. Clips from module introduction in the style of the Rod Serling "Twilight Zone" series.

(a) (b)

Figure 2. Demonstration of spring behavior when arranged in (a) parallel and (b) series

Figure 3. Structural engineering public service announcement (PSA) commercial

Figure 4. “Spring Hunter” edutainment segment: hunting for elastic springs in the wild.

Student Entergagement through Music/Singalong Segments

To engage the students in an active learning process, portions of the learning modules involve music/singalong activities containing informative lyrics and even choreography. The following sections present the music components for the three individual topics covered in the learning modules.

Waterway Designs

To aid in educating students on the importance of our inland waterway infrastructure, song lyrics on the topic of waterway lock gates were developed, recorded, and edited within the learning module. Figure 5 shows a clip from the music video segment and the following are the song lyrics (set to the tune of '*9 to 5'* by Dolly Parton).

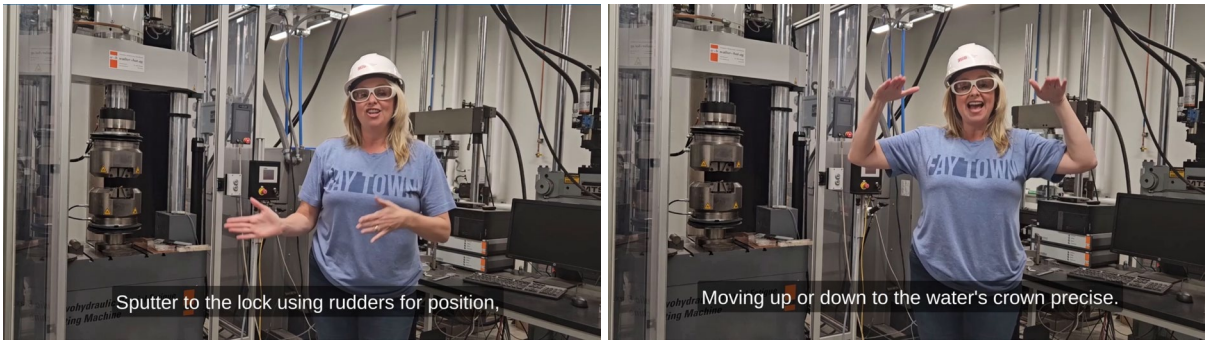

Figure 5. Clip from the learning module music video segment on "Waterway Designs" where Mrs. Hapgood teachings both the song lyrics and associated choreography.

Lyrics:

Sputter to the lock using rudders for position
Locks provide that water transition
Moving up or down to the water's crown, precise.

Pump in the water and the boat starts jumpin'
Pump out the water the level starts slumpin'
Getting ships past dams on rivers by design.

Waterway designs, reduce delays when you are shipping
We can redefine elevations for dam skipping
Locks will recombine locations of river edit
Big enough to drive your barge through, if you let it!

Waterway designs, the lock gates close in all around you
If it feels confined, there's no other way to pass through
Want to move ahead, but that's a dam and not a jetty?
Don't you worry, locks are at the ready!

In rivers and streams we've got boat ladders
They're lock gates and for shipping they matter
So we've got teams to ensure they stay okay.

The Corps of Engineers are a lock's best friend
They help ensure your ship can come in
To cross that dam and sail right on your way!

Waterway designs, reduce delays when you are shipping

We can redefine elevations for dam skipping
Locks will recombine locations of river edit
Big enough to drive your barge through, if you let it!

Waterway designs, the lock gates close in all around you
If it feels confined, there's no other way to pass through
Want to move ahead, but that's a dam and not a jetty?
Don't you worry, locks are at the ready!
In rivers and streams we've got boat ladders
They're lock gates and for shipping they matter
So we've got teams to ensure they stay okay.

Fatigue

To aid in educating students on the topic of material fatigue and it's in role in the design of our infrastructure, song lyrics on the topic of high- and low-cycle fatigue were developed, recorded, and edited within the learning module. Figure 6 shows a clip from the music video segment and the following are the song lyrics (set to the tune of '*Happy'* by Pharell).

Figure 6. Clip from the learning module music video segment on "Fatigue"

Lyrics:

It might seem crazy what I'm 'bout to say…
Repeated loads can create a break

When uh, physical strength slowly decays…
At low stress, cracks can progress, and it's got a name.

We call it FATIGUE
When cracks grow 'caus they feel large amounts of repeated stress

We call it FATIGUE
When cracks grow 'caus they feel concentrations of load excess

We call it FATIGUE
When cracks grow 'caus they feel distortions that are complex

We call it FATIGUE
When cracks grow 'caus they feel tip forces that just don't compress

Repeated loads can also be extreme…
If loaded well past yield, it's a new regime

Micro-voids grow quickly into cracks so fine
And we call it fatigue when they combine
Here's why!

We call it FATIGUE
When cracks grow 'caus they feel large amounts of repeated stress

We call it FATIGUE
When cracks grow 'caus they feel concentrations of load excess

We call it FATIGUE
When cracks grow 'caus they feel distortions that are complex

We call it FATIGUE
When cracks grow 'caus they feel tip forces that just don't compress

Bring stress down, just make the crack tip round
Stress level's too high, so bring it down

Bring stress down, just make the crack tip round
Stress level's too high, so bring it down

Bring stress down, just make the crack tip round
Stress level's too high, so bring it down

Bring stress down, just make the crack tip round
Stress level's too high, so bring it down

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We call it FATIGUE
When cracks grow 'caus they feel distortions that are complex

We call it FATIGUE
When cracks grow 'caus they feel tip forces that just don't compress

Spring-Spring

To aid in educating students on the topic of material stiffness and it's in role in the design of our waterway infrastructure, song lyrics on the topic of Hooke's Law (relating spring forces with their deformations) which forms the basis for all material behavior were developed, recorded, and edited within the learning module discussed earlier. Figure 7 shows a clip from the music video segment and the following are the song lyrics (set to the tune of '*Bang Bang'* by Ariana Grande).

Figure 7. Clip from the learning module music video segment on Hooke's Law, titled "Spring Spring"

Lyrics:

Springs got behavior that we learn in class
Stretch times the stiffness equals force applied
Springs got behavior that just bounces back
Elas-tic movement that we can derive (oh)
(You've been waiting for that)
(Stop, hold up, Spring is flat)

If a spring lecture seems bo-ring to you,
You need this science song to fill your mind, yeah

Spring Spring elastic assumed (it bounces back yo)
Spring Spring no work is consumed (that's conservation)
Force-displacement, yeah we can compare
Force-displacement, and a, whatttttt?!

Spring Spring put in the force (I know you feel it)
Stretch Stretch is pro-por-tion-al (you know its constant)
Wait a minute, I've got more to share
Wait a minute, and I'll, ahhhh!

You might have pushed or pulled a spring in school
But I'm a show you how to calculate

Just how much stretch you can ex-pect to gain
When you be pulling on e-las-tic springs, ya

Just - divide - force - by - stiff (nesss)
Then – you – are – left – with - stretch

F over K can help predict the stretch
Spring force displacement is well defined

Spring Spring elastic assumed (it bounce back yo)
Spring Spring no work is consumed (that's conservation)
Force-displacement, yeah we can compare
Force-displacement, and a, whatttttt?!

Spring Spring put in the force (I know you feel it)
Stretch Stretch is pro-por-tion-al (I know the constant)
Wait a minute, I've got more to share
Wait a minute, and I'll, ahhhh!

Its larynx vibrato
Its stretchy gelato
It's Hooke's old motto
It's oh, oh

Hittin' space with the RATO
Lack of learnin' be pasado
Calcin' stiffness super simple not compli-cado

Learnin' so good
Springs all understood
Hooke's law be the real-deal fo-sho

There's no denyin' it
Tests be supplyin' it
Spring stiffness we applyin' it, tryin' it
Applications be vari
Sus-pen-sions on Ferraris
Coiled cords on ataris
If you confused then I'm sorry
These springs hangin' we sangin'
Calculations be bangin'
Aint no scenario right that you can't be out here springin'

Oh

S to the PR, to the IN, to the G, to the, uh!

S to the PR, to the IN, to the G, heeeey!

If a spring lecture seems bo-ring to you,
You need this science song to fill your mind, yeah

Spring Spring elastic assumed (it bounce back yo)
Spring Spring no work is consumed (that's conservation)
Force-displacement, yeah we can compare
Force-displacement, and a, whatttttt?!

Spring Spring put in the force (I know you feel it)
Stretch Stretch is pro-por-tion-al (I know the constant)
Wait a minute, I've got more to share
Wait a minute, and I'll, ahhhh!

Spring Spring elastic assumed (it bounces back yo)
Spring Spring no work is consumed (that's conservation)

Yo I said,
Spring, Spring,
Spring, Spring, Spra-Spring, Spring
Spring, Spring, Spring
Spring, Spring, Spra-Spring, Spring

Spring Spring put in the force (I know you feel it)
Stretch Stretch is pro-por-tion-al (I know the constant)
Wait a minute, I've got more to share
Wait a minute, and I'll, ahhhh!

Implementation of Learning Modules in the Elemenatary Classroom

To implement the concepts from the learning modules into elementary classroom curriculum, a test case was conducted at Root Elementary. In the test case, students were taught the three learning module topics (Waterway Designs, Fatigue, and Hooke's Law) through experimentation and music memory. These classroom topic discussions occurred outside of the regular science class, and were instead delivered during the music class instruction time. Following the experiential learning, songs and choreography were taught.

This coupled science and music learning culminated in a student performance (delivered during a school assembly and separately to the community) titled a "Root Elementary School STEMusical" (see the marquee used for the program and the set design in Figure 8). This involved the students memorizing and delivering a script that described (in a fun way) the science facts they had learned. In addition to the three core learning modules developed for this project, the STEMusical included additional science songs on the topics of Newton's Laws, Vibrations, and Enery. Note that due to the speed of the Hooke's Law song, it was not selected for presentation by the students in the STEMusical. The following section presents the developed STEMusical script and Figure 9 shows clips of the resulting student musical performance.

[Show Intro]

- Hello, ladies and gentlemen! We're sooo excited you're here with us today/tonight.
- Our performance STEMs from a collaboration between science and music.
- By the way, STEM stands for Science, Technology, Engineering,… "and MUSIC!" *(said by all kids)*
- The learning and rhymes are about to flow
- and your knowledge is about to grow.

- We begin tonight by navigating the science of our inland waterways.
- Did you know that boats use water elevators to help them get over dams so they can keep shipping?
- Totally! The water elevators are called Locks.
- Just one of the many amazing waterway designs

Sing [Waterway Designs]

- We're now going to crack you up
- By singing about material science and the process of fracture
- With repeated stress
- *[Student 1: Hey my mom has that!]*
- Cracks can grow in almost any material
- We call it FATIGUE!

Sing [Fatigue]

- We're now going to send some far out sounds your way… and exciting your little ear hairs with our good vibrations!
- *[Student 1: "Don't be silly!"]*
- *[Student 2: It's not silly, it's cilia! Those little hairs help us hear!"]*
- Our next song is all about the vibrations all around us!

Sing [Good Vibrations]

- Some laws are made by governments. Other laws are just natural.
- Newton discovered a few!
- [Student 1: *"Hey I know him, isn't he that cookie guy?"*]
- No, not Fig Newton, Sir Isaac Newton!
- He's the one that said when you kick a ball, the ball kicks you back equally!
- In 1686 he caused quite a commotion with his three laws of motion.

Sing [Newton's Laws]

- The atmosphere here tonight has been electric!
- Before you head home to recharge, we want to share what we've learned about our fourth-grade science objective. It's all about energy!

- *[Student 1: "Energy…I know about that! In fact, I'm always told I have way too much of it!"]*
- Don't worry if you're feeling drained, your energy isn't lost, it's just transformed.
- And we're about to transform it back!
- Because our rhymes are poetic and the topic is kinetic!

Sing [Electr-on]

Figure 8. Root Elementary STEMusical marquee and stage design with participating students

Figure 9. Students performing in the STEMusical

Conclusion

This education development project focused on creating informative and engaging learning modules for STEM topics, including those pertaining to our national inland waterway infrastructure. A total of three entergaging (both entertaining and engaging) video learning modules were created. Application of the learning modules through in-class instruction and sing-along time resulted in the performance of a STEMusical at Root Elementary School in Fayetteville Arkansas.

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