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# Speak Loudly and Carry a Small Stick: Applying Classicle Sticks Across the Engineering Curriculum

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# Speak Loudly and Carry a Small Stick:
# Applying Classicle Sticks Across the Engineering Curriculum


## Abstract

A game played in some middle-school classrooms had been adapted for engineering lecture courses with 15-45 students and is described in detail in Classicle Sticks: An Activity to Improve Student Engagement. It was named Classicle Sticks in homage to Popsicle ® sticks, as the sticks form the basis of this student engagement activity. In this follow-on, the Classicle Stick activity was implemented in a total of ive engineering courses at Texas State University in Electrical Engineering and Engineering Technology. In addition to gathering more data regarding the effectiveness of the activity, a second Likert survey was created and administered to a subset of the students polled a year ago. Approximately half (15/27) of the students in Linear Control Systems were introduced to Classicle Sticks a year ago in Electronics-1. In addition to continuing to probe effectiveness, this second survey addresses stress and other factors associated with the activity. It is hypothesized that students who were exposed to the activity a year ago will experience less stress associated with being randomly called upon than their classmates who have not engaged in this activity. It is also hypothesized that the study habits of students who experienced the activity improved. This paper provides new engineering educators with a classroom management tool that is simple to implement and helpful to engage students in class lectures. Finally, a set of activity extensions as proposed by students is presented.


## Introduction

A student engagement activity using craft sticks in middle school classrooms was modified for college use and described previously [1]. It was named Classicle Sticks in recognition of Popsicle® sticks. Sticks are imprinted with one of several elements: a student name, a Wild Card, or the instructor's name. More potential categories are discussed later in this article. A question is asked, a stick is drawn, the question is repeated, and the student is expected to attempt to answer the question. The activity encourages every student to think about the questions, as they cannot rely on that one or two students who volunteer to answer every question. Throughout the semester it gives each student the opportunity to answer multiple questions and facilitates the checking of understanding across the class.

## Background

Education literature has shown the importance of checking understanding of a topic in the teaching environment [2], [3]. This check-in can be done in many different ways. Some research has established the relationship between student engagement and learning [4]. This relationship between the student and the teacher can have a positive effect on the student's learning [5]. In the k-12 learning environment, a wide range of techniques have been used to engage with students. Their applicability to the college engineering learning environment is not clear for some techniques. This study looks at the use of popsicle stick activity [6], [7] used in the middle

school environment in a college classroom teaching engineering topics. Previous use of popsicle sticks in the engineering classroom has primarily focused use of their physical properties and use as building resources [8], [9]. In Felder and Brent's guide to effective STEM instruction, they stressed the importance on calling on students by name (after a five second pause) rather than taking volunteers for this understanding check [10]. The popsicle stick activity works as a randomizer for calling on students. The addition of the instructor and Wild Card sticks is intended to add a sense of playfulness to the technique as playful, active learning shows links to higher student interest [11].

Description of the Classicle Sticks activity

The activity is outlined in this section and described in greater detail in [1]. In summary, the activity was designed to increase student engagement, make the class more interesting, and permit the instructor to check understanding for a wider range of students.

The instructor procures a set of hobby sticks (thus the name Classicle Sticks in homage to Popsicle Sticks®) and three containers. The containers are labeled NEXT, DONE, and ABSENT, or some variation of these terms. Three different categories of sticks are created. The first set is produced by the students who print their name on a stick in the manner of how they wish to be addressed. Daniyar, for example, preferred to be addressed as Dan. This was shown anecdotally to help the instructor learn student names more quickly.

The remaining two categories are sized according to the number of students in the class. One set has the instructor's name printed on the sticks and the other set is labeled WILD CARD. The ratio of these sticks to the number of students attending the class is set by the instructor. A higher ratio makes for more lively activity. One of us used a ratio of 1:5 corresponding to six sticks in each of these two categories for a class size of 30 students.

In general, the activity begins with the instructor posing a question, randomly drawing a stick from the NEXT container, announcing the name of the student whose stick was drawn, then repeating the question. Other variations may be implemented such as saying, "talk with your neighbor about [question topic] and in [5 second, 20 seconds, etc.] I'll call on someone to answer." When called upon, the student is expected to attempt to answer the question. If the student cannot, another stick is drawn, and the second student may assist the first. If the two students cannot answer the question a third and final stick is drawn. If the three students working together cannot answer the question the instructor may choose to briefly review the concept.

If the instructor's stick is drawn, the instructor answers the question and may review a concept or add embellishment. If a WILD CARD is drawn the last student whose stick was drawn may choose any other student in the class to field the question. If a student is called upon but is not present, his or her stick is placed in the ABSENT container. If there are any sticks in this container, they are the first to be pulled when class starts. After a stick has been drawn and the individual called upon, his or her stick is placed in the DONE container. Once the NEXT container is empty, all sticks in the DONE bin are placed in NEXT.

Questions posed are typically open-ended in nature and based upon concepts or assignments with which the students are expected to have familiarity. Such questions should have limited answers, i.e., the responses need not be lengthy. At times it may be challenging to pose questions that are at the same technical level. If a question is either too simple or too difficult it likely is not a good candidate for drawing a stick. Yes/no questions and questions that are multiple choice in nature are to be avoided because they are less effective at checking understanding. The sticks are also handy for randomly picking on students to report out after working on solving problems with their neighbor/group.

Examples of questions to avoid, open-ended questions that we found to be effective, and questions requiring too much detail or concept knowledge are listed in the Appendix.

## Methods

Two engineering instructors administered Likert-scaled surveys to a total of five classes. The same survey used in [1] was administered to all five classes. A second, follow-up survey was created and given to EE students who had been exposed to the Classicle Stick activity a year ago.

The items listed below were used in the survey instrument administered to all five classes. The order of the questions was mixed but are grouped below by concept being probed. A five-point Likert scale was used: Strongly Disagree (1), Disagree (2), Neutral (3), Agree (4), Strongly Agree (5). Negatively worded items were reverse-scored. A composite score for the seven question areas was calculated by averaging the two items within that area. Students who responded to every survey item with the same response (for instance, "Strongly Agree" for both negatively and positively worded statements) were removed from the data set prior to analysis.

The survey used in [1] and outlined in Table 1 was administered to five classes. In Electrical Engineering (EE) these classes probed consisted of Signals & Systems (n = 33) and Linear Control Systems (n = 12). In Engineering Technology (ET), classes probed with this survey were Structural Analysis in Spring of 2024 (n = 44), Structural Analysis in Fall of 2024 (n = 28), and Statics & Strength of Materials (n = 25).

*Table 1: Survey Items and Groupings* [1]

| Survey Item | Grouping |
|---|---|
| Class was more fun when we played classicle sticks than when we did not. | Overall Fun |
| When the instructor used the sticks, class was less fun than before. | |
| When the instructor used the sticks I felt less stressed than before. | Low Stress |
| I felt more stressed in class when the instructor used the sticks. | |
| I was more engaged in class when the instructor used the sticks. | Engagement |
| The use of the sticks did not make me more engaged in class. | |
| I thought more about questions asked by the instructor when sticks were used. | Thinking |
| When sticks were used I didn't think about the questions as much as before. | |

| | |
|---|---|
| I looked forward to the classicle sticks activity. | Anticipation |
| I did not look forward to the instructor using the sticks. | |
| The wild cards made the activity more fun. | Wild Cards are Fun |
| The activity was less fun when wild cards were drawn. | |
| I paid closer attention when the instructor used the sticks. | Attention |
| When the instructor used the sticks I did not pay closer attention than before. | |

A new survey as outlined in Table 2 was administered to EE students in Linear Control Systems (n = 8) who had experienced Classicle Sticks the year before in Electronics-1 as described in [1].

*Table 2: Survey Items and Groupings for Students Using Classicles for a Second Time*

| Survey Item | Grouping |
|---|---|
| I am more comfortable answering questions in class due to having used Classicle Sticks last year. | Comfort |
| Having previously used Classicle Sticks I was less comfortable answering questions in class. | |
| The Classicle Sticks exercise made me less nervous now than it did a year ago. | Low Stress |
| The Classicle Sticks exercise made me more nervous now than it did a year ago. | |
| I did not look forward to using Classicle Sticks in class this year. | Anticipation |
| I looked forward to using Classicle Sticks in Linear Control Systems. | |
| Using Classicle Sticks a year ago improved my study habits to this day. | Study Habits |
| My study habits did not improve from using Classicle Sticks a year ago. | |
| I don't look much at lecture materials before class even though we previously used Classicle Sticks. | Preparation |
| I look at lecture materials before the lecture more than I did before being exposed to Classicle Sticks. | |
| Using Classicle Sticks made Linear Control Systems more enjoyable to attend. | Fun |
| Linear Control Systems was less enjoyable to attend due to the use of Classicle Sticks. | |

The survey administered to the EE classes also contained a field for students to leave comments and no prompt was provided. In Statics & Strength of Materials and in Structural Analysis, this survey was embedded in an end-of-course survey. The comment section of that survey prompted students to ask questions regarding the final exam review and a self-reflection about how well they learned the course material versus their initial expectations. The comments received in those three Engineering Technology classes did not address the Classicle game.

## Limitations

This data relies on the self-reported measures of the Likert scale survey. At this point a limited sample size was taken, but a large set of data would be desirable. Like many activities, the instructor's role in the activity could influence the students' overall experience.

## Results

Responses for each class were averaged and the standard deviation was calculated. The results of the survey described in [1] given to the five engineering classes are depicted in Table 3. The courses were grouped by instructor. Results of the second survey administered to those who had previously experienced Classicle Sticks are captured in Table 4.

*Table 3: Results of Survey Outlined in Table 1*

| | Instructor #1 | | | Instructor #2 | |
|---|---|---|---|---|---|
| | Structural Analysis Fall (n = 27) | Structural Analysis Spring (n = 43) | Statics & Strength of Materials (n = 24) | Signals & Systems (n = 33) | Linear Control Systems (n = 12) |
| **Category** | | | | | |
| **Overall Fun** | | | | | |
| Average | 3.46 | 3.47 | 3.48 | 3.97 | 4.17 |
| Standard Deviation | 1.02 | 0.98 | 1.03 | 0.94 | 0.82 |
| **Low Stress** | | | | | |
| Average | 3.17 | 2.99 | 3.19 | 2.82 | 3.21 |
| Standard Deviation | 0.99 | 1.02 | 0.96 | 1.16 | 1.25 |
| **Engagement** | | | | | |
| Average | 4.07 | 3.82 | 3.88 | 4.33 | 4.71 |
| Standard Deviation | 0.84 | 0.95 | 1.10 | 0.87 | 0.46 |
| **Thinking** | | | | | |
| Average | 3.87 | 3.84 | 4.00 | 4.30 | 4.58 |
| Standard Deviation | 0.87 | 0.87 | 0.62 | 0.89 | 0.58 |
| **Anticipation** | | | | | |
| Average | 3.35 | 3.19 | 3.29 | 3.62 | 3.71 |
| Standard Deviation | 0.97 | 0.99 | 0.99 | 1.00 | 0.75 |
| **Wild Cards are Fun** | | | | | |
| Average | 3.69 | 3.50 | 3.56 | 4.20 | 4.33 |
| Standard Deviation | 0.84 | 0.88 | 0.97 | 0.95 | 0.70 |
| **Attention** | | | | | |
| Average | 4.19 | 4.05 | 4.02 | 4.29 | 4.54 |
| Standard Deviation | 0.73 | 0.72 | 0.79 | 1.03 | 0.66 |

*Table 4:Results of New Survey Outlined in Table 2*

| | Instructor #2 | |
|---|---|---|
| | Linear Control Systems (n = 8) | |
| **Category** | Average | Standard Deviation |
| **Comfort** | 4.19 | 0.83 |
| **Low Stress** | 3.63 | 1.15 |
| **Anticipation** | 3.44 | 1.15 |
| **Study Habits** | 3.63 | 1.02 |
| **Preparation** | 3.56 | 0.63 |
| **Fun** | 4.13 | 0.89 |

## Discussion

Table 3 captures the results of the survey described in [1] intended for students who were exposed to Classicle Sticks for the first time.

Scores are reasonably consistent across the three courses taught by Instructor #1. Students reported that the sticks did a little more than neutral in providing fun in the class, adding anticipation of questions being asked with the sticks, and the wild cards being fun. However, scores in Engagement, Thinking, and Attention were notably higher, suggesting that improvements occurred in those three categories.

Instructor #2 showed somewhat similar results with a few exceptions. Overall, Fun was notably higher. This may be due to the students in the class being more familiar with each other, and in Linear Control Systems each of the students had had Instructor #2 previously. It is noteworthy in Linear Control Systems, a senior-level elective, that students reports high scores for Engagement, Thinking, and Attention and all with relatively smaller standard deviations.

Table 4 captures the results of the new survey described in the Methods section intended for students who had the same instructor in the previous year and used Classicle Sticks. The sample size of n = 8 is small so any conclusions drawn are not solidly backed by data. It is noteworthy that Comfort and Fun had scores above 4, and Low Stress was nearly half a point improved from students using the sticks for the first time. The instructor expected more improvement in Study Habits and this indicates that more data is needed.

It is acknowledged that longer surveys, i.e., those including reverse-coded questions, may provide lower quality data. We chose to include the reverse-coded questions because we had done so previously [1]. Omitting them could be explored in the future.

Instructor #2 sought comments from students taking the survey but did not provide any prompts. Several comments were noteworthy with some of the more interesting responses reproduced here. Students experiencing Classicle Sticks for the first time wrote:

*I feel that knowing that you might ask questions gave me incentive to look at the book/slides more before class.*

*I like the classicle sticks as it gives people experience being in the hot seat with no real negative consequence.*

*While the sticks made class a bit more stressful for me, I think they are definitely beneficial for the students' education. It forces them to pay more attention and actually consider the answer to questions instead of being a spectator. It also gives the instructor the opportunity to truly assess whether or not the students understand a topic.*

*I really enjoyed the activity, I like the concept and helps students learn and stay more engaged. I also like the idea that it is okay to be wrong.*

*The use of the class sticks motivated me to study the material outside of class. But it also helped me in another perspective, it made me feel okay with "not knowing" something, and placed the emphasis on learning, not the answer.*

*It was very stressful but like the watching NASCAR or NFL type of stressful where you are engaged the whole time.*

The following were comments from students who had previously experienced the activity:

*Turned LCS (Linear Control Systems) into both a learning and a social experience.*

*I enjoy it because it makes me feel more comfortable in class even if I'm having trouble grasping concepts. And the support from our classmates was encouraging & enjoyable.*

*This semester I felt comfortable using the classicle sticks just because we used them before. I can say that using the classicle sticks made me pay attention more in class than not using them. I enjoyed hearing other people answer the questions because that way I wrote down the correct answer as a note to remember in the future as a keynote.*

## Enhancements and Improvements

Students of Instructor #2 suggested several enhancements and improvements to the activity. Many of these seem reasonable and could be incorporated with little effort.

- Remove sticks of students who are perpetually absent
- Incorporate a points reward system for correct answers
    - Points could be used to buy a pass on a wild card
- Add 'Volunteer' sticks as a new category; when drawn a student volunteers to answer

- Print more than one stick per student, so that a student's stick moving to the 'Done' container doesn't necessarily imply they will not be asked a question
- Incorporate 'Table Cards' as a new category in which students sitting at a table may work together to answer the question. The classroom must have tables for this idea, as opposed to individual desks. This idea could also be tweaked to call on groups, if the class is organized in lab or homework groups.
- Show slides as part of the lecture that have questions. Give the class a short period of time to read and think about the questions, then pull sticks to seek answers.
- Implement a way for a student to "steal" the question in order to reward preparedness.
- Incorporate sticks that say to randomly pull from the 'Done' container as a new category. In this manner students are never truly done. This new stick could potentially be a 'Jury Duty Summons' or some other playful naming.
- Incorporate more wild cards. In Signals & Systems there were 6 wild cards for 41 students.

Calling on students by name, after at least a five second pause to allow students to think about the question, has been shown to be an effective teaching technique in the realm of active learning [10]. As such, this technique for randomly calling on students is being presented to assist new engineering educators in developing their classroom management skills. As it is an instructional tool, each instructor is encouraged to make the activity their own by incorporating the students' suggestions or their own ideas to increase the playfulness of the activity. The data presented here show that, at worst, students are neutral about engaging in the activity and even that some students enjoy the sense of play that it adds to a lecture course. This activity is low cost and easy to implement.

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## Appendix

In this appendix, three categories of example questions are listed. The first exemplifies questions to avoid, as they are yes/no in nature or do not sufficiently check understanding. The second

category captures open-ended questions that we found to be effective and used during the course of the activity, and the third speaks to questions requiring too much detail or concept knowledge.

Examples of questions to avoid due to simplicity, lack of checking understanding, being too personal, and so forth:

*"Did you do difference equations in your differential equations class?"*
*"Do you understand this concept?"*
*"When did you take differential equations?"*
*"Was the exam difficult?"*
It is acceptable and often desirable to ask questions of a yes-no-justify nature, for example, *"Is this system stable?"* If the student's response is correct follow with, *"Yes that's correct. Why is this system stable?"*

Examples of open-ended questions effectively used during this activity:

Signals & Systems typical questions

*"What are the conditions for internal stability in a system?*
*"Why might it be desirable to implement a discrete-time moving average filter?"*
*"What are the two components of a system's total response?"*
*"What are the possible forms of poles in a system?"*
*"What is convolution, and what does it do for us?"*
*"What does a transfer function tell us?"*
*"Why do negative frequency indices exist when calculating a Fourier transform?"*

Linear Control Systems typical questions

*"How is steady-state error reduced in a system?"*
*"Why might it be useful to convert a non-unity feedback system into a unity feedback system?"*
*"What are some disturbances that the cruise control of your car might encounter?"*
*"Why do we care about the sensitivity of pole location to gain K?"*
*"How can we tell if a desired pole location is on the root locus?"*
*"What conditions must exist to approximate a higher order system as second order?"*
*"Under what conditions might it be desirable to implement a state estimator?"*
*"What is the gain margin and phase margin from this Bode plot?*

Statics & Strength of Materials typical questions
*Students are called upon after some amount of time (10 seconds to 2 minutes) of chatting with their neighbor about the question.*

*"Remind me how to solve for the y-component of a force."*
*"Talk me through what goes in this equation of equilibrium for our free body diagram."*

*"Which equation did you use to solve this problem? Why did you pick it?"*
*We use the sticks to call on students to report out after problem solving with their neighbors, which leads to shorter questions about their solutions.*

Structural Analysis typical questions
*Students are called upon after some amount of time (10 seconds to 2 minutes) of chatting with their neighbor about the question.*

*"Why do we hire structural engineers for a project?"*
*"Name one of the equations of equilibrium and whether we use it in the 2D or 3D system"*
*"What is an example of where you have seen trusses in use?"*
*"Talk me through how to sketch the free body diagram of the truss joint."*
*"Which equation did you select and why did you pick it?"*

Below are examples of questions to avoid due to being too difficult or requiring a response that is too lengthy. Note that degree of difficulty may vary between schools and instructors.

*"Describe the design criteria of a PID controller."* (too lengthy/involved)
*"Compare and contrast the three forms of Fourier series."* (may require instructor-level knowledge)
*"What are some applications of the Fourier transform?"* (may require experience outside of the classroom)
*"What aspects must be considered in the design of a control system for a gas turbine power generator for a power plant?"* (may require knowledge outside of the class, and if properly addressed has several elements to the answer)