Work in Progress: Interactive and Dynamic Lecture Slides for Active Learning of Concept Evaluation and Selection

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Abstract

There are many methods to integrate engaging, actively learning material into a typical lecture slide, such as live polls or clicker activities that show a histogram of the results from a multiple-choice question. These are simple to understand and implement and can be effective in many situations, but some concepts may benefit from more complex submissions and additional post-processing. For example, in undergraduate engineering design courses, concept evaluation and selection methods generally include instruction on using a weighted decision matrix. Their form and calculations are relatively straightforward, but the nuances of their proper use for reducing bias can be more difficult for design learners to appreciate. This paper describes an active learning method that uses interactive and dynamic lecture slides created with a combination of Google Forms, Sheets, Slides, and the linked objects feature, and provides an example of how this method was used to create a module on concept evaluation and selection for an engineering design course.

The method provided a unique way to engage the learners using customizable and immediate post-processing of information they submit and could be useful for a wide variety of topics. However, the learning curve for both the instructor and the learners may not always justify the investment, learner responses may vary enough that they don't provide the evidence expected to support the learning objective, and no formal assessment has been completed yet on its effectiveness.

Introduction

Active learning techniques are an important method to keep students engaged during class and improve learning outcomes, such as in undergraduate engineering education [1], [2]. Active learning can be defined as "[...] anything course-related that all students in a class session are called upon to do other than simply watching, listening and taking notes." [3] There are many different examples of active learning techniques commonly used in engineering education, such as "Think, Pair, Share" or student polling, each with advantages and disadvantages [4], [5].

Many of these are simple, tried, and true, but some concepts may benefit from the use of an active learning technique that would allow more complex learner engagement or interaction. For example, a clicker poll may be able to embed a live histogram from a multiple choice question, but an instructor may want to do additional post-processing on the learners' submissions before showing the results in order to better explain certain points. One method that can allow for this

type of interactive and dynamic lecture slide is through a combination of Google Forms, Sheets, Slides, and the linked objects feature.

This paper will describe the general procedure as well as an example of how the author implemented it in an engineering design course.

Preparation and Implementation Procedure

The method presented in the paper for dynamically updating lecture slide content based on live learner responses is based on the Google Docs Editors, which is a web-based productivity platform common in education and other workspaces [6]. The workflow uses several pieces of the software suite, starting with collecting information from the audience using Google Forms. The responses from the form are then linked to a Google Sheets worksheet. The worksheet is set up ahead of time with any post-processing required, including formatting the processed results into tables or charts. These tables and charts are then pasted into a Google Slides presentation using the "Link to spreadsheet" feature, which allows them to be quickly refreshed to match the updates that would come from new entries to the form. Implementing this chain of updates requires understanding some of the nuances of how these software platforms and features work. In addition, testing of corner cases is important to ensure smooth operation.

Creating the form to collect the responses using Google Forms can be done with any Google Form. In theory, any Google Form question type could be used, but closed-form responses, such as multiple choice, checkboxes, and linear scales, limit the amount of corner cases that could arise. If short answer questions are desired, the "response validation" feature, which can be used, for example, to limit the length of text or ensure the response is an integer, could be useful in similarly limiting corner cases. To make it easier to distinguish the column headings in post-processing, use short, but unique, question titles and add any additional clarification needed using the question "description" (Figure 1). Both response validation and description features are accessible from the 3-dot menu at the bottom right of a question box. Additional settings may also be useful, such as restricting form responses to an organization, or collecting the email address of each response. Once the form is created, use the preview feature to enter in several responses in order to simulate what the audience would see and to enter sample data. Under the "Responses" tab of the Google Form, clicking "Link to Sheets" will link the form responses to a new or existing worksheet.

In the linked Google Sheet, all the responses can be viewed and post-processed. Here, it is important to understand that each new response will be added below the row from the prior response and overwrite everything that was added to that row. This includes overwriting any cells to the right of where the last question is, which would be a tempting place to set up post-processing (Figure 2A). Google Forms also does not generally recognize deleted rows and so would leave a gap with the next entry. Best practice is to not make any edits to the linked

sheet itself, and instead setting up calculations and additional post-processing in separate sheets or tabs (Figure 2B). For convenience, portions of the responses can be inserted in the new sheet by pasting the needed question titles as column headers, and, for example, using a combination of formulas such as "offset," "indirect," and "match." Any formatting, such as adjusting font size, background colors, or even use of conditional formatting, is best done within the worksheet (Figure 2C).

Figure 1: Example from this activity of a Google Form question set up with a short title, more information in the description, and responses required to ensure results from every submission would be appropriately processed.

Once a table or chart is formatted as desired, then select and copy it, and paste it into the desired slide of the Google Slides presentation. When paste options are presented, ensure "link to spreadsheet" is selected and click paste. Note that any further adjustment of size or editing the table within Slides may be overwritten when references are updated. Continue pasting in and linking additional tables and charts into the slides as desired. To update them all at once, open the "linked objects" side panel, under the Tools menu, refresh it if needed, and click "update all" at the bottom.

Testing out how this would work ahead of time is strongly recommended. Delete the current test responses in the linked sheet and add new entries using the Google form. Generating enough test data from one account requires that the "Limit to 1 response" setting be off, but this could be turned back on afterwards. Then update all the linked objects with one click from the linked objects panel again in the presentation, and verify that they all appear as expected. Be sure to clear the test data again before the actual presentation. Google often adjusts how features work and how users access them, so for additional and updated information users can reference their help center [7].
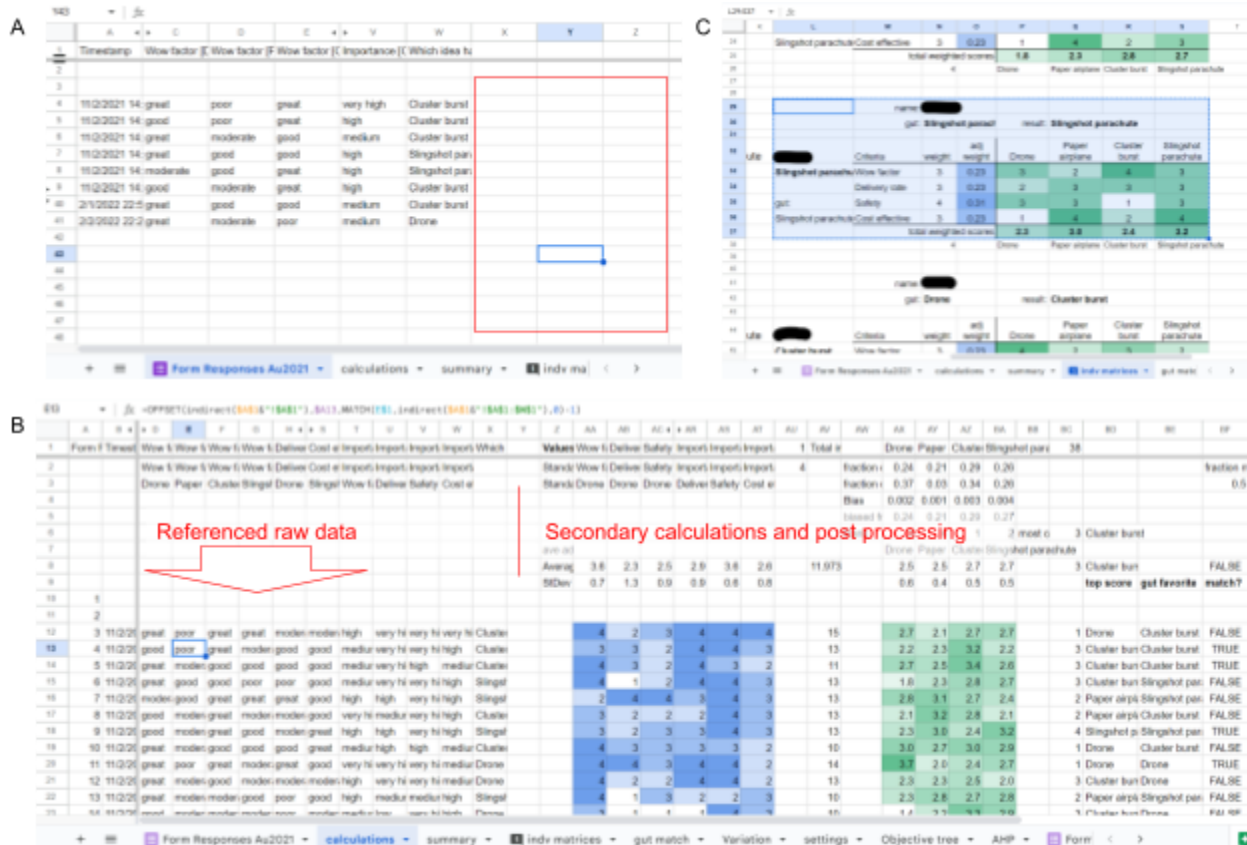
Figure 2: A) Responses from a Google Form can be output into Google Sheets, but setting up post-processing equations in the columns to the right (red box) would result in them being overwritten with blank cells when new results are submitted. B) Instead, results can be referenced from a separate spreadsheet tab (here, using the equation "=OFFSET(indirect($A$1&"!$A$1"),$A13,MATCH(E$1,indirect($A$1&"!$A $1:$W$1"),0)-1)"), ordered in a way that is more intuitive, and additional calculations can be run. C) The calculated results can be organized into tables, formatted, and copied into Google Slides as a "linked object."

The logistics of implementation should be guided by established best practices for active learning activities in general, including having clear learning objectives, non-trivial questions, clear instructions, and a short duration [3]. For this type of activity, an instructor may want to first provide some lecture or introduction to the topic in general and then introduce the prompt or scenario for the activity. To share the link to the Google Form with each learner, the instructor could use a QR code on their slides, a short url, or share the link through class chat or other platform. As participants fill out the forms, the instructor can answer any questions that arise but should also monitor the response and post-processing sheets to ensure it is working as intended. Once a sufficient number of participants have submitted their forms, if the processed results in the worksheet look good, then the instructor would go to their slides and use the "update all" button to sync all the linked objects. If something has gone wrong with the results, the instructor

should probably not update the linked objects, and proceed with the slides using the test data they had in place beforehand.

An important part of active learning activities is having some learners share their response with the class, and not relying on volunteers for this. For this activity, if instructors have the participants enter their name as part of the form, the "report-out" could be in the form of the name and post-processed results on a slide and then use that as the basis for further discussion. Having an actual participant's name displayed alongside the results also helps convey that they are looking at the actual data they just submitted moments earlier, rather than data fabricated by the instructor to make a point. Paying attention to see if their name pops up might also keep learners engaged.

Example Implementation

The author used this method to support a discussion on weighted decision matrices in a lecture on decision making and concept selection for a large, senior-level design theory course in a mechanical engineering department. These are common topics covered as part of the "evaluation of concepts" phase of an engineering design process, and weighted decision matrices are just one method that designers have to evaluate competing concepts [8]. The form and calculations of weighted decision matrices are relatively straightforward and not the focus of this paper, but the nuances of their proper use for reducing bias can be more difficult for design learners to appreciate. The goal of the activity was to demonstrate how they can be useful and where they could be misused. Specifically:

- How are the weighted scores calculated?
- What can make it difficult to evaluate a concept?
- How might results from a weighted decision matrix compare to your instinctive choice?
- Why might different individuals have a different result?
- What types of metrics might be better used for screening concepts, rather than scoring?

To set up the activity, learners were presented with 4 concepts for a "mask launcher" that a cheer squad could use to distribute swag face coverings to a football crowd (Figure 3). The concepts were described and the learners were asked to note which they liked best based on their "instinct." Then some additional background on decision theory was provided, including a brief overview of weighted decision matrices. Then the link to the Google form was shared with the learners, and a few minutes given for them to fill it out. They were informed their results would be reported out on the following slides. The form asked for a pseudonym, and several multiple choice grids that allowed them to rate each concept on a scale of poor, moderate, good, or great for the categories "Wow factor," "Delivery rate," "Safety," and "Cost effective" (Figure 3). Next they were asked to rate how important they thought each category was, as well as which concept they had selected initially.

Figure 3: Screenshot of part of the form, showing the competing concepts and how each participant would rate their performance for the first criteria.

The linked sheet had been set up with several tables and plots to prompt discussion. These were then copied and pasted into the lecture slides (Figures 4-6) as linked objects.

Why the different results?

Example of...

most common result — Cluster burst — gut: Drone

Criteria	weight	adj weight	Drone	Paper airplane	Cluster burst	Slingshot parachute
Wow factor	3	0.23	4	2	3	2
Delivery rate	4	0.31	2	2	4	3
Safety	4	0.31	2	2	1	1
Cost effective	2	0.15	1	4	2	2
total weighted scores			2.3	2.3	2.5	2.0

2nd most common result — Slingshot parachute — gut: Slingshot parachute

Criteria	weight	adj weight	Drone	Paper airplane	Cluster burst	Slingshot parachute
Wow factor	3	0.23	3	2	4	3
Delivery rate	3	0.23	2	3	3	3
Safety	4	0.31	3	3	1	3
Cost effective	3	0.23	1	4	2	4
total weighted scores			2.3	3.0	2.4	3.2

Figure 4: Example slide with weighted selection matrices filled out using the actual responses from two participants (names redacted) that had led to different concepts scoring higher.

Rarely a single objective answer

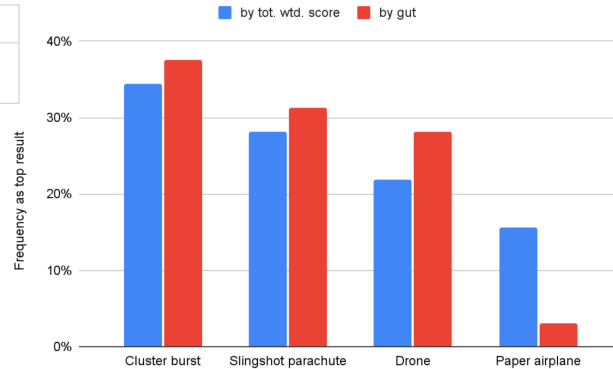| Total responses | 38 |
| result matched gut? | 50% |

Figure 5: Example slide with histograms of how many participants selected which concept as both their initial choice, and which had scored highest from their decision matrices.

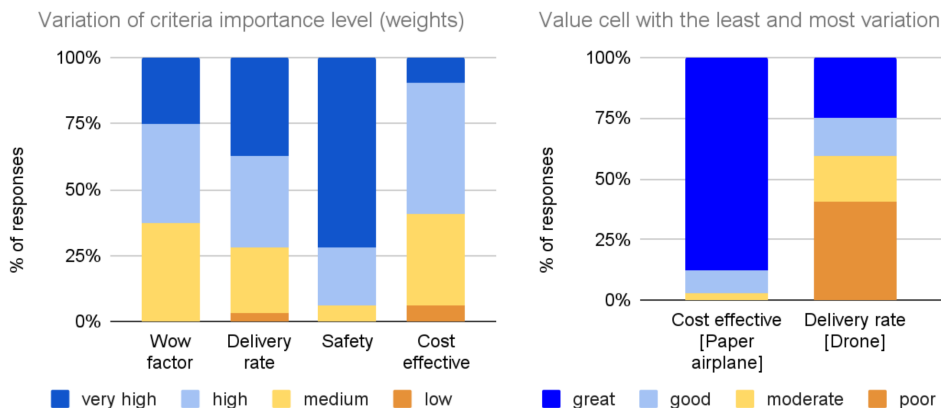## Sources of variation among evaluators?

Figure 6: Example slide with charts showing the distributions of importance ratings and category scores made from the participants' responses.

Results and Future Work

The author has used this activity in a few different quarters, but not yet formally studied if it helped learners implement better weighted decision matrices in their later projects or if it worked better than other activities. Anecdotally, and through informally reviewing related assignments, while it led to good classroom discussions, there are areas for improvement.

For example, having results from a form processed and presented just seconds after they are submitted may be impressive or grab attention, but it may also be a distraction from the actual content or learning objectives. During one session using this form, the first question was about how the slides had been made rather than about weighted decision matrices.

Additionally, while individual participants may have their weighted decision matrix calculate a top choice different from their initial instinct, the activity did not lead to more consensus overall in some classes (Figure 5). There was more agreement among the students just from their instinctual choice than from the weighted decision matrix, although it did result in many more students considering a concept they had previously neglected (paper airplane).

One helpful discussion it raised started while the learners were filling out the form and one raised their hand to ask "What do you mean by 'delivery rate?'" The author had intentionally labeled this criteria to be vague and declined to elaborate. When displaying the results they were able to reference their question, give examples of multiple ways it could be interpreted, and then show how the class' responses for the importance level for the "delivery rate" criteria varied significantly (Figure 6, left). Similarly, the delivery rate for the drone concept was the combination with the most disagreement among the responses (Figure 6, right). These were used to emphasize the importance of having criteria with a clear description or understanding of how to measure the performance as well as clarity around what each concept is.

Another example of how the responses can help guide the discussion is around the use of safety as a criteria. When safety is included, it invariably tends to be weighted highly, dominating the decision. While including safety as a tradeoff is appropriate for some designs, it more likely should have been a screening criteria and anything too unsafe to consider should have been screened out beforehand. This helps explain why the paper airplane concept had the greatest increase in top results (Figure 5).

When evaluating what the learners submitted for their design projects, many groups created decision matrices that had similar flaws of unclear criteria or concepts, or included a weighted criteria that should have been a screening criterion. The activity used here had some aspects intentionally designed poorly to demonstrate potential pitfalls, but it likely needs to be paired with a follow-up activity where a decision matrix set up properly shows how it can be an effective tool in increasing consistency.

While the first time the author set up the sheet and calculations for this activity was a significant time investment, it was relatively straightforward to reuse it for subsequent quarters. Future work could include improving the shortcomings identified and by collecting specific feedback on the activity from the learners afterwards, such as with a "minute-paper" [5], or by comparing results of a related assignment or quiz from two different sections of the course, one which used the method described here and the other teaching the content using a more typical active learning activity. Additionally, there may be other topics that would benefit from a similar type of activity but with less complicated post-processing required.

Conclusions

This method of combining Google Forms, Sheets, and Slides could be a good option for active learning activities where complex post-processing needs to be done to connect an activity that learners partook in to an immediate result. However, the time investment required to ensure it works as intended when run live can be significant, and the results may not be predictable if learners respond in unexpected ways. Additionally, while the novelty of the approach may excite and engage some learners, it may also be a distraction. An instructor should carefully consider these factors when deciding if it is appropriate for their use case.

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