Using Doodles to Assist Learning in Mechanical Engineering Courses

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Introduction

Doodles are commonly viewed as the traces of a distracted person − one who is bored with the immediate proceedings and fills the void with sketches of random shapes or objects. While the doodler may indeed be filling time, the fact of doodling is not necessarily a display of inattentiveness. Doodling may actually serve to keep the brain engaged and alert while those around the doodler concentrate themselves into a haze. Such an idea provides the premise for this paper. Engineering students commonly engage course information in a relatively one-dimensional manner − Read, Solve, Repeat. The process becomes metronomic, with the student never pausing to explore or interpret the information being presented. To break this cycle, this paper looks at the use of doodling to provide a different mode of content engagement.

The use of drawing to create an alternative method for displaying and retaining information has a number of supporters. Ainsworth et al [1] suggest that incorporating drawing into scientific education can produce increased engagement, improved reasoning, better organization, and better communication of concepts, among other benefits. Andrade [2] demonstrates that doodling provides a contrasting form of engagement that can increase attention and retention of information. Wammes [3] suggests that drawing assists in memory tasks due to its multidimensional nature where one has to make a decision on what to draw, convert that into an internal image, and then transfer that image to the page. The ability of images to enhance learning and support verbal processes has also been well documented [4, 5]. In a more specific application of drawing, Blackler [6] discusses the use of a cartooning exercise in an Industrial Design course, with the observation that students perceived the task of cartooning to assist in thinking and recall, but with concerns about the difficulty and time associated with the process. The doodle approach adopted in this current paper seeks to retain the positive aspects related to drawing while simplifying the drawing process so as to reduce or eliminate the negative aspects.

A technique similar to doodling is that of "sketchnoting", wherein notes are either presented or taken using a combination of drawings and words. Proponents [7], [8] of sketchnoting support the idea that the learning benefits of sketching and drawing are tied to the need for a person to translate ideas from one format (words) to another (pictures).

Perhaps the most comprehensive resource related to the above, and this current paper, is the book, *The Doodle Revolution* by S, Brown [9], which discusses the concept of the "Infodoodle". An Infodoodle is a simple drawing that is created with the purpose of capturing and conveying information. Brown explains not only how to create effective doodles, but also ties their use to improvements in organization, engagement, thinking, and memory.

This current paper represents an initial foray into accessing the power of sketching and doodling as a tool to assist students in their engagement with engineering courses. Doodling information has been collected over the span of two semesters in sophomore level engineering courses (Statics, Dynamics) within a Mechanical Engineering curriculum.

The sections that follow begin by examining the ways that doodling might be used to provide an alternative method for students to interact with information in an engineering course. This includes first establishing some rules for doodling, and then looking at the use of doodles to get students to prepare for class, review course information, and as a means to conceptualize the solution to a given problem. This is followed by a brief analysis of the effectiveness of the doodling exercises by examining the "correctness" of doodles, considering doodles as a component of course grades, and looking at student feedback. The paper concludes with an overview of the results and possibilities for future exploration.

How and Why to Doodle in an Engineering Course

Part of the premise of using the term "doodle" to describe the translation of written content into pictorial information is that people instinctively understand the idea of a doodle. Doodles are somewhat random, often whimsical drawings that require minimal artistic talent to produce. Some structure is required for a doodle to convey content, so in our application we will look at the "Infodoodle" as defined by Brown [9]: An Infodoodle is used *to intentionally track auditory or text-based content and translate it into words and pictures…to clarify and communicate concepts [and to] explore and display complex information using a union of words and pictures.* [Brown, p. 223]. The following subsections explore basic requirements for a well-constructed Infodoodle, and then look at some of the types of learning that can be achieved by a well-executed Infodoodle.

Infodoodle Requirements

A first step in creating an assignment such as doodling is to provide students with guidelines for the work produced. Doodling assignments are intended to engage students through the translation of written information into pictorial form. Unfortunately, the creation of a picture does not necessarily indicate that the desired engagement has taken place. As such, students are given the following requirements for the production of a successful doodle:

1. The representation will be largely pictorial.
2. Any numbers, letters, symbols etc. should be used to supplement the picture. If these play a major role in the picture, they should be in "doodle form" (word art where the letters and numbers take on the form of a picture rather than just writing the letter or number).
3. Generic shapes and drawings (for example, a drawing that shows a square with arrows pointing at it to show forces) are discouraged and will not receive credit.
4. Any solid bodies in your drawing should be real objects (a person, a wall, a teeter-totter, a log, etc.) to show how the course content describes the way people and things interact with the world around them.
5. Doodles must be the original work of each student (for example, reproducing a picture from the textbook or homework will not qualify as original work).

An example of the application of the above rules is shown in Fig. 1. Both doodles show the same concept. Figure 1(a) satisfies the doodling guidelines, but the doodle in Fig. 1(b) does not indicate that the student has made an honest effort to interpret the course information.
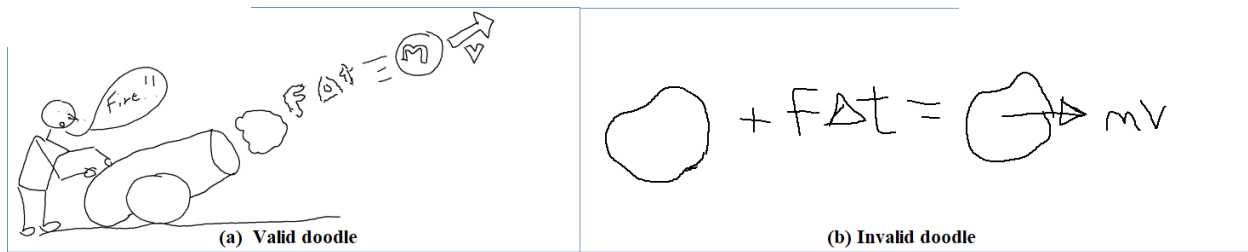
(a) Valid doodle   **(b) Invalid doodle**

Figure 1: Establishing expectations for doodles

Grading doodles is done on a credit/no credit basis to avoid any "drawing quality" bias. As long as a drawing shows an honest attempt to translate course information into pictorial form, the doodle is deemed to be acceptable. This encourages students to do their best without worrying about drawing skill. [Though with some simple tips and guidance, see Brown [9], even students who do not draw well can quickly improve their ability to create reasonably stylish doodles.]

With the above requirements in place, we can now consider the different ways that students can use doodles to interact with course information.

Using Doodles to Engage Course Content

The purpose of the doodle is to provide an alternative means for students to experience course information. This section provides several examples of how doodles might be incorporated into an engineering course. The examples include using doodles to preview upcoming course information, to interpret current topics, and to summarize/review past topics.

The Use of Doodles to Preview Course Content

Consider the following choices for the possibilities of having students prepare for an upcoming class:
1. Ask students to read a section of the course textbook.
2. Give students a simple homework problem associated with the upcoming course material and ask them to complete the problem prior to class.
3. Have students draw a doodle that summarizes one or more key points of the upcoming class topic.

Which approach is most likely to engage students?

Using doodles to preview course content can be done on either a daily basis, or a weekly basis (or similar timeframe). The author has used both timeframes and they seem equally effective. The weekly approach has the advantage of reducing grading load and providing students with a little more flexibility in managing their preview time.

The doodles shown in Fig. 2 provide some examples of student submissions for creating doodles to preview course information. These doodles were generated for topics in a Statics/Dynamics course.
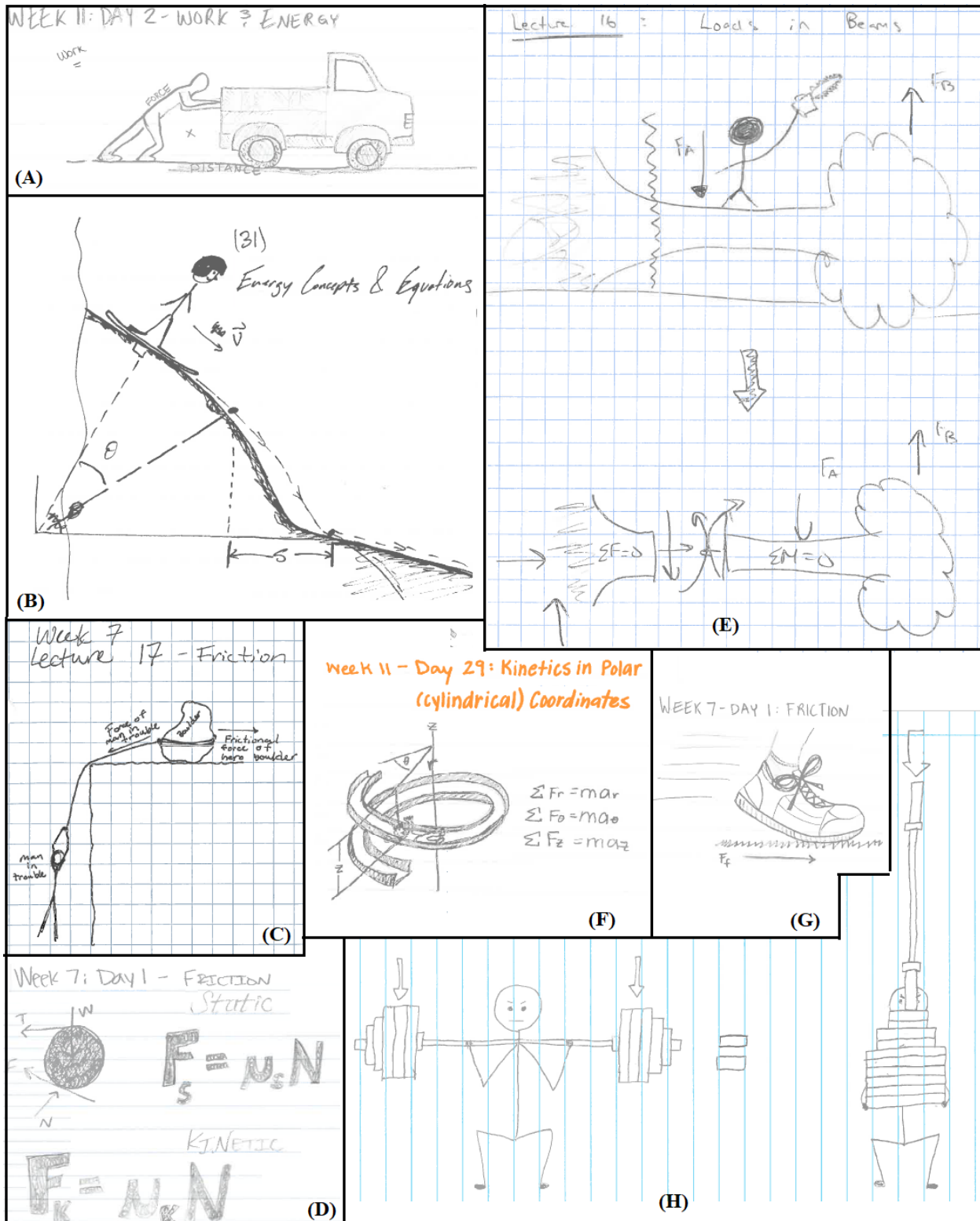
Figure 2: Sample Student Doodles for Previewing Daily Topics (Doodles contributed by: (A) J.H. (B) H.G. (C) P.H. (D) M.S. (E) Anon (F) J. J. (G) J.H. (H) K. J.)

The Use of Doodles to Interpret Current Topics

This second engagement mode is similar to the first, except that it takes place after students have been formally exposed to the course material. Several possibilities exist in this category. One is to have students summarize a class period by creating a doodle to capture the information. Another is to have students use a doodle to capture the elements of a homework problem or other assignment. As an example, the doodle shown in Fig. 3 was created as the first step for a design assignment in a Dynamics course. Students were tasked with applying dynamic elements to design part of an "American Ninja Warrior" course. The first step in the design was to doodle the course components and label the necessary dynamic principles that would be applied to solve each part of the problem.
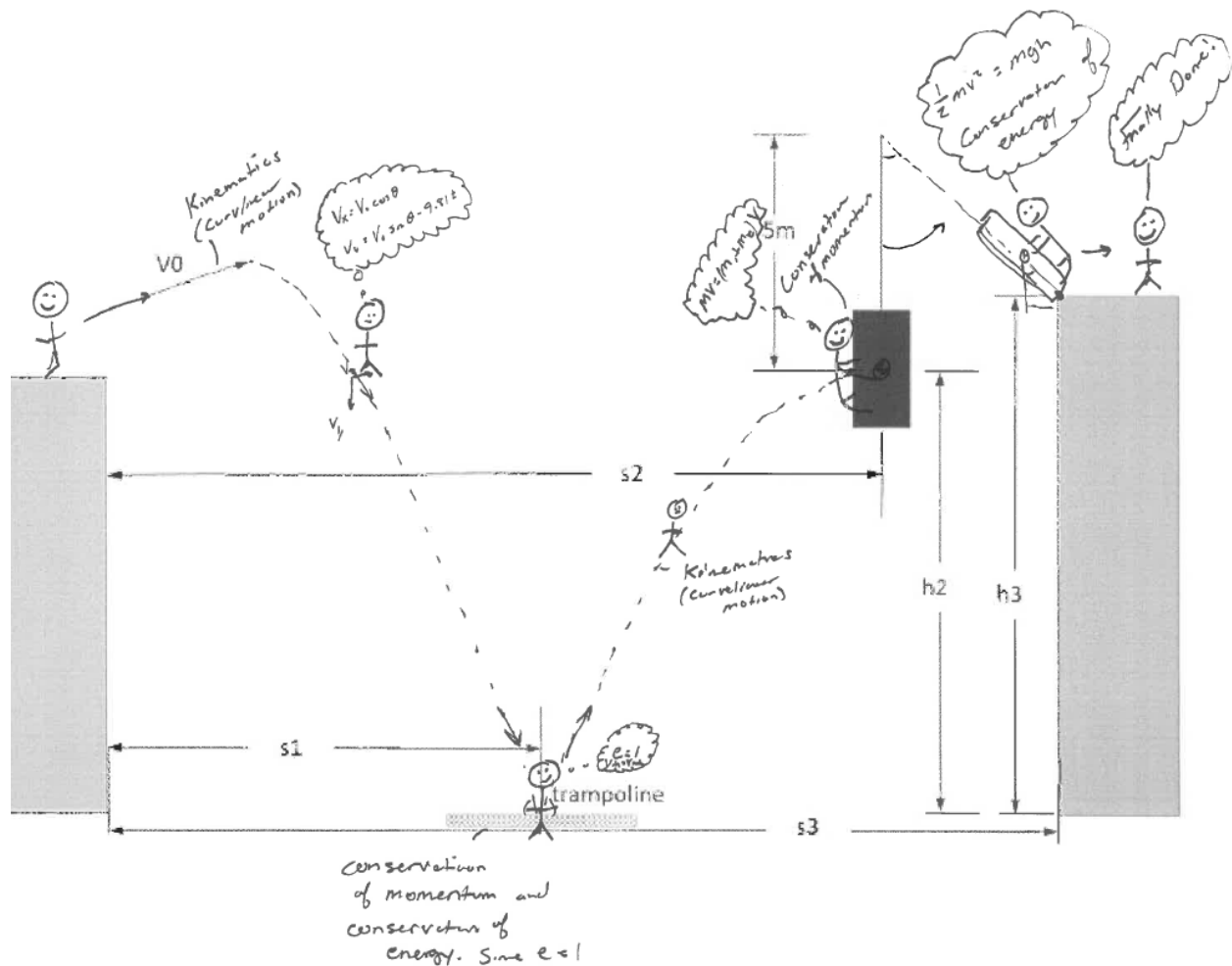

Figure 3: Doodling to capture the elements of an assigned problem. Contributed by MG

The Use of Doodles to Summarize Course Topics

Another effective use of doodles is to use them to review chunks of course information. Common methods that students use to review course materials are to read notes, go through old homework or exams, and to work course problems. Creating a doodle of past course material potentially improves upon these methods by forcing the student to begin course review by creating conceptual connections to things outside of textbook examples. This different type of engagement is consistent with best strategies for learning [10].

Figures 4-7 present several examples of students using doodles to summarize course information. Figures 4-6 are from a statics course, while Fig. 7 is from a dynamics course.
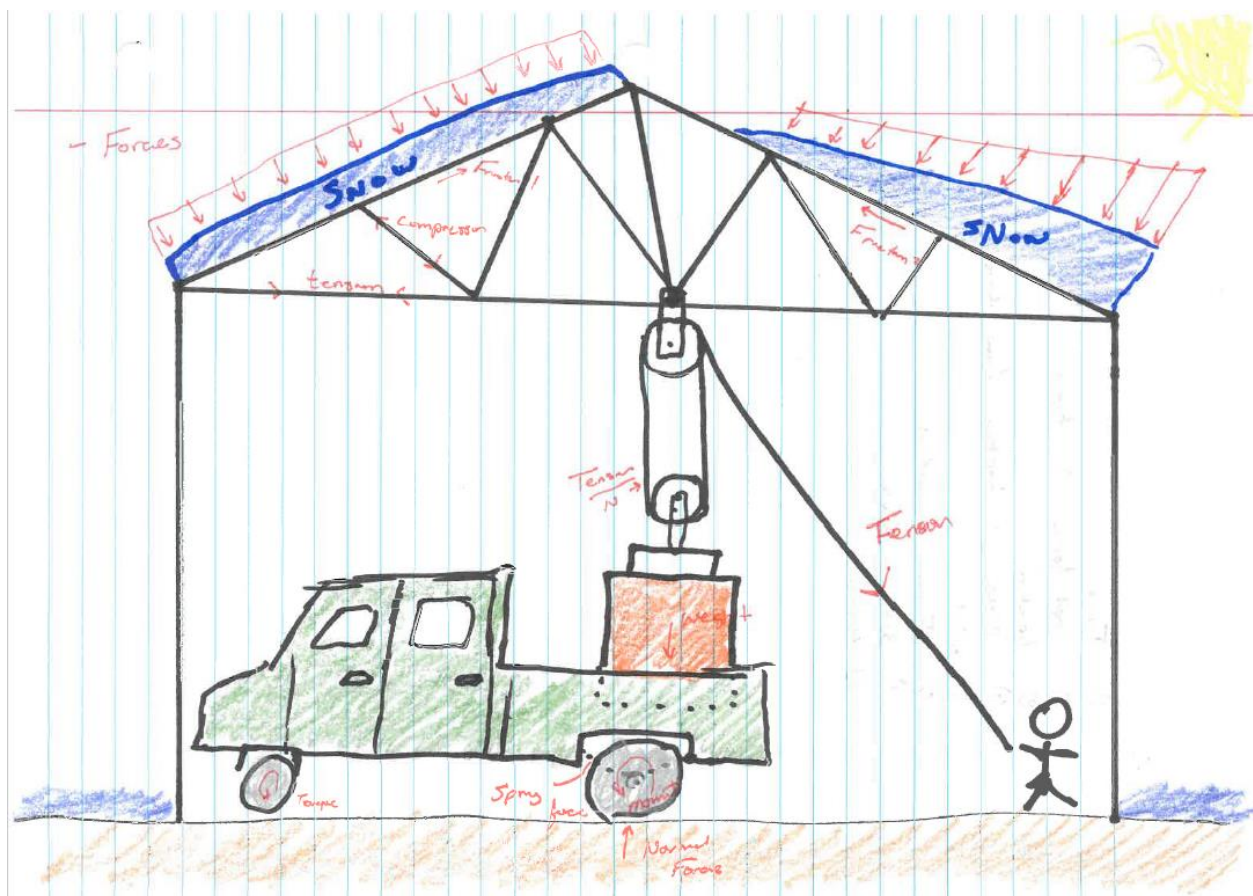

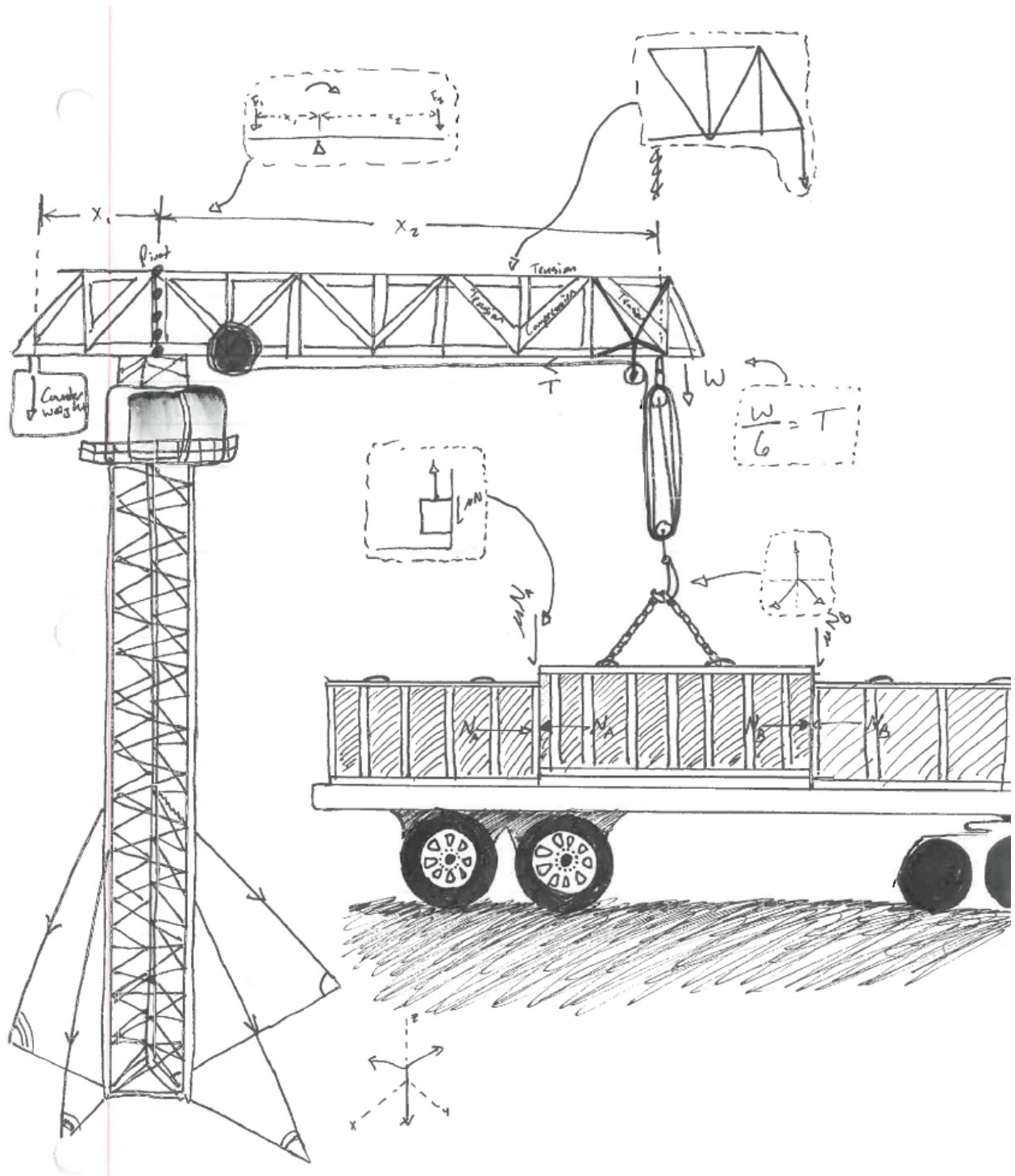Figure 4: Statics Summary Doodle 1. Contributed by MF

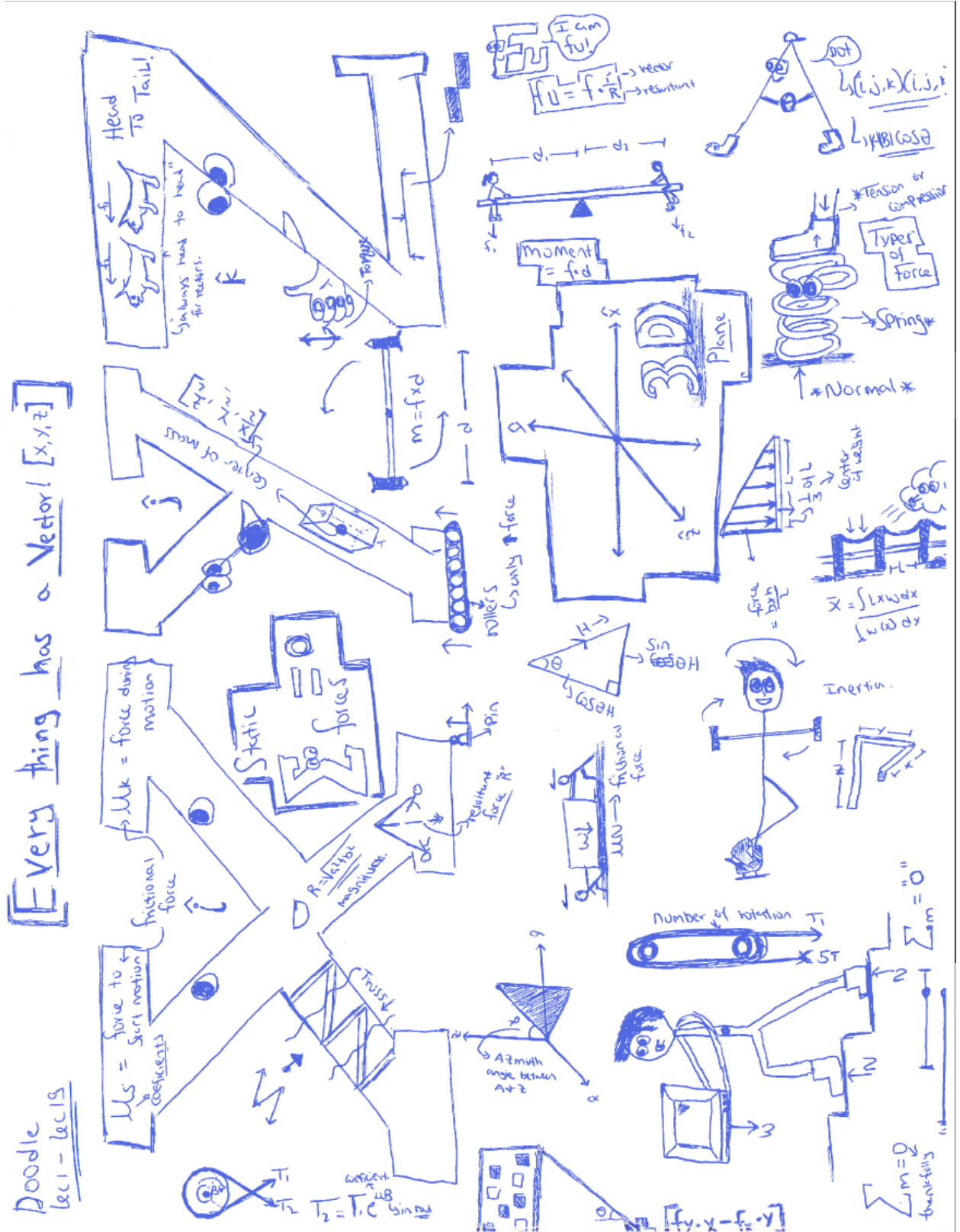Figure 5: Statics Summary Doodle 2. Contributed by HG.

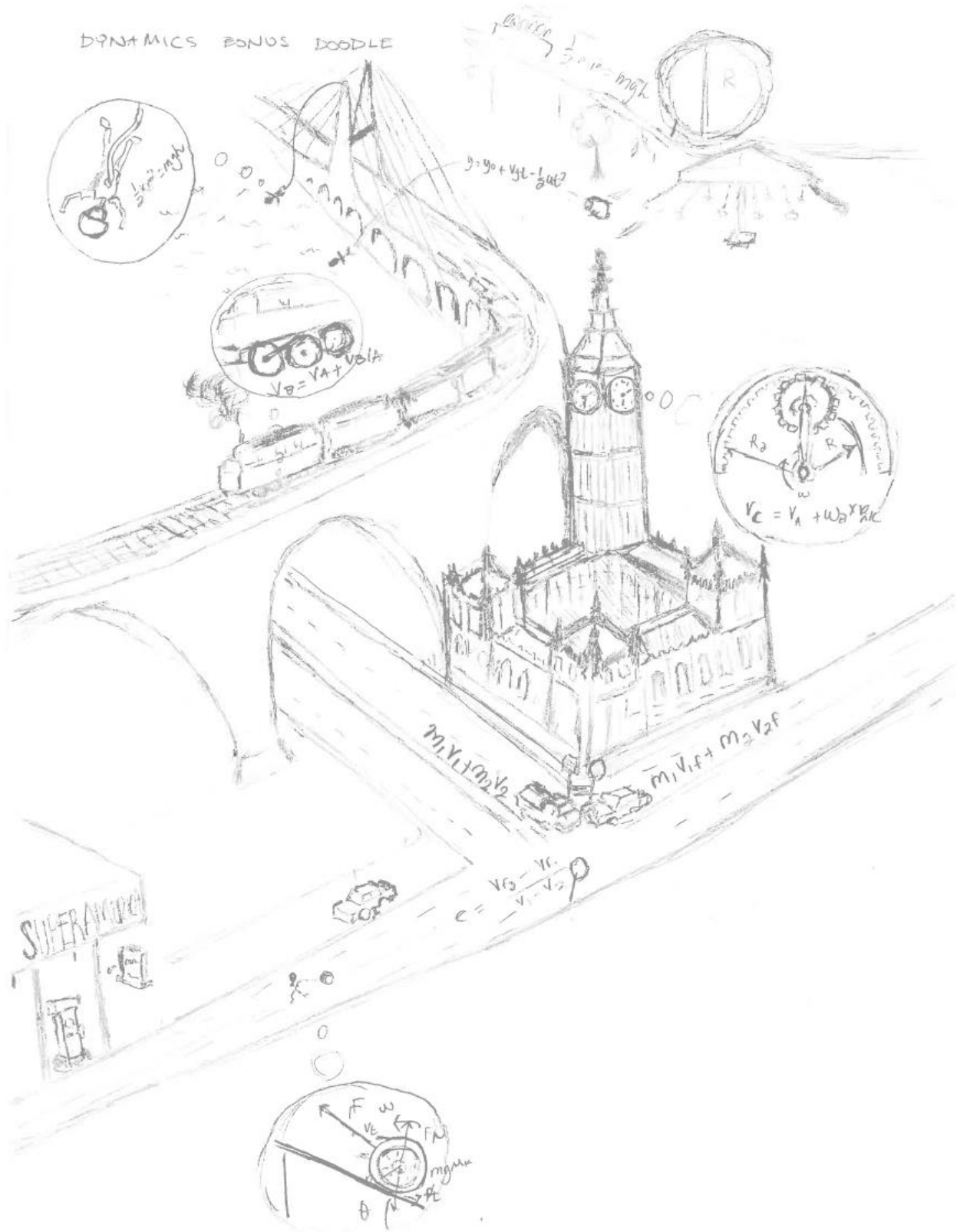Figure 6: Statics Summary Doodle 3. Contributed by FA

Figure 7: Dynamics Summary Doodle. Contributed by YT

Effectiveness of Doodling

The use of doodling as a required course element is consistent with proven methods of student engagement and learning. This section considers several pieces of evidence that suggest doodling is indeed effective. These include a review of the "correctness" of doodles, a comparison of doodle grades to course performance, and an examination of student response to doodling exercises.

Doodle Correctness

One means of evaluating doodles is to examine their overall "correctness" – do they accurately convey the course concepts and principles? An acceptably drawn doodle requires students to apply course information to something outside of the textbook presentation. As such, doodles display the student understanding of course information in an original creation.

A review has been conducted on "course summary" doodles to examine how well, and accurately, students interpret course information and apply it to their original drawings. This review provides some indication of the students' ability to transfer their learning to the world around them.

The review of a random set of summary doodles from courses in Statics and Dynamics revealed a "correct" rate of 93%. In this case, correct is defined as a proper expression of the concept. This means the doodle and any associated words or equations combine to properly present the concept. Note that this is different than simply writing equations on a notecard because the picture in the doodle establishes the context of the student understanding. The errors found did not appear to have any correlation with the student grades in other course elements. In several cases, students that performed poorly in other course elements demonstrated significant understanding of course concepts in their doodles.

Doodle Grade and Course Performance

Doodles represent a relatively small part of an overall course grade, commonly on the order of 5%. Even with this, a natural question to ask is to wonder whether students who score high in a course tend to also score high on doodles. The graph shown in Fig. 8 shows the relationship between doodle grades (vertical axis) against overall course grade (horizontal axis). While the graph shows a slight trend for good students to score higher on doodles, the relationship diverges significantly below the "A" level of student. The attempted linear fit in Fig. 8 shows no correlation between course grades and doodle grades.

The fact that students tend to create doodles that are conceptually correct, combined with the idea that doodle performance is not related to course grades suggests the possibility that doodles may provide an alternative avenue for students to display their skills and knowledge on course material. Further research is needed, but preliminary results suggest possible benefits may be obtained by placing a greater emphasis on doodling grades.
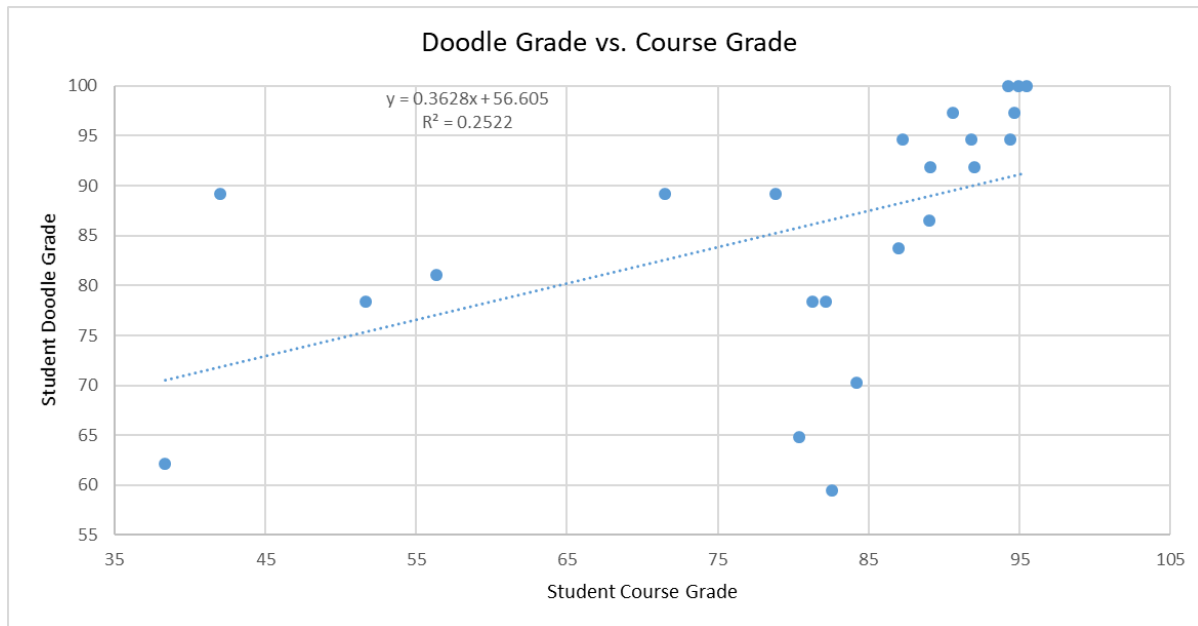
Figure 8: Student course grade compared to overall course grade

Student Response to Doodling

The doodle represents a somewhat dramatic departure from the intensive problem-solving environment that is the core of engineering education. An obvious question that arises is whether or not students see value in this alternative type of assignment. This section reviews student responses to the doodling activities in their courses.

Students were marginally positive in their response to doodling. Doodles were used in each of the contexts mentioned earlier, but the primary emphasis was as a preview exercise. In this context, students perceived doodles as being less helpful to their learning compared to other forms of course engagement such as working problems, or taking traditional notes. The following student comment reflects the "I do it because I have to" approach to doodling:

The doodles are very good in concept. However, many doodles were created last minute or without much thought in order to obtain the points.

On the positive side, several students provided comments such as:

I like the doodle because it helped visualize the concept.

I liked the doodles because I felt they gave me an opportunity to think in more detail of the actual applications of what I'm learning, other than the applications given to me in class. I think this is an important skill for engineers, when you consider how much of engineering is thinking of how to apply knowledge in new and unconventional ways.

Conclusions

The use of doodles in engineering classes provides an alternative means for students to engage course topics. Doodles can be used for a variety of purposes, including to preview course material, to help students interpret current topics, and to review course information. The overall effectiveness of student doodling is somewhat uncertain at this point in time. The fact that student doodles are largely accurate in their representation of course concepts indicates that doodles can provide useful feedback on the level of student understanding of these concepts. Doodles also allow for a different form of engagement with course material. This different engagement may be beneficial to students who do not excel at traditional forms of student evaluation. Student response is somewhat mixed, suggesting some additional thought needs to be given to how to most effectively engage students in the doodling process. The drawings included with this paper demonstrate that a number of students were well engaged, while other student drawings do not show such a level of attention.

On the whole, the precept of doodling is a sound one. Doodling forces students to engage and interpret course information in a manner that requires nontraditional thought patterns for engineering students. Research has shown that translating words into pictures has likely benefits for learning. Continuing investigations into the nuances of the use of doodling should allow for more complete access to these benefits.

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