Small Teaching via Bloom's

Dr. Marjan Eggermont, University of Calgary

Dr. Marjan Eggermont is a Teaching Professor and faculty member at the University of Calgary in the Mechanical and Manufacturing department of the Schulich School of Engineering, University of Calgary. She co-founded and designs ZQ, an online journal to provide a platform to showcase the nexus of science and design using case studies, news, and articles. As an instructor, she was one of the recipients of The Allan Blizzard Award, a Canadian national teaching award for collaborative projects that improve student learning in 2004. In 2005, she was one of the recipients of the American Society of Mechanical Engineers Curriculum Innovation Award. She is a former board member of ASEE.

Small Teaching via Bloom's

Abstract

Engineering 481 is a typical *Technology and Society* course that most engineering programs offer that covers, as listed on abet.org: "the impact of engineering technology solutions in a societal and global context." It is a course all students take and can therefore have large classes: 180 students in Fall and 240 in Winter in our case. The course has a large end of term deliverable but in order to maintain attendance in class (class was at 8 am and 6:30 pm respectively) a lecture deliverable was added in the form of 'question chits' based on the revised Bloom's taxonomy which redefines the cognitive domain as the intersection of the cognitive process dimension and the knowledge dimension (Figure 1). In each class, a question was asked that corresponded to one of the 24 options in the revised taxonomy. Each question used a verb that generally referred to an action associated with the intended cognitive process and a noun that generally described the knowledge students were expected to acquire or construct [1]. This paper will discuss this experiment and provide examples of questions posed.

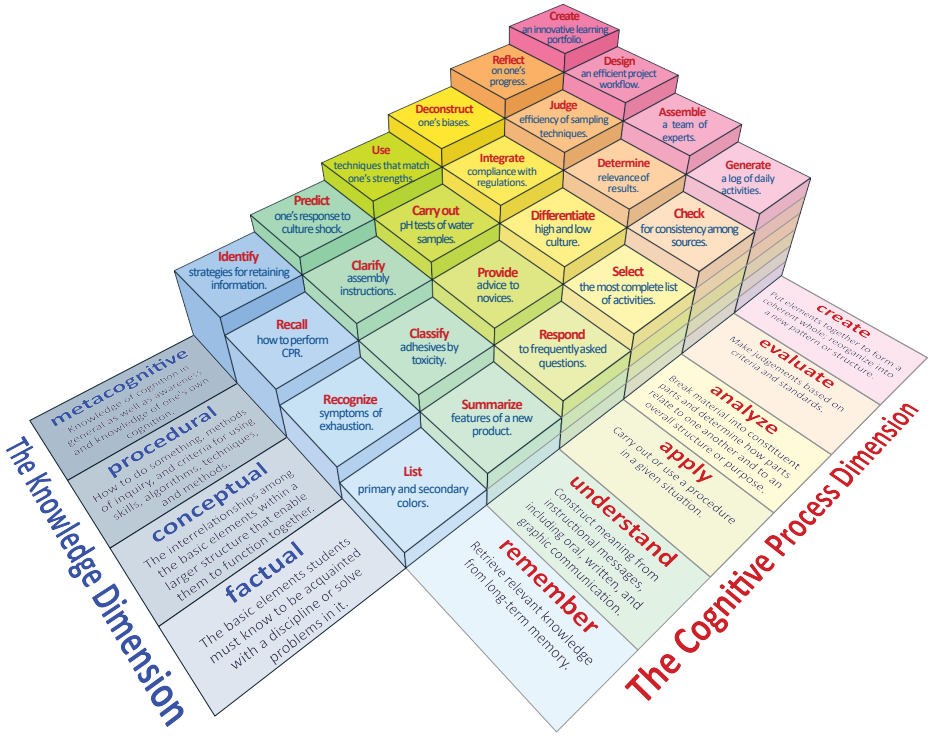


Figure 1 A Model of Learning Objectives–based on A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational [1].

1.0 Introduction

Small teaching in the title of this paper stems from the book *Small Teaching: Everyday Lessons from the Science of Learning* by James Lang. Lang's book presents incremental changes that can be applied to the classroom based on cognitive science. Techniques discussed include short classroom activities of which the activity described in this paper is one. Others include one-time interventions, online activities, or small changes in communication with students.

A past ASEE paper [2] discussed this same course when students were asked to read a technology and society related non-fiction book and to summarize each chapter as a data visualization.

This paper will discuss the revised course including lecture themes, and student deliverables. Then Bloom's taxonomy in 2D is described and the subsequent challenge of creating questions for each or the 24 dimensions: the cognitive process dimension combined with the knowledge dimension. Finally, class examples are shown. The course *Technology and Society* is a course that partially satisfies one of the twelve graduate attributes prescribed by the CEAB (Canadian Engineering Accreditation Board): "Impact of engineering on society and the environment - an ability to analyze societal and environmental aspects of engineering activities. Such ability includes an understanding of the interactions that engineering has with the economic, health, safety, legal, and cultural aspects of society, the uncertainties in the prediction of such interactions; and the concepts of sustainable design and development and environmental stewardship [3]."

1.1 The themes

The class consists of three 50-minute lectures per week. After a full introduction to the class including all deliverables for the semester, the lectures are presented as themes. Each theme covers 1800 to present. The material starts in 1800 because this is about the time that engineering becomes an education and profession as we know it today. The French started focused on civil engineering with emphasis on mathematics and developed university engineering education sponsored by their government. The British established mechanical engineering and self-governing professional societies, which allowed information to flow more quickly through organized meetings and journal publications. Practical thinking became scientific in addition to intuitive, as engineers developed mathematical analysis and controlled experiments, and technical training shifted from apprenticeship to university education.

The time before is summarized as the great dispersal (100,000 to 10,000 BCE | BCE: Before the common era and CE: common era), the Neolithic (10,000 to 3,000 BCE), land-based empires (3,000 BCE to 1500 CE), ocean-based empires (1500 to 1800 CE). 1800 to 2000 is characterized as the Anglo-American world and 2000 to present as the new globalization [4]. The course discusses the last two periods in detail.

The lecture themes are layered. Images from past lectures are included in subsequent themes as reminders of topics we discussed and where relevant connections are made between the various themes. In figure 2 for example, a slide is shown from theme five: *Military conflict and technology*. Along the top and bottom the imagery from the previous 4 themes (in this case: production processes, communication, computation, and energy) is available for discussion and linking. The 20-year period shown (one of 11 periods within the 1800-present timespan) has been characterized as Steel/Electricity in part the latter made possible by Tesla and Edison, the former causing changes in weapons production, the way wars are fought, and resulting in some of the first skyscrapers. Improvements in photography and the arrival of film allows images of the Boer and Opium wars to be recorded and archived. The lectures cover 15 themes in total to address the accreditation board requirements and beyond.

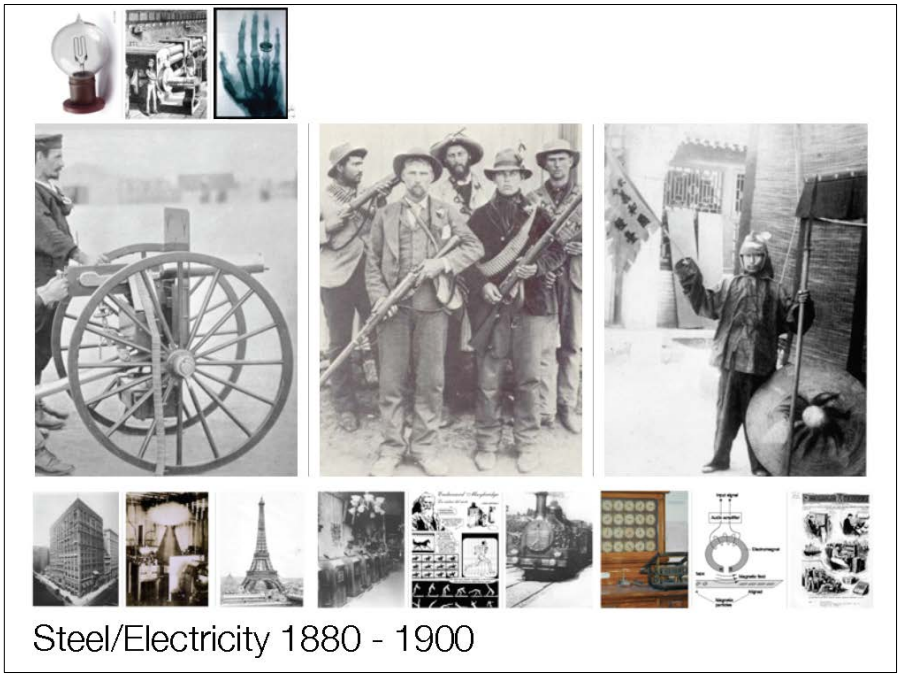


Figure 2. Sample page from theme lecture Military conflict and technology

1.2 The deliverables

The course is treated as a data course: the students are provided with a myriad of data points throughout the semester and rather than having them memorize these data 'facts' the course has shifted to having them work with the data. The course projects therefore are not directly related to the lecture content. However, students are in general time-stressed and this led to a large lecture attendance/deliverable portion of the grade: a third in fact.

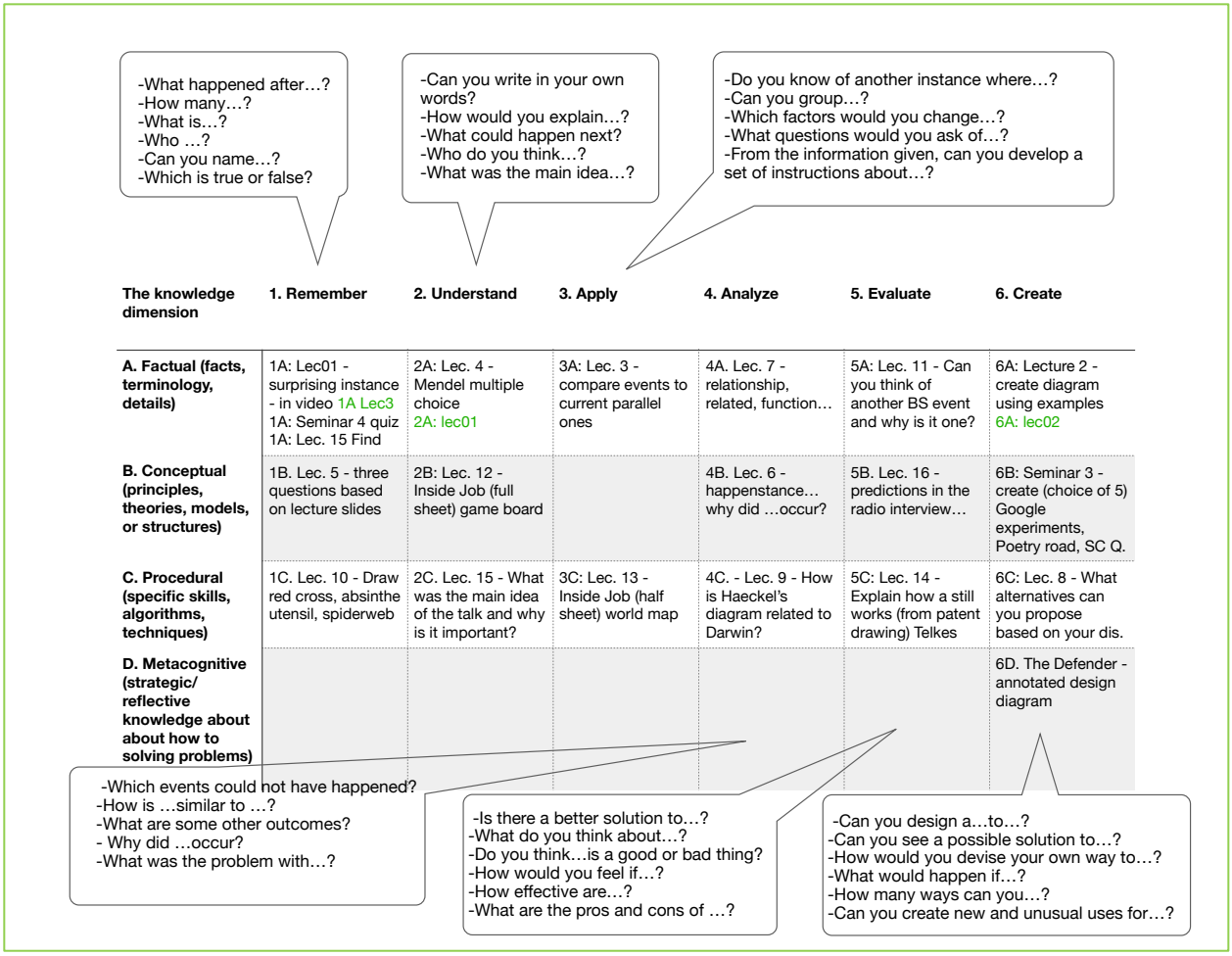
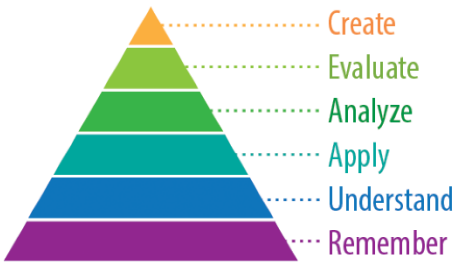


Figure 3. 2D Bloom's grid lecture questions working document

It was a challenge to come up with 24 lecture-based questions to be answered in class based on the revised Bloom's taxonomy. The working document in Figure 3 shows a mid-semester snapshot of some of the questions asked. The document in the meantime has been updated three times to date and will be an ongoing reminder to vary questions, to think about creative ways to have students think about the material from different angles, to find parallels in their own lives, and to apply historical examples to current situations. Students are free to consult their neighbors and their phones but at the end of class have to hand in a small chit with their answer(s) to the TAs for the course.



The revised taxonomy combines the pyramid most of us are familiar with (Figure 4) also known as the cognitive dimension with the knowledge dimension ranging from concrete to abstract (Table 1).

Figure 4. Bloom's taxonomy pyramid [5]

Table 1. The Knowledge Dimension – major types and subtypes

concrete knowledge → abstract knowledge			
factual	**conceptual**	**procedural**	**metacognitive***
knowledge of terminology knowledge of specific details and elements	knowledge of classifications and categories knowledge of principles and generalizations knowledge of theories, models, and structures	knowledge of subject-specific skills and algorithms knowledge of subject-specific techniques and methods knowledge of criteria for determining when to use appropriate procedures	strategic knowledge knowledge about cognitive tasks, including appropriate contextual and conditional knowledge self-knowledge

1.3 The chits

Students are each given a chit at the start of lecture and at random moments during the lecture, one or more questions will appear on the screen asking students to remember, understand, apply, analyze, evaluate, and create in the context of facts, concepts, procedures, and where possible strategic, contextual, and self-knowledge. Sometimes the question will refer to something said a few slides ago; other times the questions ask them to duplicate a method and apply it to personal data or general knowledge. Figure 5 is an example of questions asked during a documentary. In the case of lecture-long films the chits are more elaborate and have multiple activities that need to be completed while watching.

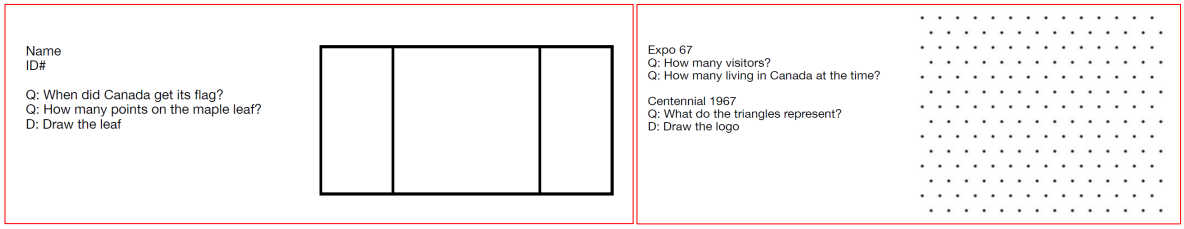


Figure 5. Lecture chit for a design documentary

During an introductory lecture on the history of data visualization they were asked to summarize their day up until the lecture using one of three historical examples (Figure 6).

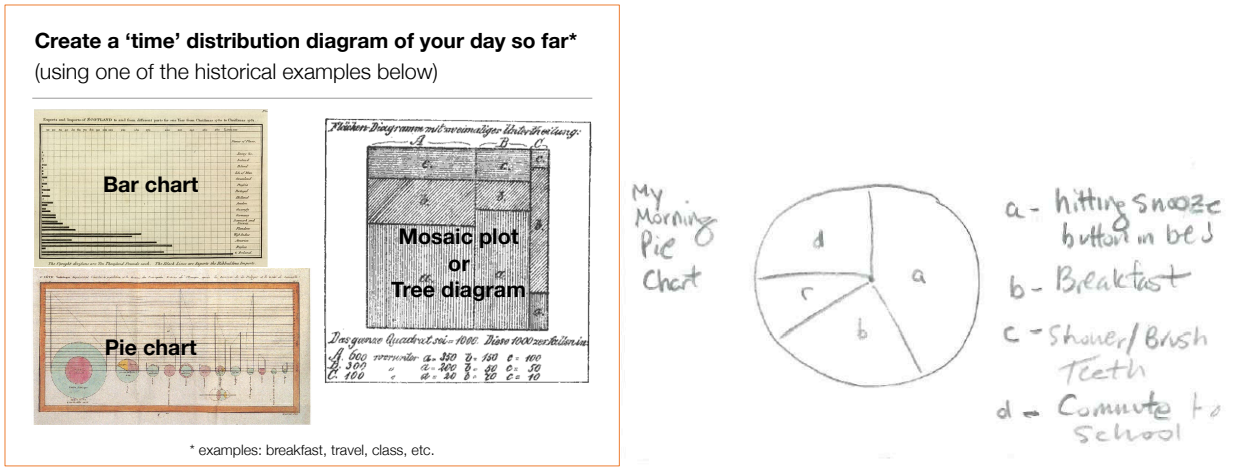


Figure 6. Bloom's question category 6A (create a diagram based on examples using your data) and student deliverable for 8 am class.

A lecture on the theme of communication included a discussion of the history of genetics. Gregor Mendel's study of pea plants showed that one in four pea plants had purebred recessive alleles, two out of four were hybrid and one out of four were purebred dominant. Students were asked to complete a Punnett square and answer a question based on the results (Figure 7).

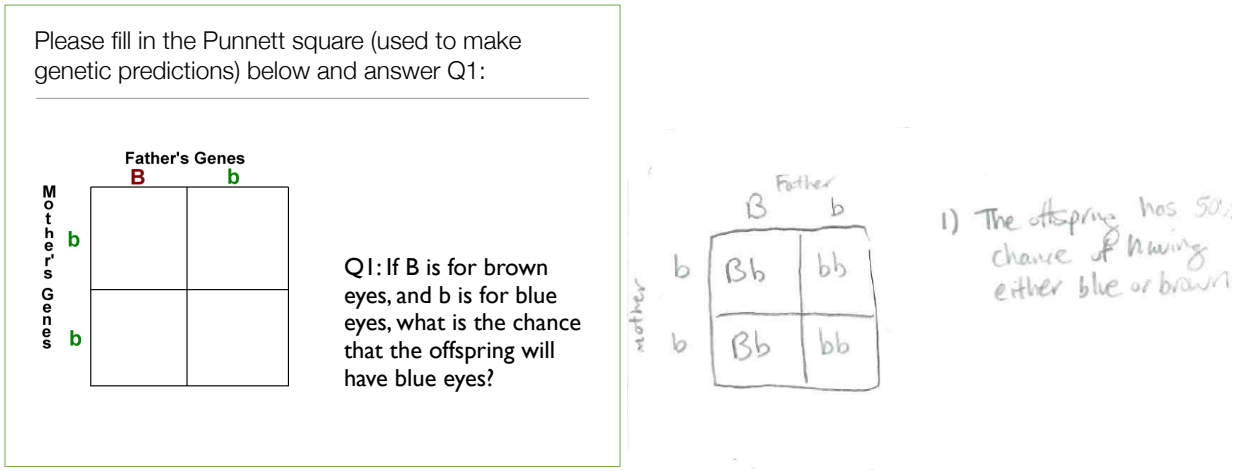
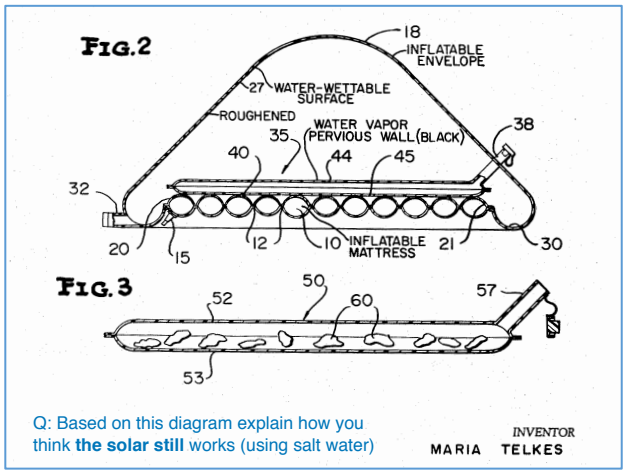


Figure 7. Mendel's Laws of Inheritance.

During a theme lecture on engineering and food we discussed Maria Telkes, who from 1939 to 1953 was involved in solar research at MIT. She is known for creating the first thermoelectric power generator in 1947 and the first thermoelectric refrigerator in 1953. One of her specialties was phase-change materials, including molten salts to store thermal energy. She also developed a collapsible solar still, which was included in emergency medical kits. The motivation for the design was of military origin: soldiers stranded at sea were faced with a lack of drinking water –

a threat to their survival. The still was perfect for warm, humid, tropical latitudes. Students were shown the patent drawing of Telkes' design and asked to explain how they thought the still worked.



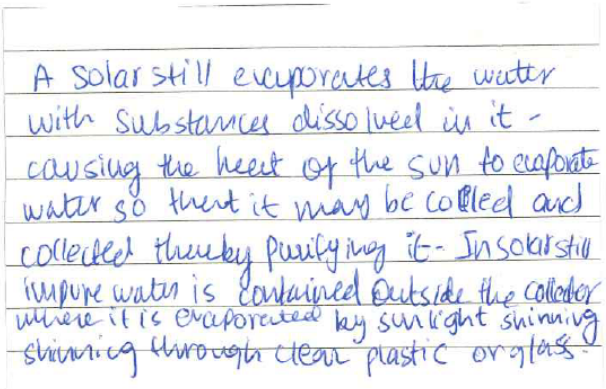


Figure 8. Bloom's question category 5C (evaluating a technique) and student deliverable.

2.0 Conclusion

This work-in-progress paper discussed a type of *small teaching* example to engage students with the lecture material of a mandatory technology and society course common in engineering programs. The lecture deliverables were designed with the revised 2D Bloom's Taxonomy in mind. Examples of questions and student deliverables were discussed. Possible changes include having students create their own Bloom's questions [6]. A multi-year study will follow this paper to report on learning outcomes.

References

[1]"Revised Bloom's Taxonomy - Center for Excellence in Learning and Teaching - Iowa State University", Celt.iastate.edu, 2020. [Online]. Available: http://www.celt.iastate.edu/teaching/effective-teaching-practices/revised-blooms-taxonomy/. [Accessed: 13- Jan- 2020]

[2] Eggermont, M. (2013, June), Information Graphics and Engineering Design Paper presented at 2013 ASEE Annual Conference & Exposition, Atlanta, Georgia. https://peer.asee.org/19763

[3] *Mcgill.ca*, 2020. [Online]. Available: https://www.mcgill.ca/engineering/files/engineering/ceab_graduate_attributes_and_their_definitions.pdf. [Accessed: 29- Feb- 2020]

[4] "Globalization: Past and Future - SDG Academy", *SDG Academy*, 2020. [Online]. Available: https://sdgacademy.org/course/globalization-past-and-future/. [Accessed: 02- Feb- 2020]

[5] "Applying Blooms Taxonomy in Corporate eLearning with mLevel » mLevel", mLevel, 2020. [Online]. Available: https://www.mlevel.com/blog/applying-blooms-taxonomy-in-corporate-elearning/. [Accessed: 13- Jan- 2020]

[6] Hane, E., & Franklin, S. (2019, April), *Improving Inclusivity and Diversity in College STEM Programs Through Metacognitive Classroom Practices* Paper presented at 2019 CoNECD - The Collaborative Network for Engineering and Computing Diversity, Crystal City, Virginia. https://peer.asee.org/31770