Personalized Learning: Building a Model

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Abstract

At the author's university, Wentworth Institute of Technology, 'Advanced Civil Engineering Materials' is a predominantly hands-on, lab-based course and is a new elective. Understanding how to build an experiment is an important aspect in this course. While developing the curriculum, this topic was intended to be a smaller unit which would take one week to complete. The students were taught the different types of models, both physical and virtual. They were also taught the situations where one would prefer one type of model over another. For example, strength model v/s an elastic model. To increase student enthusiasm, the students were encouraged to make a model. This model could be any kind of model and of any size. The only requirement needed to discuss with the instructor and provide the instructor with the estimated cost. This was done to ensure that the scope of the model was feasible, and it was within the budget. Students made a variety of models including wood models, the model of a dam, and the DaVinci bridge to name a few. The students used their own background, strengths, and interests to develop a personalized learning module which is evident from the student abstract that accompanied the model. This paper illustrates the lesson plan, the timeline, cost, and planning for the models, the lessons to be learned from each model, and the appropriate method for assessment of such topics.

Introduction

This was a one-week module in an advanced materials class to teach the concept of theory to practice. Essentially, the goal was to teach the students the concept that the experiment might look very different than the original but still be able to get the desired result.

Lesson Plan

The students were taught various models as explained below.

Types of models: Structural models can be defined in a variety of ways. When building a model, the most important question one should ask is, "What do I want from this model?". Do I want to know when this model is going to fail? Do I want to demonstrate a behavior? Or is it something else? Based on the requirements, it is decided what type of models should be built. Some popular models are described below [1]:

- Elastic Model: An elastic model usually is geometrically like the original but may be made of a different elastic material. This is a good model to study the elastic behavior but is not useful is predicting the plastic behavior. This model is usually built with plastics such as Plexiglass or polyvinylchloride (PVC).
- Indirect Model: An indirect model usually is a type of the elastic model that is used to obtain influence diagrams for reactions, shear force, bending moment and axial force. This model might look very different from the original structure.
- Direct Model: A direct model is geometrically like the original structure. The loading is also similar. An elastic model can also be a direct model.
- Strength Model: A direct model is a direct model which predicts behavior up to failure.
- Wind Effects Model: There are various. ways of classifying wind effects modeling. We can utilize shape or rigid models, where either total forces or the wind pressures on

the structure may be measured, and aeroelastic models, where both the shape and stiffness properties of the prototype structure are modeled to measure the wind-induced stresses and deformations and the dynamic interaction of the structure with the wind.

- Dynamic Model: A dynamic model is usually used to study earthquake loading, blast or wind tunnel effects.
- Instructional Model: is a simple model made to demonstrate a concept of study.
- Research Model: is a highly accurate model used to aid a theory.
- Design Model: is usually used to explain a concept. Sometimes it may be used to predict the failure as well.
- Virtual Model: is a model built using a software. It might be an elastic model, instructional model, or any other type of model.

After this, the students were asked to submit a plan to build their own model along with a cost estimate. The students were told to decide a topic and proposal with a cost estimate in one week. They were then given one more week to build the model. Class time allotted for this module was one-week (1 hour lecture and 4-hour lab). The students had another week to work on the project as a homework.

The students made a variety of models including a Residential House Frame Demonstration, Da Vinci bridge, soil structure model, a canoe, 3-D printed shapes, and a septic tank. The students used their own background, strengths, and interests to develop a personalized learning module which is evident from the student abstract that accompanied the model. The student who made the Da Vinci bridge is an ROTC student and wrote this about her project, "Drawing from a concept first introduced by Leonardo Da Vinci to support troops, this span can be quickly, easily, and safely constructed over spans and obstacles such as creeks or ravines". Similarly, the student who worked extensively in a 3D printing laboratory gravitated toward printing complex shapes. To show the ability of the 3D printer to go from design to complete product in the classroom allows for experimentation with designs and testing with a very low turnaround time. Some of the student models are described below.

Description of the Models

The description of the models is based on the description given by the students. The students were aware of the possibility of this work being shared with the community.

Da Vinci Bridge: The objective of this project was to build and demonstrate the use of a self-supported bridge using no fasteners. Using only planks and dowels, students will be able to construct a 10 feet bridge span themselves that can support the weight of a person

Fig. 1 Da Vinci bridge.

walking over it. This allows students to explore and visualize firsthand forces and how they act. Drawing from a concept first introduced by Leonardo Da Vinci to support troops, this span can be quickly, easily, and safely constructed over spans and obstacles such as creeks or ravines. It does not take an advanced level of education, a copious amount of materials, or an additional amount of time. Refer Fig. 1.

Residential House Frame Demonstration: This model will be used to demonstrate the proper techniques required for structural framing in residential homes. This model is comprised of a sample floor, wall, window, and roof frame. This model will demonstrate the proper cutting, fastening, and assembly techniques as well as the proper terminology for all parts of a residential house frame. This model can be used as an educational example for students of all ages and experience levels. Refer Fig. 2.

Fig. 2 Residential house frame demonstration.

Canoe: This project is about creating a mini model canoe to study the different materials that can utilized to create a full scaled, functional canoe. More specifically, this project will provide insight on how the utilization of concrete can produce a fully functional canoe. Although the production of the model is suited for all ages currently attending school, the reason for creating such a model is best understood by anyone at a high school level education or above. Refer Fig. 3.

Fig. 3Model of a canoe.

Using 3D Printers to Explain Complex Shapes: Complex shapes have historically been difficult to reproduce with high precision in a classroom environment. This is due to the relative high cost of machining and required precision needed for them to exhibit the intended behaviors. The ability of the 3D-printer to go from design to complete product in the classroom allows for experimentation with designs and testing with a very low turnaround time. To illustrate this, two 3D-printed complex shapes have been printed exemplifying unusual behaviors to be used in the classroom setting in order to supplement teaching on related topics. Refer Fig. 4.

Fig. 4 Using 3D printers to explain complex shapes.

Model Earth Dam: This design intends to model a small earth dam fill constructed of different types and gradations of soils. The final model will clearly demonstrate the ability of an earth fill to be engineered so that it can retain a large amount of water without failing. The audience will learn the basic concepts of the mechanics of soils and the ability to achieve structural strength based on grain sizes and interparticle locking. The concepts will be presented in a fashion that is suitable for students from middle – high school ages to understand. Ref. Fig. 5

Fig. 5 Model earth dam

The students were evaluated based on the rubric shown in Table 1.

Assessment Rubric

An open-ended project is usually tricky to grade. A rubric was developed to grade the models. The students were evaluated based on the capability to build a sturdy structure where civil engineering concept is clearly visible and their ability to accurately explain the presented information. Additionally, topic selection, proposal submission, final submission and presentation was also evaluated.

	4	3	2	1	Score	Multiplier	Total
Interpretation	Model has the ability to accurately explain the information presented	Model has the ability to explain the information presented	Model makes an effort to explain the information presented	Model partly explains the information presented		2	
Representation	Clear explaination of which type of model is represented, and why	Good explaination of which type of model is represented, and why	Clear explaination of which type of model is represented	Some explaination of which type of model is represented		3	
Application	Model is directly relaed to civil engineering concepts and the student clearly shows the connection	Model is directly relaed to civil engineering concepts and the student makes an attempt to show the connection	Model is directly relaed to civil engineering concepts.	Model is relaed partly to civil engineering concepts.		4	
Construction	Concept is clearly visible because the model is constructed with engineering principles. Construction of the model is sturdy.	Model is constructed with engineering Principles and the concept is established	Model is constructed with engineering principles and the attempt at the concept is seen	Model does not fall apart		5	
Communication	Presentation clearly expresses the concept and purpose of the model. Explaination is meaningful and concise	Presentation expresses the concept and purpose of the model	Presentation expresses the concept or purpose of the model.	Presentation was attempted		4	
Topic	Topic was submited on time. If revisions were suggested, that was done in an appropriate manner	Topic was submited on time. If revisions were suggested, that was done with multiple iterations	Topic was submitted on time. If the revisions were suggested, they were not done on time	Topic was submitted after due date		1	
Proposal	Proposal was submitted on time, gramatically correct and contained clear vision, cost estimate and plan	Proposal was submitted on time, gramatically correct and contained cost estimate and plan	Proposal was submitted on time, some grammar errors, good attempt at cost estimate and plan	Proposal was submitted on time, signigicant grammar errors, cost estimate and plan were incomplete		2	
Final	Proposal was submitted on time, gramatically correct and contained clear vision, cost estimate and plan	Proposal was submitted on time, gramatically correct and contained cost estimate and plan	Proposal was submitted on time, some grammar errors, good attempt at cost estimate and plan	Proposal was submitted on time, signigicant grammar errors, cost estimate and plan were incomplete		4	
						Total =	

Reflections

This was an elective course which did not have a set curriculum yet and was run as a trial. We got to experiment a little with the course presentation. The authors were trying to base this module on the Montessori method of education. The Montessori method is based on the principle of auto education. When a proper prepared environment is built, the eager mind teaches itself. The learning happens through play, and the result is that the child learns in a way that cannot be forgotten at the end of the semester. This method was developed by Dr. Maria Montessori to teach preschool age children and is a popular method of education in younger children. Recently there has been some use of this method in Engineering Education[2]. Building on the Montessori method the classroom was in a lab. Various geotechnical instruments were a part of the classroom. These were considered inspirational artifacts. When the students were presented with various models, they could see the various models in the Geotech lab. When they were presented with this module, several of the examples used were strategically placed around the room. The assignment given was purposely very open ended to see the reactions of the students. Since it was relatively low stakes, just one week in a semester, the idea was to observe if the students learn when they are given a lot of flexibility and control of their own learning.

There were 9 students in the class. The mean of the grades earned by all students was 93.7 and standard deviation was 3.7. This grade was considerably higher than the grades earned by the same students in other traditional module which was 85 with a standard deviation of 5.8. Short answer questions on this topic were asked in the final exam. All but one student answered perfectly. One student earned slightly less than perfect grade in that question in the final.

The short term grades as well as long term grades show that the students benefitted from this module. The students comments like, “It was very fun, but I also learned a lot” and “It did not feel like homework” were beneficial in determining what the students felt about the module. Inspiring the students was one of the goals of the experiment which was achieved as can be seen by these comments.

An unintended benefit of this module is that the school will also have plenty of demonstration models for outreach activities and admission events like open houses.

Conclusion

This was a good starting point for a module. However, it would have been helpful to encourage the students to make different types of models instead of mostly instructional models. When this course is taught again, this change will be incorporated. More data needs to be obtained to find the true effectiveness of this pedagogy. With limited data, this model of teacher seems promising.

References

[1] Harris, H. and G. Sabnis. “Structural Modeling and Experimental Techniques, Second Edition.” (1999).

[2] Kamat, A., Kazemiroodsari H. and Anderson, L. “Classroom Demonstration Module for Two- and Three-dimensional Force Analysis: The Montessori-based Engineering (MBE) Model”, ASEE (2020).