OFFICE OF EDUCATIONAL ASSESSMENT
Improving Learning Through Assessment

Pilot of Embedded Multimedia for Engineering Mechanics Education Overview Evaluation Report

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BACKGROUND

During the 2005-2006 academic year, engineering classes at three different universities (University of Washington, University of Wyoming, and California Polytechnic State University at San Louis Obispo) piloted several interactive, computer modeling exercises. Funded by a National Science Foundation Course, Curriculum, and Laboratory Improvement Grant, one purpose of the project was to pilot some existing exercises. However, another key aspect to the project as a whole is giving faculty a scripting and programming "tool box" to create their own exercises and meet their unique instructional needs.

This report summarizes evaluation data collected during all four iterations (including two at Cal Poly) involved in this pilot. The first purpose of the evaluation was to understand students' experiences using existing interactive exercises. To the end, students completed online surveys before and after each exercise. The second purpose of the evaluation was to gather data from the faculty involved in the pilot so as to understand their experience using the tool, to gauge the likelihood that they would create their own exercises, and to explore what types of support should be in place if the tool were to be disseminated to other instructors at their institution or beyond.

METHODS

A. Student Surveys

In total, three different exercises were used focusing on three general structural concepts: trusses, frames, and stiffness. Links to brief, online surveys were embedded into the introductory text as well as the final page of each exercise. Using this pre- and post-format, participants answered content related questions and provided ratings for how confident they were about their answers to these questions. On the post-survey, participants provided ratings and answered open-ended to indicate the value of the exercises, their satisfaction with them, and how they thought the exercises could have been improved. The surveys are presented in their entirety in the Appendix.

Pre- and post-survey participation levels for each exercise at each institution are provided in Table 1.

Table 1. Participation in pre- and post-surveys for each exercise, listed by location and exercise focus

Institution & Focus	# Pre	# Post
University of Washington (Trusses)	26	26
University of Wyoming (Frame)	13	11
Cal Poly (Frame)	20	18
Cal Poly (Stiffness)	14	13

B. Faculty Interviews

Three participating faculty members (two from University of Wyoming and one from California Polytechnic) were interviewed by telephone about their perspectives on using embedded multimedia presentation of course content, the perceived barriers for developing and using such exercises, and their thoughts on how best to disseminate these educational tools. The interviews lasted approximately 20 – 30 minutes during which the evaluator took detailed, typed notes. The entire list of questions used in the interviews is presented in the Appendix.

RESULTS

A. Student Surveys

This section contains a summary of results form the pre- and post-student surveys across all iterations of the three different exercises, with separate sub-sections for results from (1) the content questions (including confidence ratings) and (2) the evaluative questions presented on the post-survey only.

1. Content Questions

For each iteration of the pilot exercises, participants were asked two to three technical, content-related questions on both the pre- and post-surveys. These essentially served as quiz questions to indicate how well participants understood the material. In addition, after each question, participants were asked to rate their confidence about their response.

Aggregating across all the relevant content questions, Figure 1 shows the overall proportion of correct responses from each iteration (pre- and post-) and Figure 2 shows mean confidence ratings for all four iterations of the project (pre- and post-) on a scale of 1 “No confidence at all” to 6 “Completely confident.”

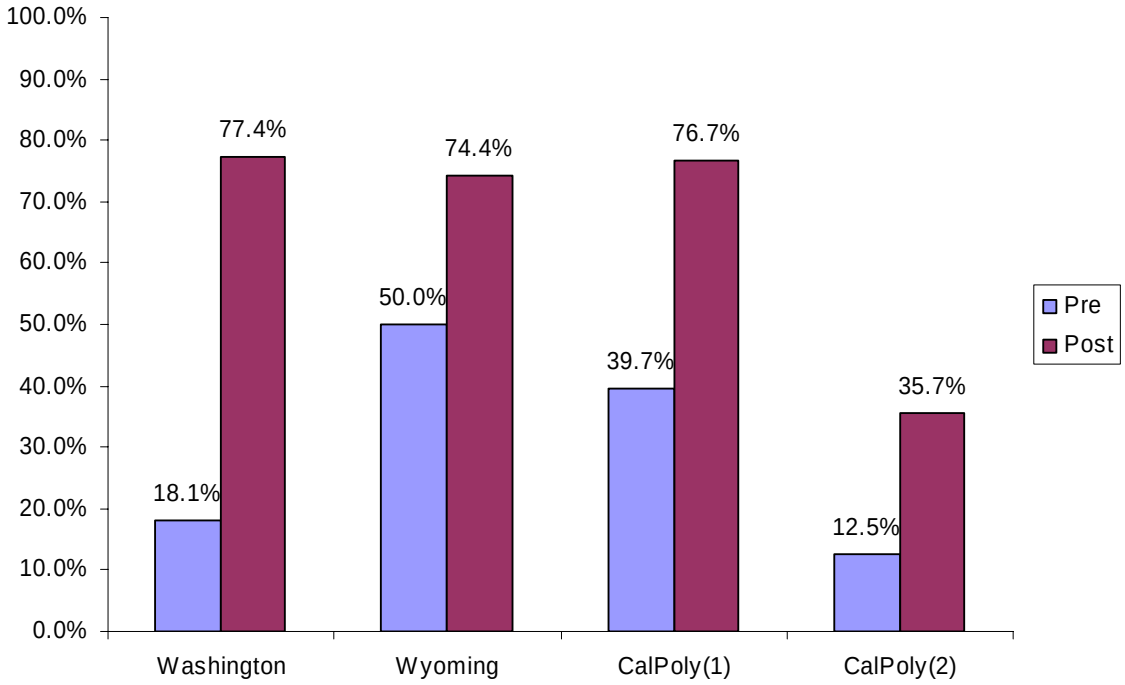


Figure 1. Overall proportion of correct answers to the content-related questions on the pre- and post-survey, separated by iteration

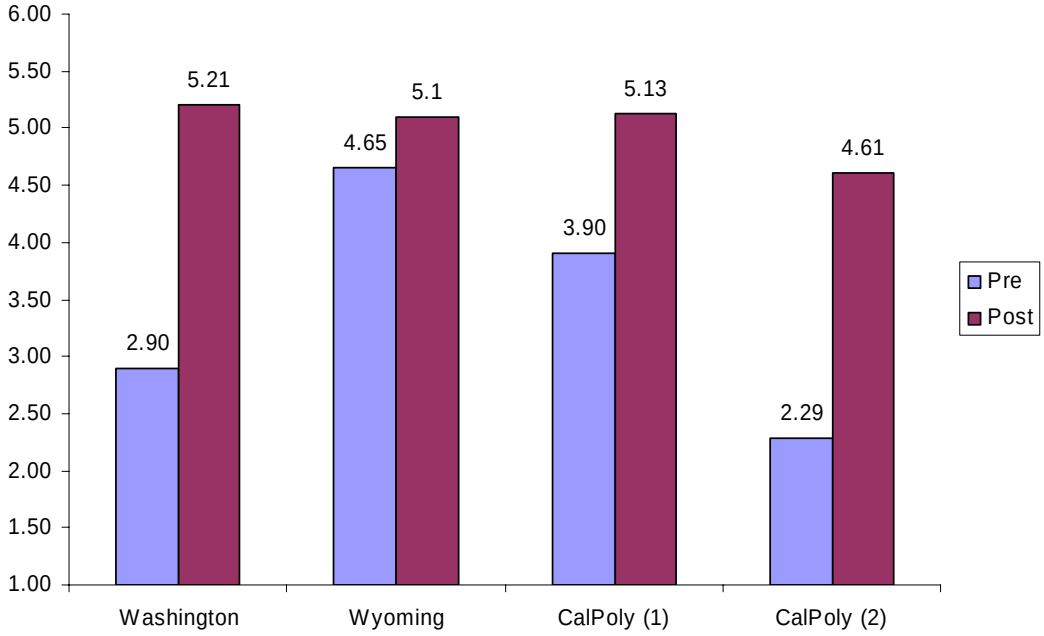


Figure 2. Mean pre- and post-confidence ratings about the content-related questions, separated by iteration.

2. Evaluative Questions

On the post-survey only, participants were asked to indicated how much they agreed or disagreed with evaluative statements about the exercises. Figure 3 shows mean responses to these items, separated by iteration, with ratings from 1 "Strongly disagree" to 5 "Strongly agree."

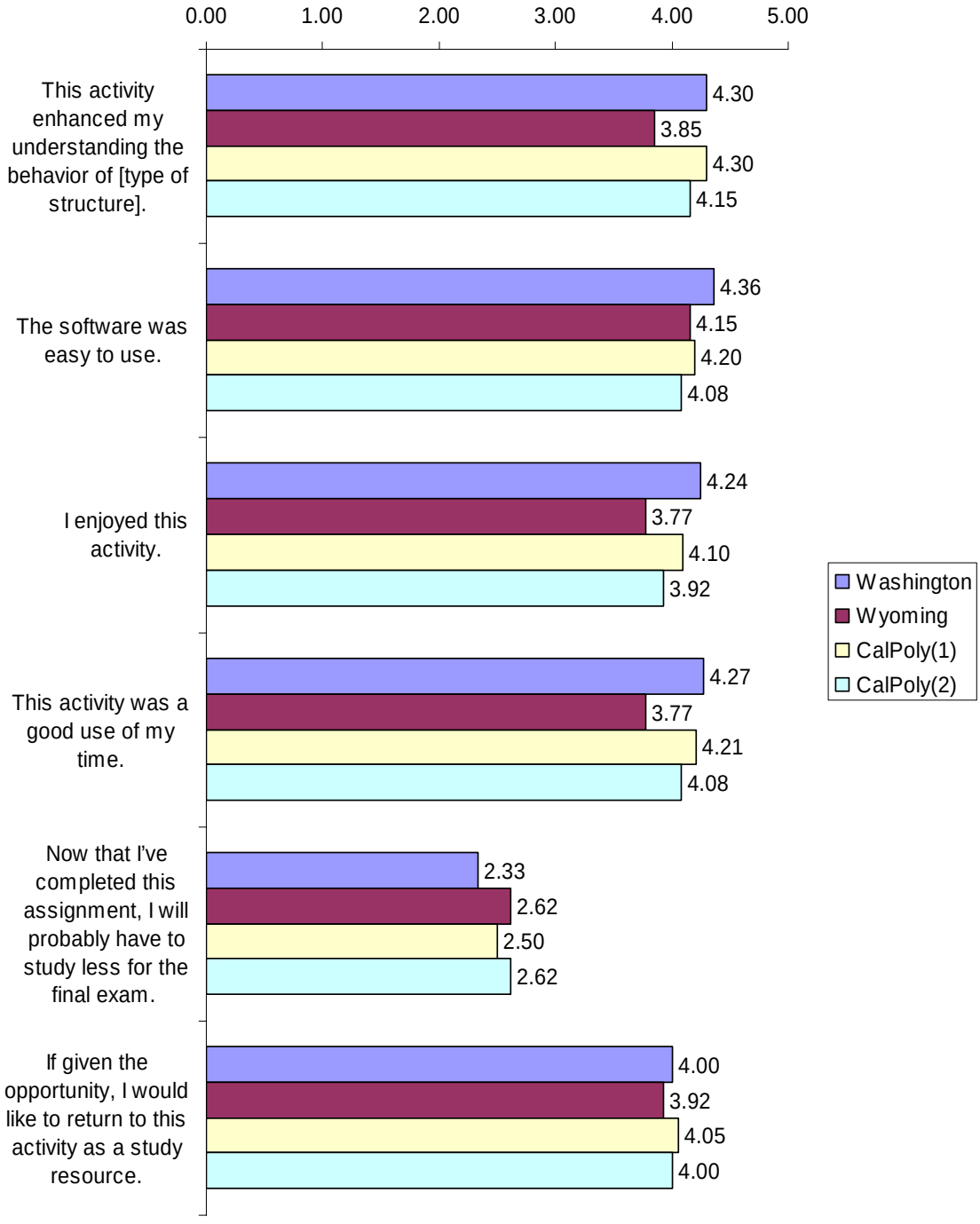


Figure 3. Mean responses to evaluative questions about the exercises, separated by iteration

B. Faculty Interviews

Responses to the faculty interviews were analyzed according to three primary topics: Benefits of using the exercises, costs of developing the exercises, and dissemination. Results from the interviews are summarized below, according to these topics.

1. Benefits of the exercises

When asked about how students benefited from the exercises above and beyond regular instruction, all three faculty interviewees indicated that by interacting with the visual models, **students gained a "bigger picture" view** (i.e., "Students can focus on concepts rather than on particular problems.") **or an intuitive sense for how these types of structures behave** (i.e., "Recognizing when something is just *wrong* is important."). Two of these participants compared the modeling tool to the cumbersome and non-intuitive process involved in performing a series of calculations. The third participant indicated that that the text provided along with the interactive models was particularly useful in highlighting what students should be seeing, even if the instructor was not there to do so.

In addition to allowing for a more conceptual and/or intuitive understanding of structures, participants also described the exercises as **unique teaching tools** unlike anything they had ever used before. One instructor also indicated that the exercises were good complements for teaching tools he already used, particularly for assisting students who might think in a more applied and less abstract way. Another faculty member indicated that the exercises can be a good way to introduce related mathematical concepts in a way that does not intimidate students, noting that applying math can be a barrier for some students.

Participants also discussed how to make the exercises most effective. Two participants indicated that the activities **must be required** as students would probably not complete the exercises if they were optional. One participant also suggested that the activity worked best if it covered content students already know and it can be a review that students do on their own.

2. Costs of developing exercises

In addition to the benefits of these exercises, participants were asked about potential costs of implementation. **First and foremost was the time it takes to develop the exercises** and participants were asked to estimate specifically how much more time it would take to develop an online exercise in comparison to a regular lesson. Responses to this question were mixed, with one participant estimating that it would take twice as much time to develop an online exercise and the other two indicating that it would take about the same amount of time. As one participant said (paraphrased), "Once the technology skills are there, the time is mostly the constant problem of 'Why am I teaching?'"

Two participants also commented that as they developed more exercises, they would become faster at it. One participant noted specifically that in addition to the content development time, there was also time investment in the form of becoming familiar with the technology involved. The topic of learning to use the technology was also addressed when participants discussed how to encourage and support faculty in adopting the modeling exercises (see below).

In an additional question, participants were asked specifically whether the benefits of these exercises outweighed the costs of development. The two participants who responded to this question indicated that **the balance between costs and benefits depends on the size of the class and the number of exercises**. One of these instructors felt that with a small class, it was as useful for him to draw figures and to provide extra help to the few students who needed it. This individual noted, however, that with a larger class, the scalability of the online exercises would increase the number of students who benefited, making the benefits outweigh the time investment. The other participant indicated that the costs of developing many different exercises might not outweigh the added benefits of having many different concepts addressed through this technology, but that the small cost of developing a few exercises for a couple of selected difficult concepts was worth the benefits to student learning.

3. Dissemination and Adoption

One individual noted that there were two or three other faculty in his/her department who were probably going to use the exercises in their classes. Beyond these actual connections, participants were asked about how best to encourage or "sell" the exercises to instructors and administrators, what barriers might exist to prevent faculty from adopting them, and what support would be necessary for faculty to implement the exercises.

When asked about how best to encourage other faculty and perhaps whole departments to adopt these exercises, two of three participants emphasized the importance of **assessment data** as a way to get the attention of other faculty and administrators. They said that evidence that the exercises impact student learning would be compelling to almost anyone considering adopting the tool.

Another theme (mentioned by two participants) was that **dissemination would work best from personal referral or through a "champion."** These individuals suggested that a more systematic dissemination (through departments or a Center for Teaching and Learning) would probably not motivate them or other faculty to adopt the exercises. One individual indicated that without his/her existing personal connection to the PI for this project he probably would not have considered trying out the exercises in his/her class.

In discussing potential barriers for adoption, two of three participants expressed fairly strong concerns about faculty being **daunted by the scripting technology** but that one-on-one tutoring and basic training might help overcome this barrier. All three participants also agreed that such training would be essential support for faculty who might use these exercises. One individual suggested developing an online tutorial for exercise development.

Another individual indicated that motivation might be a barrier for using the exercises and definitely for faculty creating their own exercises.

All three participants agreed that the best way to support faculty in using these exercises would be to **provide a repository of exercises that were already made**. One participant was a bit embarrassed to admit that the one way to ensure that he/she used the exercises would be for someone just to create them for him/her ("That would make me really happy.").

Participants provided several other ideas for how to support faculty in using these exercise, including:

- Providing summer support for developing exercises

- Release time from classes for development
- A graduate student or teaching assistant to help in the development and implementation of the exercises.

EVALUATOR COMMENTS AND RECOMMENDATIONS

Below are a few comments and suggestions from the evaluator's perspective. Note that this section represents the evaluator's interpretation of the data and does not represent a summary of information provided directly by participants.

The survey data suggest that, in general, participants did gain some understanding of the content material from the exercises, with approximately three-quarters of responses to the technical questions on the post-survey being correct. The one exception was in the stiffness exercise piloted at CalPoly, where on the post-survey, only approximately one-third of responses were correct. However, interview data indicated that the students who participated in that particular exercises might not have been adequately prepared for the content material.

In general, these exercises seem to be beneficial in that they improve students' understanding, at least immediately, of certain concepts. The interviewed faculty also pointed out that the exercises were useful in enhancing students' intuitive understanding of certain ideas. Students were also very satisfied with the exercises, with most agreeing that they enhanced their understanding of the material. There were no strong indications for how the exercises could be improved.

Looking ahead, there are some key factors that seem to be important for encouraging and supporting faculty in adopting these exercises. The need for additional, more compelling assessment data seems to be warranted and with a larger scale project, a more in-depth evaluation would be more feasible.

The idea of using "champions" to promote the activities is key and might be something to consciously consider and build into a plan for disseminating the tools more widely. Identifying enthusiastic faculty members who are willing to promote the tools in an informal way might be more effective than trying to connect with department chairs or campus instructional support centers. However, certain support mechanisms for faculty using the execises, such as summer support or teaching release time to develop the activities would require buy-in from administration, but that investment might be more easily gained if a critical mass of instructors were already enthusiastic about the technology.

APPENDIX: INSTRUMENTS
A. PRE- AND POST-SURVEYS (TRUSSES)

1. Do you wish to take part in this brief pre-activity survey administered by the UW's Office of Educational Assessment?

- o Yes
- o No (Please click "Submit Responses" at the bottom of this page).

2. The joints in a real truss are rarely true pin joints, which you are likely to have noticed when looking at normal bridge or roof trusses. For a typical truss, what kind of error would you expect for axial force values computed using a pinned-joint assumption (i.e., the standard truss model) versus a restrained-end assumption (i.e., rigid joints)?

a. Less than 1%
b. About 5 %
c. About 10%
d. About 20%
e. About 40%

3. How confident are you about your answer to question #2?

No confidence at all					**Completely confident**
1	2	3	4	5	6

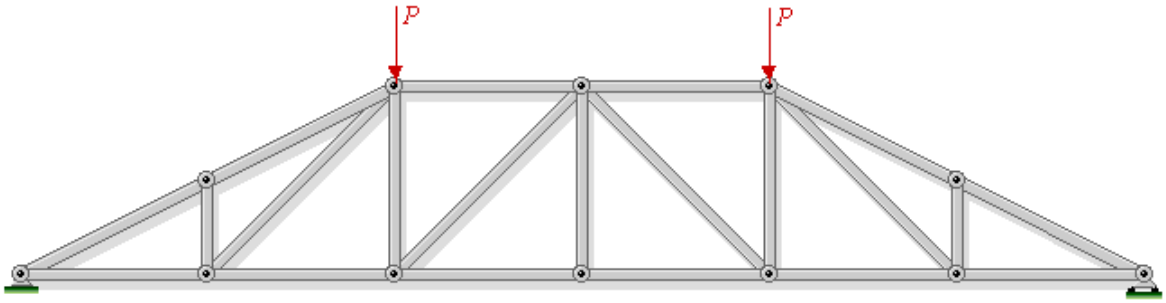
4. Following on from question #2, which of the following factors has the biggest influence on the difference between pinned versus restrained end axial force values for a truss?

a. The span of the truss.
b. The materials used to make the truss.
c. The joint details.
d. The slenderness of the members.
e. The shape of the truss.

5. How confident are you about your answer to question #4?

No confidence at all					**Completely confident**
1	2	3	4	5	6

6. Without doing any calculation, how many zero-force members are there in the truss loaded as shown below?



a. Zero
b. One
c. Three
d. Five
e. Nine

7. How confident are you about your answer to question #6?

No confidence at all					**Completely confident**
1	2	3	4	5	6

The post-survey included Questions 1 – 7 as above as well as the following questions:

8. For the following items, please indicate how much you agree or disagree with each statement.

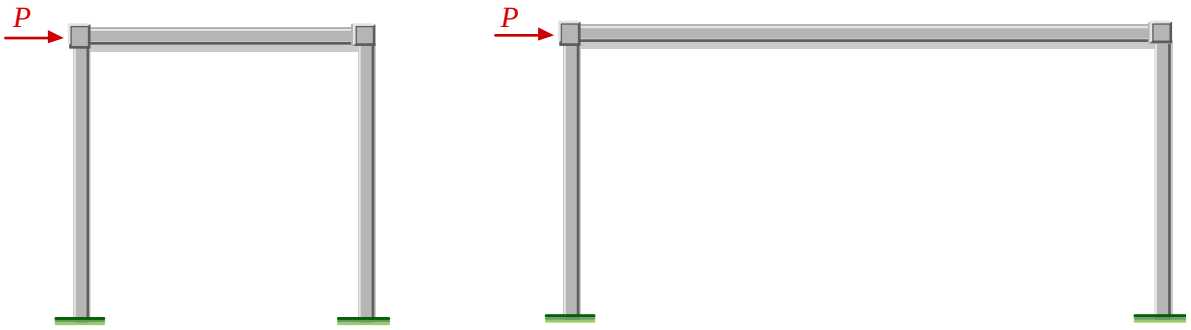
	Strongly Disagree	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**
This activity enhanced my understanding the behavior of trusses.	1	2	3	4	5
The software was easy to use.	1	2	3	4	5
I enjoyed this activity.	1	2	3	4	5
This activity was a good use of my time.	1	2	3	4	5
Now that I've completed this assignment, I will probably have to study less for the final exam.	1	2	3	4	5
If given the opportunity, I would like to return to this activity as a study resource.	1	2	3	4	5

9. What, if anything, did you find particularly valuable about this activity?

10. How, if at all, do you think this activity could have been improved?

B. PRE- AND POST-SURVEYS (FRAME)

The two frames shown below are identical except for the bay width:



A B

1. Which frame will have larger base moments at the supports?

(a) Frame A
(b) Frame B
(c) They will be equal

2. How confident are you about your answer to question #1?

No confidence at all					**Completely confident**
1	2	3	4	5	6

3. Which frame will have a larger horizontal displacement at the loaded joint?

(a) Frame A
(b) Frame B
(c) They will be equal

4. How confident are you about your answer to question #3?

No confidence at all					**Completely confident**
1	2	3	4	5	6

5. What would be the most effective way to reduce the horizontal displacement of frame A?

(a) Increase the moment of inertia of the columns by a factor of 2.
(b) Increase the moment of inertia of the cross beam by a factor of 2.
(c) Reduce the moment of inertia of the cross beam by a factor of 2.
(d) Reduce the moment of inertia of the columns by a factor of 2.

6. How confident are you about your answer to question #5?

No confidence at all					Completely confident
1	2	3	4	5	6

The post-survey included Questions 1 – 6 as above as well as the following questions:

7. For the following items, please indicate how much you agree or disagree with each statement.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
This activity enhanced my understanding the behavior of frames.	1	2	3	4	5
The software was easy to use.	1	2	3	4	5
I enjoyed this activity.	1	2	3	4	5
This activity was a good use of my time.	1	2	3	4	5
Now that I've completed this assignment, I will probably have to study less for the final exam.	1	2	3	4	5
If given the opportunity, I would like to return to this activity as a study resource.	1	2	3	4	5

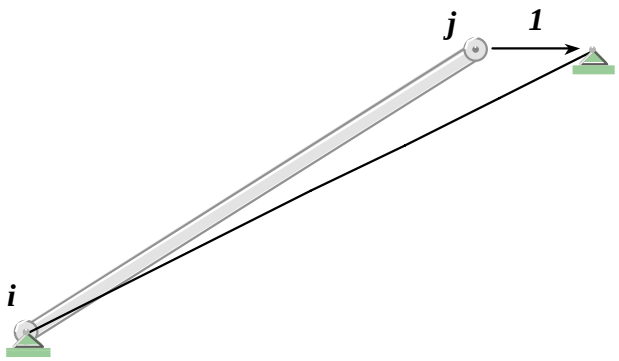
8. What, if anything, did you find particularly valuable about this activity?

9. How, if at all, do you think this activity could have been improved?

C. PRE- AND POST-SURVEYS (STIFFNESS)

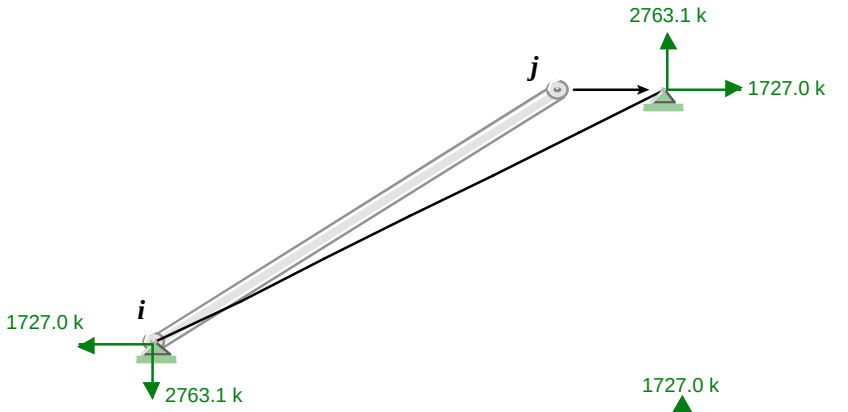
1. A truss element is subjected to a unit displacement in the horizontal direction at joint *j* as shown below. The global stiffness matrix for this element is given by:

$$K = \begin{bmatrix} 2763.1 & 1727.0 & -2763.1 & -1727.0 \\ 1727.0 & 2763.1 & -1727.0 & -2763.1 \\ -2763.1 & -1727.0 & 2763.1 & 1727.0 \\ -1727.0 & -2763.1 & 1727.0 & 2763.1 \end{bmatrix} \text{ k/in}$$

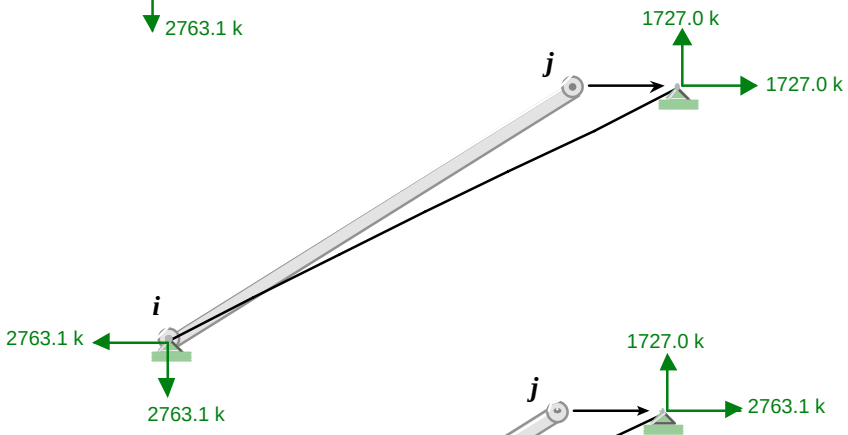


Identify the correct set of reaction forces:

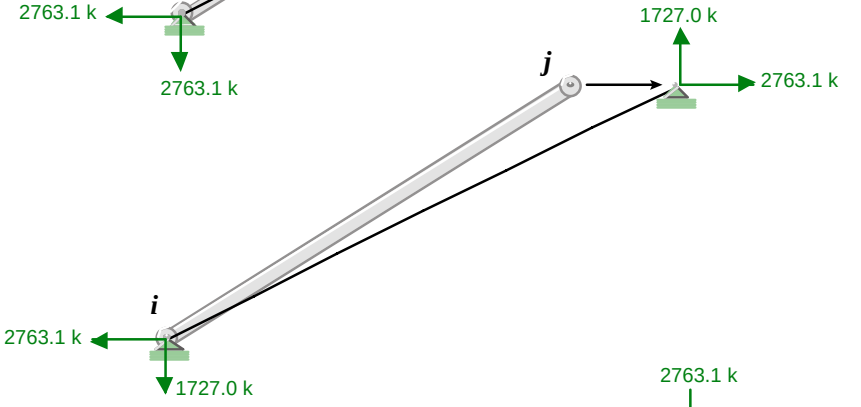
(a)



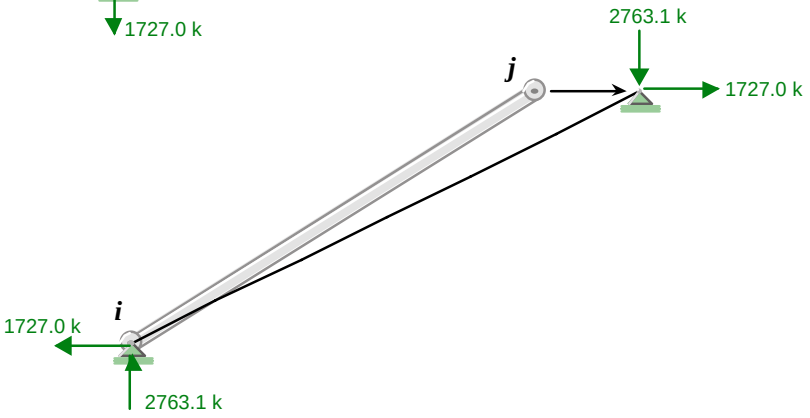
(b)



(c)



(d)

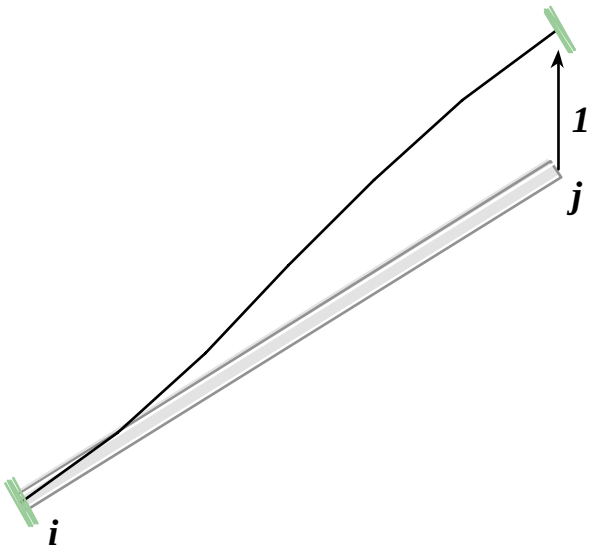


2. How confident are you about your answer to question #1?

No confidence at all					**Completely confident**
1	2	3	4	5	6

3. A frame element is subjected to a vertical displacement at end *j* with all rotations fixed, as indicated. The stiffness matrix for this element is given below:

$$K = \begin{bmatrix} 2772 & 1712 & -163.1 & -2772 & -1712 & -163.1 \\ 1712 & 1103 & 261.0 & -1712 & -1103 & 261.0 \\ -163.1 & 261 & 3870 & 163.1 & -261 & 1935 \\ -2772 & -1712 & 163.1 & 2772 & 1712 & 163.1 \\ -1712 & -1103 & -261.0 & 1712 & 1103 & -261.0 \\ -163.1 & 261.0 & 1935 & 163.1 & -261.0 & 3870 \end{bmatrix}$$



What is the moment at end *j* (assuming consistent units)?

(a) 163.1
(b) 1103
(c) -163.1
(d) -261.0

4. How confident are you about your answer to question #2?

No confidence at all					**Completely confident**
1	2	3	4	5	6

The post-survey included Questions 1 – 4 as above as well as the following questions:

5. For the following items, please indicate how much you agree or disagree with each statement.

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
This activity enhanced my understanding the behavior of frames.	1	2	3	4	5
The software was easy to use.	1	2	3	4	5
I enjoyed this activity.	1	2	3	4	5
This activity was a good use of my time.	1	2	3	4	5
Now that I've completed this assignment, I will probably have to study less for the final exam.	1	2	3	4	5
If given the opportunity, I would like to return to this activity as a study resource.	1	2	3	4	5

6. What, if anything, did you find particularly valuable about this activity?

7. How, if at all, do you think this activity could have been improved?

D. FACULTY INTERVIEW QUESTIONS

1. Just to get started, based on your experience with Dr. Frame and thinking more broadly, what do you see as the benefits, if any, of using these types of exercises?
   - *[Possible prompt]* More specifically, how do you see these types of exercises as enhancing student learning (if at all)?

2. Other than the Dr. Frame pilot, to what extent do you use computational technology in your current instructional methods?
   - How do you see the use of an interactive computer exercise as fitting with your existing teaching methods? Would it be a radical departure or does it fit with how you currently teach?

3. Do you currently have any specific ideas in mind about any such exercises you might be interested in constructing?

4. *[This series of question can either be in reference to exercise referred to in Question 3 or asked more hypothetically]*

If you were to construct an interactive exercise such as Dr. Frame, how would you use it?
[Possible prompts]
   - Would you use it as part of a required classroom assignment or in some other way, such as a lab session, group learning exercise, or optional independent study?
   - In terms of enhancing student learning, what function would the exercises serve (e.g., would they review concepts, introduce new ones, or perhaps focus on consideration of behavior or derivation of fundamental theories)?

5. How likely is it that you will develop your own interactive computer exercise within the next academic year?

6. What types of barriers, if any, do you see to the creation of your own computer-based learning materials?
   - From your experience with Dr. Frame, do you have any specific questions or concerns about developing your own exercises?

7. What type of support or assistance would be crucial to the development of your own interactive exercises?
   - Do you have any insight into what might make the process easier for you?

8. Now I'd like to get specific about how much time and effort you think is required to develop one of these exercises. Using the time required to write a hand-out set of notes to explain a particular topic as a baseline, what level of effort would be required for you to construct an interactive exercise on your own of the type used in the pilot?

   [Possible prompts]

   - Would it take less or more effort?
   - How much less effort (one-third, half, three-quarters?)
   - How much more effort (1.5 times, 2 times?, 3 times?)

9. More generally, do you think the potential benefits of developing an interactive computer-based exercise as Dr. Frame outweigh the potential costs or do you think the costs outweigh the benefits?
   - In a related question, imagine that all the barriers you had described had been eliminated and you had all the support you needed, would you use such an exercise in your class?

10. Again, thinking generally, to what extent would you say that instructors or faculty would be interested in developing their own interactive computer exercises if they were given a staring "tool box" of scripting/presentation/authoring components?
   - *[If appropriate]* What do you think would be the best way to encourage faculty to use such tools?
   - Are there any instructors at your institution who are currently exploring the idea of creating their own exercises *[If so, get contact information to possibly invite those individuals to participate]*

11. Do you have any additional thoughts about these interactive exercises?