Ashlee DeLine (adeline3)
CS-6460
Project Proposal, Due Sunday June 18th, 2017

**Project Plan Description**

This project will utilize a Jupyter Notebook [9] to create auxiliary material for Chris Pryby's Udacity refresher course on Linear Algebra [6]. The ultimate goal of this material will be that it will facilitate student-engagement in the course, promoting long term retention of concepts. The secondary goal of this Notebook, is that it will act as a framework for educators to utilize for other (similar) topics.

**Task List (w/ Hour Commitment Estimation in '()')**

Tasks from Assignment 5:

- Linear Algebra Refresher Course, Udacity – Review Entire Course (3.5)
- Setup GitHub Environment (0.5)
- Initialize Jupyter Notebook – High-Level Content Outline (2)
- Research Engagement Methods Using Jupyter (5)
    - Examples: Widgets [3], Matplotlib, IPython Audio [2], etc.
- Create Engagement Framework (1)
    - i.e. Based on the research done and the tools available, what framework will I follow throughout each concept.
- Create basic engagement samples/frameworks (8)
    - Widgets (Sliders, etc.)
    - Widget Events
    - Interactive Quiz
    - Buttons
    - Graphical Illustrations (Animated)
    - Embedding Videos
    - Embedding Sound
    - Quiz example where student input and output is run, verified
    - Other

Tasks for Remainder of Course (separated by week):

**Week #6**

1. Build out Jupyter Notebook Base (3.5)
    a. Includes: All Notebooks set up in framework
    b. Includes: Introduction to Course
2. Complete Lessons:
    a. Points & Vectors (3)
    b. Vector Operations (3)
    c. Magnitude, Direction (3)
3. Weekly Status Check One (<0.5)

Ashlee DeLine (adeline3)
CS-6460
Project Proposal, Due Sunday June 18th, 2017

**Week #7**

4. Complete Lessons:
    a. Inner (Dot) Product (2.5)
    b. Parallel/Orthogonal Vectors (2.5)
    c. Projecting Vectors (2.5)
    d. Cross Products (2)
    e. Intersections (2.5)
5. Weekly Status Check Two (<0.5)
6. Milestone One (2)

**Week #8**

7. Complete Lessons:
    a. 2D Lines (2.5)
    b. Greater than 2D Lines (2.5)
    c. Planes in 3D (2.5)
    d. Intersections of Planes in 3D (2.5)
8. Adjust Content Based on Feedback with Milestone One (2.5)
9. Weekly Status Check Three (<0.5)

**Week #9**

10. Complete Lessons:
    a. Manipulating Equations (2.5)
    b. Solving Systems of Equations (2.5)
    c. Gaussian Elimination (Including Special Cases) (2.5)
    d. Systems with No Solutions (2.5)
11. Weekly Status Check Four (<0.5)
12. Milestone Two (2)

**Week #10**

13. Adjust Content Based on Feedback with Milestone Two (3.5)
14. Complete Lessons:
    a. Systems with One Solution (2.25)
    b. Systems with Many Solutions (2.25)
    c. Characterization of Results Summary (2.25)
    d. Extending to Higher Dimensions (2.25)
15. Weekly Status Check Five (<0.5)

**Week #11**

16. Polish Material (5.5)
    a. Adjust any last-minute changes
    b. Add features if time allows
17. Project Presentation (3)
18. Project Paper (5)
19. Project Deliverable (1.5)

Ashlee DeLine (adeline3)
CS-6460
Project Proposal, Due Sunday June 18th, 2017

## Weekly Milestone Calendar

| Due Date (Sundays) | Goals, Project-related Assignments Due, Associated Tasks Due |
|---|---|
| June 18, 2017 | **Goal:** Completion of work detailed within Assignment 5<br>**Assignments Due:** Project Proposal<br>**Associated Tasks:** All tasks listed under "Tasks from Assignment 5" |
| June 25, 2017 | **Goal:** 12.5 Hours on Project<br>**Assignments Due:** Status Check One<br>**Associated Tasks:** 1-3 |
| July 2, 2017 | **Goal:** IM (2) + 12 Hours on Project<br>**Assignments Due:** Status Check Two, Intermediate Milestone One<br>**Associated Tasks:** 4-6 |
| July 9, 2017 | **Goal:** 12.5 Hours on Project<br>**Assignments Due:** Status Check Three<br>**Associated Tasks:** 7-9 |
| July 16, 2017 | **Goal:** 12 Hours on Project<br>**Assignments Due:** Status Check Four, Intermediate Milestone Two<br>**Associated Tasks:** 10-12 |
| July 23, 2017 | **Goal:** 12.5 Hours on Project<br>**Assignments Due:** Status Check Five<br>**Associated Tasks:** 13-15 |
| July 30, 2017 | **Goal:** Project Presentation (3), Project (5.5), Project Paper (5), Project Deliverable (1.5)<br>**Assignments Due:** Final Project (Project, Paper, Presentation)<br>**Associated Tasks:** 16-19 |

## Milestones – Descriptions + Deadlines

### Milestone One

The deadline for Milestone One is Sunday, July 2. For the first milestone, the delivery will include the overall engagement framework and the following topics built out based on the engagement framework: Points & Vectors, Vector Operations, Magnitude & Direction, Inner (Dot) Product, Parallel, Orthogonal Vectors, Projecting Vectors, Cross Products, and Intersections. The goal of this first Milestone is to receive feedback from others in order to spend some time during Week Eight refining the framework and any affected material. The content will be provided in the form of a video screencast presentation that will walk a reviewer through the Notebook Framework and some examples of the content covered.

### Milestone Two

The deadline for Milestone Two is Sunday, July 16. For the second milestone, the delivery will include Milestone One, as well as the changes based on feedback received. In addition, the following lessons will also be covered: 2D Lines, Greater than 2D Lines, Planes in 3D, Intersections of Planes in 3D, Manipulating Equations, Solving Systems of Equations, Gaussian Elimination and Systems with No Solutions. Again, the content will be provided in the form of a video screencast. Note that the screencast should not include a walk-through of all material (as this might be overwhelming for a reviewer), but a snapshot of the material, changes made, etc.

## Covered Content

The content covered for this project will include all content covered by Chris Pryby's Udacity Linear Algebra refresher course. As a high-level outline, the following topics will be included in the coverage (both the topic, as well as the associated Python code will be included):

- Points, Vectors
- Vector Operations
- Magnitude, Direction
- Inner (Dot) Product
- Parallel/Orthogonal Vectors
- Projecting Vectors
- Cross Products
- Intersections
- 2D Lines
- Greater than 2D Lines
- Planes in 3D
- Intersections of Planes in 3D
- Manipulating Equations
- Solving Systems of Equations
- Gaussian Elimination (Including Special Cases)
- Systems with No Solutions
- Systems with One Solution
- Systems with Many Solutions
- Characterization of Results Summary
- Extending to Higher Dimensions

## Content Platform

The content will be developed and delivered via a series of Jupyter Notebooks hosted on GitHub. Instructions will be presented for a user to export to their local machine and view. Web hosting for the Jupyter Notebook is not included in the scope of this project.

Ashlee DeLine (adeline3)
CS-6460
Project Proposal, Due Sunday June 18th, 2017

**Current Resources, Importance of Change**

The current Linear Algebra refresher course was built out by Chris Pryby and is available through Udacity. The course was built explicitly for OMSCS students to facilitate better experiences and easier understanding in classes where a background in Linear Algebra is required (like Computational Photography).

The addition of supplemental material via Jupyter Notebooks is needed because of the missing engagement factor with the material in Udacity. Engagement is important because it facilitates a better long-term understanding and retention of material over short-term, simple memorization. Engagement can come in many different formats – a few that could improve this Linear Algebra course will be included below.

Contextualization is an example of a very simple engagement method. In general, this means that an educator should give a real-life use case for the topic of discussion. Barkley (the EVP of Performance Learning Systems Inc.), agrees with this – saying that educators should "…connect real life to the content being taught to get the emotional engagement that draws students to learning" [4]. Throughout the Linear Algebra lectures, there is some minimal contextualization. However, context should be included for all concepts to allow students to reap the greatest benefits.

Another engagement method is simply chunking the material into smaller pieces. A few of the current videos in the Linear Algebra lectures (one example is "Operating on Vectors") show multiple concepts without allowing the student to practice one concept before moving onto the next. These concepts should be broken down accordingly. Overall, chunking facilitates a simpler learning environment – allowing the student to "…organize and synthesize information" [3].

Content that stimulates multiple senses is another potential engagement method. This is curriculum that is presented so that it touches many different senses. Doing this, creates a stronger relationship with the concept in our brains and we are more likely to remember it. The Department of Cognitive Science at the University of California presented a figure that stated humans remember (on average) "…90% of what we see, hear, say and do" [1]. The current Linear Algebra lectures, on their own, only stimulate an individual's visual and auditory sense. In order to make this more engaging, a student would need to actually work with the concepts while they learn them. Other examples of how to create multisensory content include first, that background noise or music could be included throughout the notebook to stimulate the learning experience. Additionally, interactive visualizations might be used to display concepts – requiring a student to not simply view an image, but participate in creating and effecting its' image.

One more engagement strategy is Bloom's Taxonomy. The goal of this, is to cover a series of six cognitive domains (remembering, understanding, applying, analyzing, evaluating and creating) when learning a new concept. Doing so, according to Bloom, will "…promote higher forms of thinking in education… rather than just remembering facts" [2]. The current course is not built out with a framework involving all six cognitive

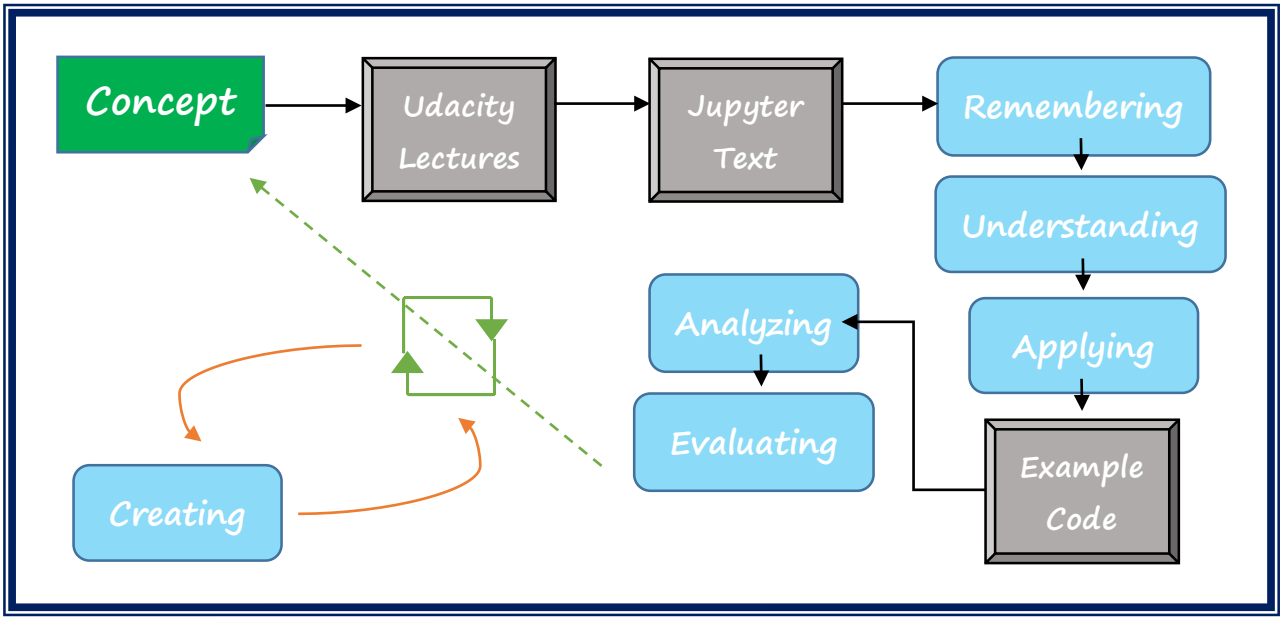
domains. The quizzes stimulate understanding and the requests for individuals to code on their own might be considered applying – if the student takes the time to do this.

Overall, there are many possibilities regarding how the content could be adjusted and presented in a more effective and engaging manner. Additionally, the Linear Algebra Refresher course could greatly benefit from some supplemental content such as which is being proposed because it would then create an overall better understanding of the material in the long-term.

**Content Structure**

The content that will be covered within this project is included in the "Content Covered" section above. The content will be presented utilizing a framework based on the six cognitive domains of Bloom's Taxonomy (remembering, understanding, applying, analyzing, evaluating, and creating). A diagram of the framework is included below – it encompasses Bloom's Taxonomy as well as multisensory content, contextualization and chunking.

Notice that the creating domain is separated. This is because the creating domain can be used to combine multiple concepts (for example, a calculator after talking about an add, subtract, multiply and divide function).




Overall, the content will be structured in short lessons, with little text and interactive learning sections throughout the Notebook.

**Nature of the Development**

The content will utilize a minimum of IPyWidgets [5], Audio [10], NumPy [8] and Matplotlib [7] libraries to present material in an engaging fashion. While some of the framework details are being finalized yet, in general, within each cognitive domain (in Bloom's Taxonomy) will be a different interactive activity to help re-inforce the topic.

(Note Figure 1 above showing the framework). Below are a few examples of the initial framework activities.

First, the point of remembering is recall. For this domain, one might make an interactive example by using a series of button widgets or check boxes to ensure one remembers the basics of the topic.

Next, understanding is comprehension. Therefore, for this domain, one might create a matching module. Or ask the student to classify a series of images as various important parts of a concept.

Third, the act of applying is to actually implement something. In this scenario, a student might be asked to code the concept they are learning about. For instance, if the topic is addition, the student might be asked to implement an addition function.

Next, to analyze is to classify or categorize. For this an educator might give a few multiple-choice questions or multiple choice multiple answer questions to respond to.

For evaluating, a student might be asked to assess a series of statements as correct or incorrect – and then explain why they are incorrect if incorrect.

Finally, creating is inventing. As an example, an educator might describe a problem and ask the student to create a solution (example – creation of a calculator). The solution might incorporate all the topics covered throughout a course.

Overall, the nature of the development will be a single topic presentation and then a series of activities that hopefully trigger the full mastery of a concept (and eventually Linear Algebra).

## Conclusion

The project being proposed is a Jupyter Notebook that is to be used as supplemental material for Chris Pryby's Udacity Linear Algebra course. The material will be presented in an engaging fashion to encourage long-term understanding. A framework – based heavily on Bloom's Taxonomy (but also including contextualization, chunking and multisensory content) will be utilized to present each concept.

Ashlee DeLine (adeline3)
CS-6460
Project Proposal, Due Sunday June 18th, 2017

## References

Project Proposal:

[1] Benefits of Multisensory Learning. Joslin, Sara, Alfred. University of California Department of Cognitive Science. Retrieved June 11, 2017, from http://www.cogsci.ucsd.edu/~ajyu/Teaching/Cogs180_sp16/Slides/week8a.pdf

[2] Bloom's Taxonomy of Learning Domains. Knowledge Jump. Clark, Donald. June 5, 1999. Retrieved May 25, 2017, from http://www.nwlink.com/~donclark/hrd/bloom.html

[3] Chunking. Facing History and Ourselves. Resource Library. Teaching Strategies. Retrieved June 7, 2017 from https://www.facinghistory.org/resource-library/teaching-strategies/chunking

[4] Instructional Strategies Motivate and Engage Students in Deeper Learning. April 2013. High Schools That Work. Retrieved June 5, 2017, from http://www.sreb.org/sites/main/files/file-attachments/13v06w.pdf

[5] ipywidgets — ipywidgets and jupyter-js-widgets 7.0.0a3 documentation. (n.d.). Retrieved May 28, 2017, from https://ipywidgets.readthedocs.io/en/latest/

[6] Linear Algebra Refresher Course | Udacity. (n.d.). Retrieved May 28, 2017, from https://www.udacity.com/course/linear-algebra-refresher-course--ud953

[7] Matplotlib, https://matplotlib.org/

[8] NumPy. Retrieved June 11, 2017, from http://www.numpy.org/

[9] Project Jupyter. (n.d.). Retrieved May 27, 2017, from http://www.jupyter.org

[10] Using Audio in IPython. Retrieved May 31, 2017, from http://musicinformationretrieval.com/ipython_audio.html