Curriculum Development for Visualization Capacity Building

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Abstract

The Polytechnic Institute at Purdue University is introducing a new undergraduate major in data visualization. New curricula are being developed to build visualization competencies for visualizing large complex data. The curriculum offers an appreciation for the visualization process, hands-on experience with a wide range of visualization tools coupled with design and development experience. The new major complements the Polytechnic Transformation mission to graduate students with transferable skills desired in industry, research and academia. This paper describes the Polytechnic Transformation, the new major to be offered in fall 2017 and the development of new courses designed to facilitate visualization capacity building.

Introduction

An understanding of the data visualization process can help to facilitate the dissemination of results, the understanding of complex concepts and aid in telling the story the data represents. The need for knowledgeable persons with an understanding of the visualization process beyond Excel and MATLAB continues to grow as data sets continue to grow in volume, variety, and velocity (McAfee, 2012). Many students are not aware of the visualization process (Fry, 2007), the value of visualization (van Wijk, 2005), the purpose of visualization (Card, 1999) or the benefits of visualization in academia (Educause, 2007, 2009), research, and industry (Gatto, 2015). The Purdue Polytechnic Institute is committed to equipping students with knowledge and marketable skillsets

to enable them to contribute to the growing digital global economy. The following sections describe the Polytechnic Transformation, the new major in data visualization to be offered in fall 2017 and the development of new courses designed to facilitate visualization capacity building.

Polytechnic Transformation

Since 2013, Purdue University's College of Technology has been transforming itself into the Purdue Polytechnic Institute (PPI). Following the lead of major national and international polytechnic entities (e.g. California Institute of Technology, Massachusetts Institute of Technology, Worcester Polytechnic Institute, etc.) as well as small innovative thinking institutions, such as Olin College and Alverno College, the PPI is endeavoring to totally transform the undergraduate learning experience. This massive change includes transitioning education methods, traditional classroom and course structures, instructor roles, and student participation. There are ten targeted characteristics for the Purdue Polytechnic: theory-based applied learning, team project-based learning, active-learning teaching methods, integrated learning-in-context curriculum, integrated humanities studies, competency-based credentials and programs, year-long sponsored capstone projects, required internships/workforce activities, required global/cultural immersion activities, and faculty/student mentoring. The new major in data visualization embodies these characteristics.

New Undergraduate Major in Visualization

The new data visualization major, offered in the Computer Graphics Technology (CGT) Department in the Polytechnic Institute, comprises four core courses (shown in Table 1). An additional 108 credits of required courses and electives must be taken to complete the degree. The required courses cover fundamental topics, such as programming, art and design, and statistics. CGT 270, the foundational course, may be taken as a prerequisite or corequisite to CGT 370, which introduces design principles and development skills for creating interactive visualizations. For students in other majors (e.g. web development or game development) who have finished most required courses, it is possible to complete the core courses within one year.

Table 1 Core Courses for Data Visualization Major

Core Course	Description	Prerequisites	Term Offered
CGT 270	Foundations of Data Visualization	None	Spring
CGT 370	Interactive Data Visualization	CGT270	Spring
CGT 371	Introduction to Scientific Visualization	CGT270, 370	Fall
CGT 470	Visualization Studio	CGT270, 370	Fall

Curriculum Development for Visualization Capacity Building

In order to prepare the next generation of students for a data-driven world, exposure to the process, tools and techniques of data visualization must begin early. To address this need a new foundational visualization course, "*Introduction to Visualization Tools and Applications*," was

introduced in spring 2016. The course provides an introductory examination of the visualization process through lectures, readings and hands-on experiences with current visualization tools. Although students who enrolled in the inaugural course offering were engineering and technology majors, the course is designed to reach multi-disciplinary interests, and attract students majoring in STEM and non-STEM related fields. Students enrolled in the course are expected to have little to no background in visualization; there are no prerequisites for the course.

The course begins with an overview of the seven stages of visualizing data: acquire, parse, filter, mine, represent, refine and interact (Fry, 2007) and encourages students to think beyond bar, line, and pie charts for visualizing data. An understanding of this process is essential to understanding the transformation of raw data into a visual representation. A methodical approach is taken to examine what happens to the data as it is transformed from raw and unstructured to a refined and visually insightful state.

Learning objectives, shown in Table 2 along with expected outcomes, for the course are threefold: (1) students gain a working knowledge of the visualization process, (2) students participate in practical hands-on exercises using commonly used visualization tools, and (3) students demonstrate the ability to evaluate different techniques of visual representation. Expected outcomes are achieved by engaging students in a number of interactive activities that include: critiques of visualizations found in the media or print, reviews of seminal visualization research papers to complement course lectures, and hands-on demonstration of visualization tools by students (students can choose any visualization tool not listed on the course syllabus as tools to introduce to the class). Students show mastery of some aspect of a visualization tool of their choosing and provide a short in-class exercise for the class to ensure the class can demonstrate understanding of the material presented.

To assess student understanding of the visualization pipeline, regular self-assessment and reporting of project status in the visualization pipeline are incorporated into the structure of the course. Students report what stage of the visualization pipeline they understand their project to be in. Students learn firsthand the purpose of visualization is insight (Card, 1999). This exercise provides an additional benefit for students by allowing them to give and get feedback on their challenges and progress. Regular reporting of the status of projects in the visualization pipeline fosters deeper understanding of the data, an appreciation for the visualization process and enforce the concept: visualization is an iterative process. This course prepares students for more advanced visualization courses offered in the new visualization major. Learning objectives for this course will be expanded to include learning objectives for design and development for courses in the new major.

Table 2 Learning Objectives

Knowledge of the Visualization Process	Practical Experience Using Various Visualization Tools	Evaluate Different Techniques of Visual Representation
Understand the purpose of visualization	Exposure to common data domains	Think creatively about mapping conceptual and physical space
Understand the importance of visualization	Ability to analyze the merits and potential uses of visual representations created by others	View and discuss the effectiveness of different visual representations of data
Understand key techniques and theory used in the visualization process	Experience developing visual representations of their own	Understand how different types of visualizations serve different purposes

Conclusions

Visualization literacy is becoming an increasingly important skill (Educause, 2007). "Visualization capacity" means having the technological knowhow to process complex data, to understand the needs of the user in order to design the proper visualization for a specific task which results in greater insight as to what the raw data represents. There is a demand in research and industry for persons with the transformative skillsets that include visualization capacity to be innovative, creative, technologically savvy and well learned in the process of visualizing data in its various forms. Every company, in any industry, that deals with large volumes of data can benefit from having a person with a major in data visualization on their team (Teradata, 2016). Knowledge of the visualization process coupled with the capacity to transform raw complex data into a visual representation that does not overwhelm will give graduates of the new visualization major a competitive edge and the flexibility to work in any industry with driven by data visualization needs.

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