Visualizing Repertory Grid Data for Formative Assessment

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Abstract. Repertory grid tools systematically collect data that consists of a topic, its elements, constructs and element ratings. Gaining meaningful insights from repertory grids data is a challenge because data analysis is time-consuming and a significant mental effort is needed. Visualizations aim at facilitating data analysis through a visual and interactive approach, which allows users to understand their data, reflect, and make better decisions. This paper presents an interactive visualization tool for teachers and students. The tool visualizes repertory grid data using two dashboards, where teachers and students can investigate constructs and rating elements of students at the individual or group level. Visualizing the repertory grid data is an initial attempt towards teaching analytics. Future work will focus on evaluating the tool in a real setting with teachers and students, and collecting suggestions for improvement.

1 Introduction

The advancement of technology has enhanced data generation for personal and professional use – know as Big Data. Instead of producing WORN data (write-once, read-never coined by Powsner and Tufte), researchers are continuously studying data from different fields in order to benefit and to extract knowledge. This also is the goal of Learning Analytics (LA). LA is "the collection and analysis of usage data associated with student learning" and aims at improving education through interventions after observing and understanding learning behaviors (Brown, 2011).

Nowadays, data collection is less challenging than data analysis, because the latter requires additional cognitive effort. Data analysis can be enhanced using visual representation. Information visualization enhances human cognition by visually presenting abstract data and revealing patterns, trends and outliers (Card et al., 1999). Visual Analytics is the science of combining interactive visualizations with analytical reasoning techniques to enable users to understand their data, reflect more effectively, and make better decisions (Keim et al., 2010).

This paper presents how the Repertory Grid data (i.e. topic, topic elements, topic constructs and elements ratings) are visualized. Data were collected from a Social Media course at the Copenhagen Business School using a software application called Repertory Grid for Formative Assessment (RGFA, http://cssl.cbs.dk/software/rgfa). Using these data, we developed a visualization tool with two interactive dashboards for teachers and students. They can investigate constructs and rating elements of students at the individual or group level. Future work will focus on evaluating the tool in a real setting with teachers and students, and collecting suggestions for improvement.

2 Background

Repertory Grid is a technique which uses personal constructs of individuals to determine the relation among elements of a topic. Repertory Grid Technique (RGT) is based on the Personal Construct theory developed by George Kelly (1963, 1992). A grid consists of: a topic, a set of elements, a set of constructs, and a set of rating elements of constructs. Vatrapu et al. (2012) provides a clear example of a grid, and discuss how to integrate RPT in "teaching analytics" as in-class activity or a take-home exercise. The Repertory Grid Technique for formative assessment can indicate to teachers the knowledge students have on specific topics (Vatrapu et al., 2012). In addition, teachers can benefit as they can identify the ability students have to distinguish between concepts (Vatrapu et al., 2012). Obtaining an overview, viewing details-on-demand, and comparing data are some of the tasks where a visual approach can facilitate data analysis.

Information Visualization (InfoVis) is representation of abstract data; data that "has no inherent mapping to space" (Card et al., 1999). As an example from social networks, abstract data are information stored in the database regarding a user (i.e. name, age, number of followers, number of friends, etc.) InfoVis attempts to reduce the time and the mental effort users need to analyze large datasets by visually presenting abstract data (Card et al., 1999). The InfoVis community has developed several frameworks and taxonomies. Shneiderman (Shneiderman, 1996) presented a task by data type taxonomy for InfoVis. This taxonomy classifies visualization data types (1D Linear, 2D Map, multidimensional, temporal, tree and network) and identifies the tasks (overview, zoom, filter, details-on-demand, relate, history and extract) that have to be sup-ported. The result of this taxonomy, lead Shneiderman (Shneiderman, 1996) to define the visual-information seeking mantra: "Overview first, zoom and filter, then details-on-demand".

Visual Analytics VA is the science of combining interactive visualizations with analytical reasoning techniques to enable users to understand their data, reflect more effectively, and make better decisions [10]. In comparison to visualization, visual analytics is seen as an integrated approach combining visualization, human factors and data analysis (Keim, 2005). Keim defined the visual analytics mantra: "Analyze first, show the important, zoom, filter and analyze further, details on demand".

The work presented in this paper focuses on visualizing repertory grid data to facilitate data analysis. Presenting an overview, details-on-demand and supporting interac-

tivity features allow teachers and students to visually explore constructs and element ratings among students.

3 Repertory Grid Visualization Tool

This section describes the repertory grid visualization tool, which consists of two dashboards. Before we present the dashboards, we discuss the data used.

3.1 Data

Data were collected during a Social Media course at the Copenhagen Business School. Students were asked to use the RGFA website (http://cssl.cbs.dk/software/rgfa) and answer to a grid designed for the course. The task aimed at obtaining an understanding of the students' level of Social Media knowledge. Eight popular social networks (i.e. Facebook, Google+, Twitter, Pinterest, Yammer, Foursquare, Flickr, and Youtube) were used as grid elements. Students had to elicit constructs using a triadic sorting method of elements. Six triads were designed for the purpose of this course. For each triad, they describe why one of the elements is different from others (Opposite Construct) and why the other two are similar (Similar Construct). Next, they were asked to rate the rest of elements using a five-point Likert scale. Figure 1 shows and excerpt of the repertory grid data from one student.

Triad	Opposite Construct	Facebook	Google	Twitter	Pinterest	Yammer	Foursquare	Flickr	Youtube	Similar Construct
Facebook, Google+, Twitter	Adresses peoples moods towards companies, organisations brands ect. Content public, can be seen by anyone.	5	5	1	5	2	4	3	4	Limitet sharing to your friends. Possibility to create events and groups of interest.
Facebook, Google+, Twitter	For companies only	5	5	3	1	5	5	4	5	Focus on personal life.
Facebook, Google+, Twitter	Only videos are uploaded	3	3	3	3	5	3	1	1	Only pictures are uploaded
Facebook, Google+, Twitter	Discount using the app. App for on the go. City guide.	5	5	3	5	3	1	4	5	On an app for when you move around in the city.
Facebook, Google+, Twitter	Only videos are published. Both private persons as well as companies use this online marketing channel	3	3	5	2	4	5	1	5	Personal opinions are published, text as main tool.

Figure 1. An excerpt of the repertory grid data extracted from RGFA.

3.2 Dashboard 1: Constructs and Elements Ratings

Figure 2 shows how repertory grid data are visualized. The screen is divided in two areas to enable comparison between two or more students. The word cloud technique

is used to provide an overview of all elicited constructs (i.e. Opposite and Similar Construct). Details-on-demand are shown in the bubble chart after clicking on a word in the word cloud. Color and size encodings are used in the bubble chart to distinguish easier element ratings. Small red letters (S-similar and D-different) are positioned above bubbles that represent triad's elements. In this way, teachers and students can easily view the opposite and the similar elements, and relate them to the other elements. In addition, they can filter words by frequency and triads using the track bar and checkboxes respectively. The scope of this dashboard is to indicate teachers the knowledge students have on specific topics, and more specifically answer questions such as: which elements are perceived similar and different, which terms are used to express similarity and difference, are there any differences between two students or group of students, etc.

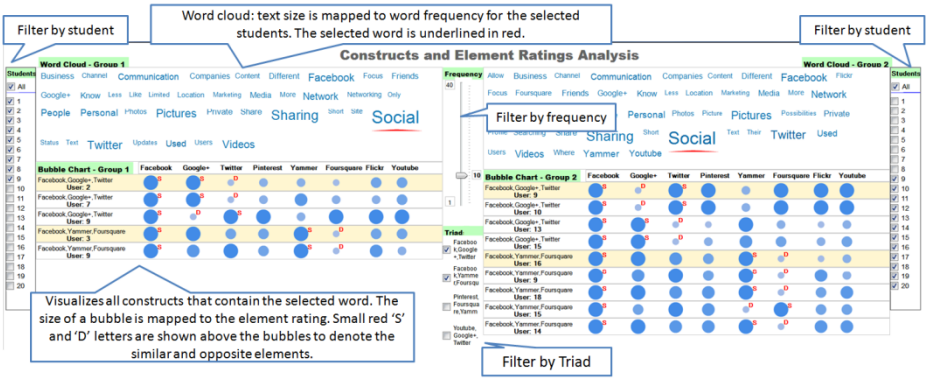

Figure 2. Constructs and Elements Ratings Analysis. The teacher clicks over "Social" to compare triads between two groups of students. Word frequency is set to 10 and all triads are shown.

3.3 Dashboard 2: Word Analysis

This dashboard also builds on the wording of the elements and constructs that make up a repertory grid, and uses the word cloud representation. After investigating constructs and elements ratings, teacher use this dashboard to investigate in details constructs elicitations. They click on a word in the word cloud, and students' constructs elicitations related to this word are shown, which are categorized in two groups: Opposite and Similar Constructs. To facilitate text analysis, the selected word is also underlined in red in the details view. This dashboards aims at enabling teachers and users at answering questions like: which term is most used to distinguish elements, and how the term relates to the context, is the term used to express similarity or difference, etc.

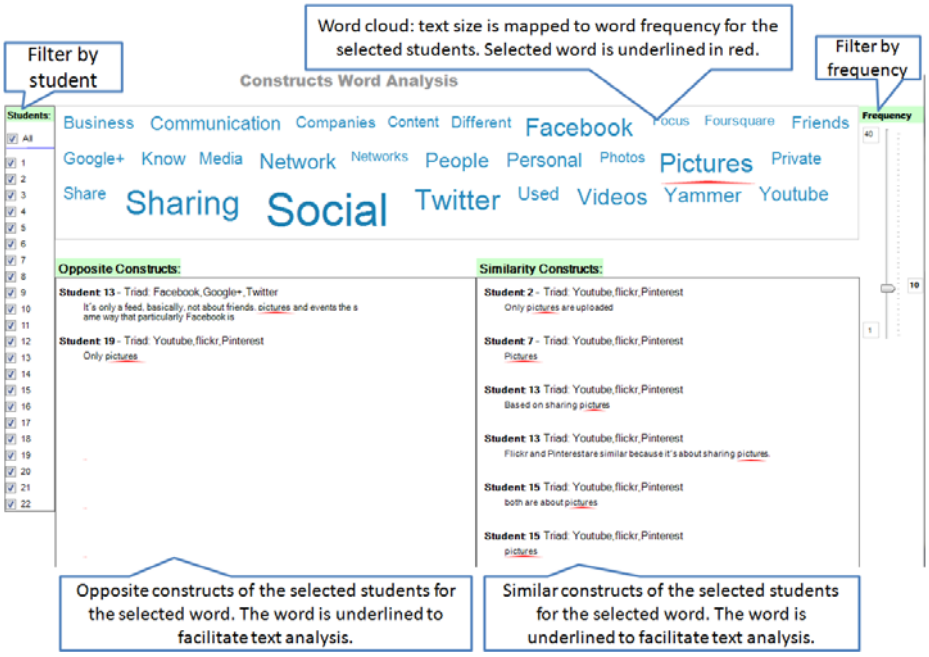

Figure 3. Word Analysis. The teacher clicks over a word to view details from constructs elections for all students.

4 Discussion and Future Work

This paper describes a visualization tool for repertory grid data to facilitate data analysis for teachers and students. We used visualization techniques and design principles from Information Visualization and Visual Analytics to allow teachers and students to obtain an overview of the data and drill-down into details. The word cloud representation of constructs provides an overview of the most used terms during construct elicitations. Details-on-demand views present information regarding the element ratings and constructs. Filtering among users supports comparison and allows teachers to perform a formative assessment, and distinguish students' knowledge based on elements ratings and constructs. Students can compare their element ratings and constructs with other students. Color and shape encoding were used in order to improve readability.

We decided to use the word cloud visualization due to its popularity. To enrich the variety of supported visualizations, other visualizations techniques such as treemap and parallel coordinates are being investigated and will be included in the future versions. Implementing additional interaction techniques is another important aspect under investigation. In addition, current limitations such as space, color-blindness and additional functionalities will be addressed.

Currently, we have not performed any user study to evaluate the tool. We will conduct studies with teachers and students to evaluate whether the tool is useful. Design-

ing studies in real environment will allow us to conclude whether this approach empowers teachers to obtain a better overview, reflect more efficiently, and make better decisions. The results of the study will serve as inputs for further improvement.

We presented our work in progress on visualizing repertory grid data. Information visualization and visual analytics has gained special attention and is widely used in other areas, such as healthcare, logistics, etc. Introducing information visualization and visual analytics in education is a promising research avenue in order to improve education.

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