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Beyond Just Following Data: How Does Visualization Strategy Facilitate Learning Analytics Design?

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Abstract: In this poster, we reviewed 38 articles on learning analytics research, focusing on the data visualization interface designs. After examining the original ideas their interface design, a new *visualization strategy* was proposed to categorize and characterize them premised on their principles and approaches in four types, namely, (1) directly-presented, (2) outcome-oriented, (3) process-oriented, and (4) theory-oriented. Then, how these types of the visualization strategy could help facilitate learning analytics design and make data-interpretable by users was presented.

Keywords: Visualization strategy, Learning dashboard, Design principle, Learning analytics

1. Introduction

Learning analytics is defined by the Society for Learning Analytics Research (SoLAR) as "the measurement, collection, analysis, and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which learning occurs (Siemens, 2010, para. 6)". In the past, the learning analytics community focused more on how to make use of educational datasets and identify potential information in learning contexts, but less on how the analysis results could make sense to users through different types of the visualization design. This is why we need to examine the original ideas of visualization design in the learning analytics tool. As a result, we proposed a new *visualization strategy* to categorize and characterize the principles and approaches for the visualization design. In this paper, we reviewed 38 articles containing interface designs of visualization in learning analytics research among 2010 and 2019 to identify the visualization design strategies of existed tools.

2. Related literature

Data visualization is a paradigm tool to support the judgment, inference, and decision-making in learning analytics (Alhadad, 2018). The design of visualization plays roles in (1) executing data interpretation into understandable and readable dimensions (Dzemyda, Kurasova, & Žilinskas, 2013), (2) incorporating relevant visualizations to support awareness, self-reflection, and sense-making of stakeholders (Ochoa, Suthers, Verbert, & Duval, 2014), and (3) organizing factors to support and transfer actionable decisions (Sacha et al., 2017). Thus, the design of visualization in learning analytics could influence the effect of learning analytics to gain insights into educational issues.

When a learning analytics tool is embedded in a learning system/platform for educational use, the data visualization is commonly employed as a bridge to demonstrate analytical results to general users and make educational data interpretable by them. However, many features included in the current visualization design have failed to meet their purposes as they claimed. Some studies have found that the majority of learning dashboards, and standard forms of the visualization in learning analytics, consist of a basic pie chart, line graph or scatterplots without actionable information for teaching and learning (Schwendimann et al., 2017).

Learning analytics research uses data to inform decisions for a diverse set of educational stakeholders (e.g., learners, instructors, and administrators), which is a significant difference comparing to traditional educational research (Dragan, Shane, & Abelardo, 2016). If having no actual impact, learning analytics development might be reduced to "simplistic rhetoric of quick technological fixes" (Dragan et al., 2016, p. 1). How to design visualization to facilitate wider stakeholders rather than the statistical experts is crucial to achieving the expected impact on implementing learning analytics in practice. However, currently, there is no clear picture of visualization designs adopted in current learning analytics research. This review study aims to solve the issue.

3. Methods

The searching range of the literature review was set from 2010 to 2019 using the keywords "visualization", and "learning dashboard" because "learning dashboard" is a popular visualizing tool in current literature. One hundred fifty-nine articles were found in the areas of education, machine learning or other domains. Then, we used the keywords "educational", or "education" to filter the articles. Finally, 38 articles were identified, which contain the description of visualization or learning analytics dashboards in detail.

Open coding was adopted to categorize and characterize the visualization strategies in the selected learning analytics designs. Three themes were identified: (1) their selection of indicators for demonstration, (2) their cognitive approaches intended by a viewport, and (3) the forms of visual content organization on the user interface (mainly dashboards).

4. Results

This study distilled four types of visualization strategies in reviewed cases and listed in Figure 1. They are (1) directly-presented, (2) outcome-oriented, 3) process-oriented, and 4) theory-oriented.

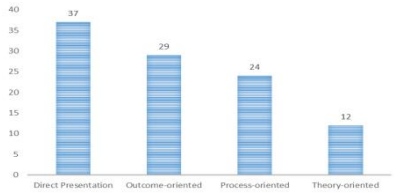

Figure 1. Types of visualization strategies in reviewed cases.

The directly-presented data is the fundamental realization of learning analytics visualization, which presents some scattered datasets from sensors or system logs that might contain educational concerns. Designers adopt statistical graphs or tables to outline data distribution in its original form. Users need to interpret data by clustering and regression from scatted table or plot to get desired information. By doing so, less information is lost.

The outcome-oriented visualization strategies focus on checkpoints, such as the score of quiz or the completion rate. Some critical performance could be identified by comparing results with standards, history, or peers through scale bars or scores. This type of strategies highlights information like achieving some milestones or grades but ignores the meaning of changes in progress.

The process-oriented visualization strategies attempt at representing learning trails. Such kind of visual designs makes indicators continuous in forms of the path and able to "paint out" the footprints in the learning process. By tracking the progress, users could find out and reflect on their personal learning experiences better.

However, stakeholders need a certain level of statistical skills to understand and interpret some of the artifacts generated from the three strategies mentioned above, such as clustering and regression. Thus, it remains a barrier for users to make sense and interpret the information in a certain background.

The theory-oriented visualization strategies align educational theories with organizing both selected and continuous indicators to address educational concerns holistically. The indicators adopted in the type of strategies are presented in a hierarchy, which is aligned with educational theories, such as

five phases in inquiry-based learning. An educational theory generally recognizes the nature of a specific setting and organizes key checkpoints and processes, so that interpretation of the indicators in context is more insightful and for educational decision-making.

The characteristics of four types of visualization strategies in learning analytics are also presented in Table 1. In order to make the audience understand more intuitively, the demonstration models of different types of visualization strategies in learning analytics is presented in Figure 2.

Table 1
Characteristics of Types of Visualization Strategies in Learning Analytics

Strategy	*Directly-presented*	*Outcome-oriented*	*Process-oriented*	*Theory-oriented*
Indicator	*distributed*	*selected*	*continuous*	*hierarchical*
Focus	*phenomenon /behavior*	*checkpoint/result*	*trail*	*explanation of potential insight*
Approach	*cluster/regression*	*compare*	*track*	*interpret*
Possible form	*scatted table/plot*	*scale / score*	*trend / path*	*theory-based feedback*

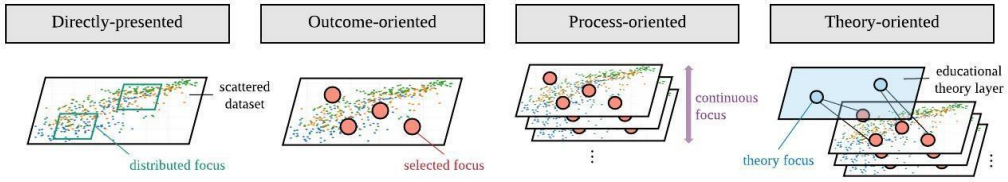

Figure 2. Demonstration models of different types of visualization strategies.

5. Limitation and future work

A primary limitation of this poster is that the categorized strategies were classified only based on the simple standards according to the user interface without in-depth analysis, to gain profound insights into their design principles. In a further study, we are going to identify a holistic framework of visualization design and presentation to deepen the understanding of orientations included in different types of strategies.

References

Alhadad, S. S. (2018). Visualizing Data to Support Judgement, Inference, and Decision Making in Learning Analytics: Insights from Cognitive Psychology and Visualization Science. *Journal of Learning Analytics, 5*(2), 60-85.

Dragan, G., Shane, D., & Abelardo, P. (2016). How do we start? State and Directions of Learning Analytics Adoption: International Council for Open and Distance Education.

Dzemyda, G., Kurasova, O., & Žilinskas, J. (2013). Multidimensional Data and the Concept of Visualization *Multidimensional Data Visualization: Methods and Applications* (pp. 1-4). New York, NY: Springer New York.

Ochoa, X., Suthers, D., Verbert, K., & Duval, E. (2014). Analysis and reflections on the third Learning Analytics and Knowledge Conference (LAK 2013). *Journal of Learning Analytics, 1*(2), 5-22.

Sacha, D., Sedlmair, M., Zhang, L., Lee, J. A., Peltonen, J., Weiskopf, D., . . . Keim, D. A. (2017). What you see is what you can change: Human-centered machine learning by interactive visualization. *Neurocomputing, 268*, 164-175.

Schwendimann, B. A., Rodriguez-Triana, M. J., Vozniuk, A., Prieto, L. P., Boroujeni, M. S., Holzer, A., . . . Dillenbourg, P. (2017). Perceiving Learning at a Glance: A Systematic Literature Review of Learning Dashboard Research. *IEEE Transactions on Learning Technologies, 10*(1), 30-41.

Siemens, G. (2010). *1st International conference on learning analytics and knowledge 2011*. https://tekri.athabascau.ca/analytics/