Communicating Learning Analytics: Stakeholder Participation and Early Stage Requirement Analysis

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Abstract: This paper reflects on a user-centered design methodology for requirements elicitation at early stages of a design process for Learning Analytics tools. This methodology may be used as a domain specific instrument to elicit user perspectives about the communicational aspects of learning analytics dashboards. The focus of this work is identifying ways to communicate the data analysis findings in a way that is easily perceptible and facilitates actionable decision making. We present the structure as well as the logic behind the design of this instrument. As a case study, the paper describes an implementation of this methodology in the context of school-wide analytics communicating to stakeholders quality indicators through summarising and visualising data collected through student and parent surveys. We provide high-level and transferable recommendations derived from the analysis of the workshop with key stakeholders and identify future improvements in our methodology.

1 INTRODUCTION

Learning dashboards have grown in popularity over the past few years and are becoming a mainstream tool for monitoring and decision making. While people are using them to address real world problems, there is little evidence that these dashboards convey the right information to stakeholders and reflect those burning issues in a way that facilitates actionable decision making. According to (Schwendimann et al., 2017), the question of how to present relevant information effectively remains largely unresolved.

The core concern of this paper is not 'what' to present but 'how' to present it. In our view, this aspect is relatively neglected as there is a lot of work on how to analyse and enhance the data but very little work on how to make this data easily understandable by end users and usable with very little cognitive load for decision making. While the same view is being supported by (Davenport and Kim, 2013) and by others looking at the design of learning analytics mostly in higher education (Avella et al., 2016; Ferguson, 2012; Dawson et al., 2014), this issue is even more pronounced at K-12 where additional data literacy training needs have been identified (Mandinach and Gummer, 2016). Research in the field has, with a few isolated exceptions that we review below, so far focused on the analytical methods themselves and not enough on how to communicate the analysis results effectively. This is predicated on the false assumption that it is enough for the end users to be exposed to data to be able to make sense and take appropriate decisions.

A sign of this fallacy can be seen in the Reference Model for Analytics (Chatti et al., 2012), that defines the four benchmarks: what, who, why and how. The latter refers to methods and techniques about analysing data but fails to address the specific need for techniques on how to present data and convey the appropriate information to end users. Shifting from matrixes to dashboards is not enough. We opine that challenging the way a visualisation is designed in order to express interesting aspects in a meaningful way should be in line with the 'how' benchmark. Another example is the Framework of Characteristics of Analytics (Cooper et al., 2012). This is an attempt to describe the ontology behind analytics at a very high level. One aspect of it is referring to data presentation and the only level of detail it prescribes is limited to visual and numerical. There is no reference to forms of expression that should be used to answer user questions. In that respect, we are following this work and we are extending this particular aspect of it to make it more relevant to what is actually needed in real im-

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plementations.

A methodology that is specifically developed to provide a framework for the design of learning analytics tools is LATUX (Martinez-Maldonado et al., 2015). This is presented as a systematic workflow for producing learning analytics tools that are both technologically feasible and truly underpin the learning experience. Although this methodology is mostly intended for learning analytics tools for classroom awareness, orchestration and for informing pedagogical decisions, rather than institutional-wide analytics for decision-making at a school level, we consider it a very useful framework that offers a transferable solution to design such analytics. In that respect we are inspired by LATUX as we have a common objective. The part that relates to what we do is the first two steps of stage 1: "what are the requirements?" and "what are the unexplored possibilities?". LATUX simply mentions requirements elicitation without giving a workflow for it. This particular step is the contribution of our work. We are focusing on the requirements step of LATUX to provide a systematic workflow that helps elicit stakeholder requirements and involve them in early stages of the design process in a meaningful way.

Consequently, the focus of this work is on how to involve stakeholders at early stages of the design process. Our premise is that learning analytics is a communicational process whose primary purpose is to enable and facilitate timely and actionable decision-making. Therefore, we are focused on stakeholders and are concerned with their preferences, needs, and requirements with regard to data communication in terms of meaningful visualisations and actionable feedback. Our research instrument materialises through a case study in the form of a requirements elicitation workshop that investigates ways to communicate analysis findings in a simple, easily understandable and actionable manner.

2 RELATED WORK

Learning analytics is aimed at a wide range of stakeholders on both individual and organisational level (Chatti et al., 2012). Learning analytics stakeholders can be learners, instructors, teachers, trainers, administrators, developers, researchers, parents, and government bodies or other policy makers (Khalil and Ebner, 2015). In the context of this project, potential stakeholders are people who work in the educational sector holding a managerial or teaching position, come into contact with students and can use the outcome of this project to the benefit of one or more schools. The fact that learning analytics has a wide variety of stakeholders leads to challenges due to individual differences. Focusing particularly on dashboards as a display that "aggregates multiple visualizations of different indicators about learner(s), learning process(es) and/or learning context(s)" (Schwendimann et al., 2017), the challenge is that they are created for various audiences and this affects both their appearance and functionality. The key advantage of visual displays is the fact that they present complex concepts in an accessible format and allow stakeholders to capture vital information easily and quickly. A learning analytics dashboard is a powerful communication medium that increases awareness, supports reflection, and facilitates decision-making and intervention (c.f. (Karkalas et al., 2016; Schwendimann et al., 2017)). (Chatti et al., 2012) also admit that text, tables of data and other traditional report methods lag behind dashboards that utilise user-friendly graphical representations. Moreover, they declare the advantages are not in the dashboard per se. The key is to use proper visual indicators to effectively go through the objectives of each project. Similarly, (Davenport and Kim, 2013) overstress the importance of the effective findings presentation explaining that problem solving is not the core of analytical thinking. Problems must be framed correctly to reflect a relevant context. Then the results need to be communicated in a manner which facilitates correct interpretation and sense-making (Davenport and Kim, 2013; Zowghi and Coulin, 2005). (Baker and Inventado, 2014) specify that learning analytics is a methodology that extracts actionable information. Reporting and theoretical description is not the end of the learning analytics process as it does not fulfil its ultimate purpose.

Learning analytics is a scientific field that seeks and provides answers that lead to practical actions (Cooper et al., 2012). As such, in our view, actionable is a word that should be at the core of the nature of learning analytics. Educational stakeholders leverage learning analytics in order to make rational decisions and follow a reasonable course of action to achieve their purpose (Dietz-Uhler and Hurn, 2013).

2.1 Early Stakeholder Design Involvement

Involving the stakeholders early enough minimises the risk of failure, improves the usability, and draws greater understanding from LA interventions (Dollinger and Lodge, 2018). In the literature there are several cases where stakeholders are asked to contribute to the improvement of aspects of learning an-

alytics. There is also a lot educational projects that follow this approach. The project in (Drachsler and Greller, 2012) makes use of a survey in order to collect information on stakeholders understandings, expectations and confidence on learning analytics. Another project that captures stakeholders perceptions is described by (Van Harmelen and Workman, 2012). Stakeholders completed a survey giving their opinion about benefits and challenges of applying learning analytics on institutional level. The project presented in (Ali et al., 2012) involved stakeholders of online learning as evaluators of a system designed to inform teachers about students activities and performance. The project shown in (Mavrikis et al., 2016) describes the stakeholders contribution in the evaluation of an assisting tool for teachers. The tool provides the teachers with visualisations to help them monitor students activity when they work on an exploratory learning environment. (Holstein et al., 2017) adopted a participatory design approach with the aim to design a dashboard that answers real-time teachers' needs in the context of an intelligent-tutoring system. Finally, the project presented in (Govaerts et al., 2012) involved teachers and students in designed based research iterations to evaluate the effectiveness of visualisations used to increase awareness and support self-reflection.

3 METHODOLOGY

To elicit stakeholders' requirements means to learn, uncover, extract, surface, or discover their needs (Hickey and Davis, 2004). The activities that are involved in this process must allow communication, prioritisation, negotiation, and collaboration (Zowghi and Coulin, 2005). Requirements elicitation is a very crucial process that defines the success or the failure of the final product (Gottesdiener, 2003). There is a significant number of techniques that can be used in order to facilitate requirements elicitation (see examples in (Fernandes et al., 2012; Nistala et al., 2013; Millard et al., 1998; Hofmann and Lehner, 2001)).

In this project, the primary technique employed is a requirements workshop. Complementary techniques are scenario, hybrid personas, and focus groups. The purpose of the workshop is to present to the stakeholders alternative ways of presenting and communicating surveys findings, gather their feedback on these and elicit further requirements. The process to gather the desired information is to elaborate on existing data communication models, propose alternative models, and give the ability to stakeholders to express their preferences, thoughts, and suggestions on them. The following section provides a detailed step-by-step presentation of this process.

3.1 The Instrument

The instrument is structured as follows:

Scenario: The first step utilises the requirements elicitation technique of scenario or use case. In this part the participants are given the following scenario: *You work for a secondary school in London. For the past four years the Ofsted rating for your school is Good. Last year the new school governors launched a series of actions for school improvement. One of these actions is to use a survey to take students feedback on certain aspects of the school life. The survey was completed by the students at the end of the school year. A commercial partner has undertaken the survey data processing and the findings presentation through visualisation dashboards. Now, it is your turn to see the dashboards and take the information you need.* The aim of the scenario is to stimulate the participants interest, to help them situate themselves in a real context, and to put the early prototypes in a context of use.

Hybrid Personas: For the second step the participants are asked to complete a fill-the-gaps card (figure 1). They have to consider their real-life roles, to express the main need they would have had if they were part of the school presented in the scenario, and to explain the way they would expect this to help them. This could be seen as an alternative way to create personas (Caddick and Cable, 2011) with the participants emerge themselves in the context of the given scenario. The card is designed to have a very simple layout and help the participants to articulate the elements needed for the exercise. After they complete the cards, the participants have to present themselves through the cards to the group.

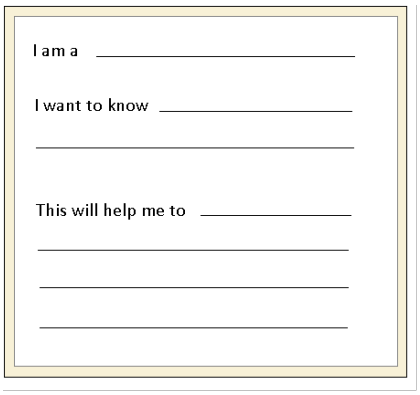

Figure 1: Fill the gaps card.

The aim of this is twofold. Firstly, to implicitly force the participants to think about and articulate their primary needs. Secondly, to make all the participants aware of the others viewpoints in order to be able to participate and contribute to the subsequent discussions.

Current Model: For this part we present a dashboard that is fairly representative of the current model used for learning analytics. In our case we used a commercial platform provided by a company the name of which will not be revealed for confidentiality reasons. The goal of this process is to provide stakeholders with easily perceptible information allowing them to focus on specific areas that need improvement.

The participants are asked to explore the company platform and answer four questions regarding the effectiveness of the platform. The aim of this is the participants to see the platform not as a presentation but with an exploratory eye, to think about advantages and disadvantages, to discuss about the provided services, and to start thinking about alternative approaches.

Dimension-factor-Question Scheme: This is intended to discuss alternatives in terms of level of specificity. This feature is inspired by the Shneiderman's Mantra principle "overview first, zoom and filter, then details-on demand" (Shneiderman, 1996). As mentioned above, the company's current data communication model displays information in two levels: question and group of questions. Once it is clear that the stakeholders establish an understanding of this, they are presented the rationale of the Dimension-Factor-Question Scheme as a principle of configurability (figure 2). The level of dimension

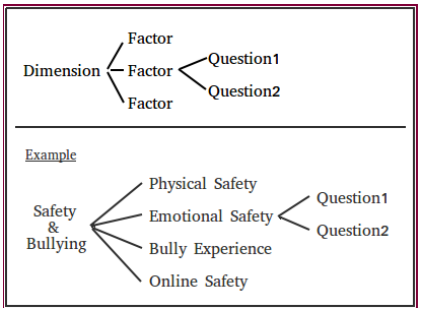

Figure 2: The Dimension-Factor-Question Scheme.

provides a general overview and informs on general trends. The level of factor provides a greater level of granularity and focuses on more specific issues. Finally, the level of question is optional as sometimes the user may need to delve into particular questions whereas other times this may not be necessary. The presentation is followed by a discussion and feedback on the scheme.

Evaluation of Alternative Designs: This step is concerned with the evaluation of:

- Alternative designs of individual visualisations on the level of factor (figure 3). The purpose is to investigate whether alternative visualisations that can convey the same messages can be used to communicate survey findings to the stakeholders and to see whether certain visualisations are more popular than others. The visualisations are developed with Tableau 3.

Figure 3: Visualisations on factor level.

- Visualisations of additional information (progress and comparison) (figure 4). In this part the stakeholders are also asked whether they want to see the full range of the answers or only the positive (or negative) ones.

Figure 4: Visualisations on Additional Information.

- Visualisations of navigation or organisation of the data. The purpose here is to elicit stakeholders preferences regarding the different approaches to accessing the available information in the dashboard. The company's dashboard gives a flat presentation of all the given questions and the way to narrow down the information that is presented is through the use of filters. Alternatively, systems use menus as navigation tools. There are different types of menus like flat menus or tree-like menus that may be used for navigation. For the purposes of this project there are two interactive menus presented (figures 5 and 6). These representations - that also adopt the Mantra's guidelines- give the ability to multiple users to view the data on different levels of specificity. For instance, a school principal would be possibly more interested at first in school-level data. After the first reading

of the data, they can drill down to the levels of subject, teacher, and class in order to obtain information in more depth. This part attempts to address the challenging task of satisfying needs of multiple stakeholders (Siemens and d Baker, 2012).

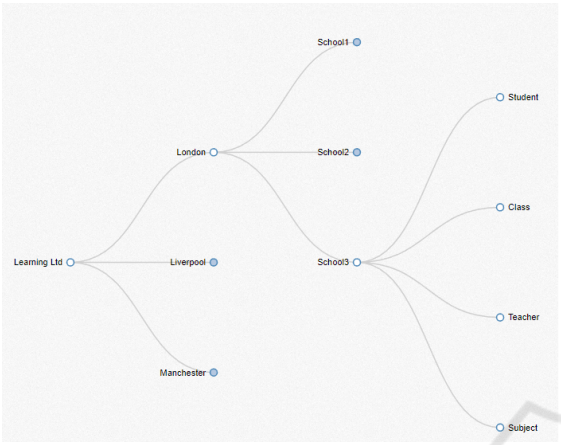

Figure 5: Interactive Menu 1.

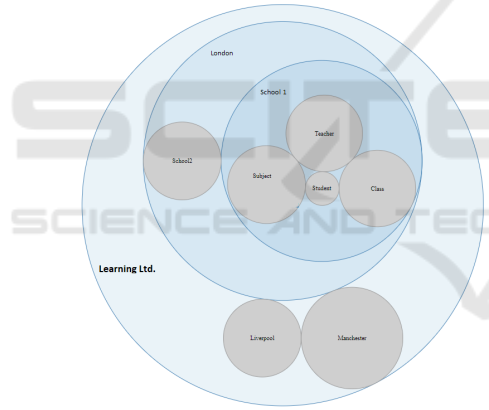

Figure 6: Interactive Menu 2.

The participants are given a series of visualisations and are told to rate them according to their preferences (1 - least preferred to 4 - most preferred). After that they are given space to write the criteria they used to rate the visualisations and draw or describe the ideal visualisation for them.

Evaluation of Additional Information: This step is also divided into three parts:

The first part seeks answers on both the content of information as well as the visual representation of the information. More specifically, it has to do with the presentation of all the dimensions in a list alongside the percentage of the positive answers on dimension level. Proposed visual representations for this information include dark/light blue thumb-ups and dark/light red thumb-downs (the answers are divided in four equal parts), traffics lights (three parts), smiley/sad emoticons (two parts). The second part asks about the amount of information on the level of factor. Simply putting it, once the user selects a factor from the respective dimension they can see only the graph that corresponds to this particular factor. Additionally the user can see the progress of the factor over time and to comparatively look the answers of this factor on the level of class, teacher, or subject. The third part is complementary to the second part. It asks the stakeholders if they want the system to present all the information in one dashboard (figure 7) or to give the ability to the user to see one visualisation at a time using different buttons.

Features for Effective Data Interpretation: The aim here is to gather stakeholders' feedback on features that may be used to facilitate effective data interpretation without excessive cognitive load. This includes consideration of colours (one colour, one colour in different hues, different colours), thresholds set by the user, banners that briefly describe the visualised information, push notifications (SMS, e-mail) to the user with worth noting findings, voice chatbots i.e. Alexa by Amazon, which interacts with the user and simplifies the presentation of desired findings on the users screen.

Features for Actionable Decision Making: The final step deals with features that may be used to facilitate actionable decision making. The stakeholders feedback is required in the following four features:

1. A blank box with a prompt to the user to keep notes on immediate thoughts
2. Direct question to the user about what they are planning to do to address possibly problematic cases
3. A box that contains information on how other people usually react to similar cases
4. A drop down window with a list of predefined alternative reactions

4 A CASE STUDY

4.1 Requirements Workshop

The requirements elicitation process took place in the context of a requirements workshop. The workshop took place at the UCL Knowledge Lab (London) on the 2nd of December 2017. It was a 90-minute session attended by a cohort of seven stakeholders. The group of participants was fairly diverse as it comprised one teaching assistant, two teachers (history and ICT), one

special educational needs teacher, one school principal, one school manager, and one member of a school committee. The diversity among the stakeholders created opportunities for stimulating and engaging discussions. The models presented were seen and evaluated from different viewpoints and that was perceived as beneficial by the participants. The workshop was driven by the four general pillars on running workshops as they presented by (Lysén, 2003). The pillars suggest that the workshop must be built on participants experience and understanding, the aims need to be understandable by all the participants, the language used has to be adjusted to the participants level, and all the participants must be involved and have opportunities to talk and participate. Following these rules proved to be a challenge especially when participants were approaching things from quite diverse viewpoints.

The methodology of the workshop is an adaptation of the SCRAM (Sutcliffe and Ryan, 1998). The workshop was organised as a series of eight phases that took place in a linear manner. The structure of each phase follows the scheme "presentation, focus group discussion, summarisation through written feedback". These scheme borrows from the task characteristics technique proposed by (Browne and Rogich, 2001).

4.2 Findings

The workshop brought to the fore several specific requirements but here we focus on two general requirements that could be transferred to other work. The first is the participants' need to take answers easily and quickly without putting effort to interpret the visualisation of the findings. The second one goes one step further. The participants require the system to provide suggestions that assist the decision-making process. The workshop also facilitated the elicitation of more specific requirements. According to these requirements:

- The participants would prefer visualisations to contain simple graphs that provide certain information in a straightforward manner. Enhancement of visualisations with additional and assistive indicators should be very careful and limited. In many cases, the additional information seems to confuse instead of help.
- They want to see the way a variable moves over time so that they can be aware of its progress. They also want to be able to compare analysis results between entities (schools. classrooms, teachers, subjects). They want this information to be part of the main visualisation of a variable in order to take the maximum amount of information at once.
- They need to see a navigation menu -preferably multidimensional and interactive- in order to understand the way the information is organised and access the level of interest easily. For instance, a teacher might be interested in classroom-level answers, a principal in school-level answers, and a manager in company-level answers.
- Once they find the organisational level they are interested in, they want to be able to select the level of specificity, that is the level of dimension, factor, and question. Configurable presentation of analysis results enables them to find the information easily and quickly.
- The system must provide the user with a "search engine". The search engine has to enable the user to find answers easily and quickly providing them with the maximum selection of options that can be combined during the search.

The first four points are in essence agreements, disagreements, or enhancements on the given prototypes. These suggestions can be taken into account and inform the refinement of the prototypes. On the contrary, the last point needs further discussion as it is a new idea emerged from the focus group discussions during the workshop.

5 CONCLUSION

This paper introduces a new instrument that can be used to elicit educational stakeholder requirements and inform the design process of learning analytics tools and dashboards in particular. This instrument addresses an existing problem and complements other well-established frameworks and techniques in the area of learning analytics design. The instrument can be used to capture their requirements with regards to communication of learning analytics results to end users through learning analytics visualisation dashboards. Its aim is to explore characteristics of visualisations that help stakeholders firstly access easily the analysis findings and secondly make well-educated decisions based on these findings.

The instrument was implemented as a case study in the form of a workshop. The logic of the workshop was to develop early prototypes as demonstrations of various data visualisations and to present them to stakeholders. The stakeholders' role was to look at the prototypes with a critical eye and discuss the degree that they achieve their purpose as alternative communicational approaches. The design

of the prototypes was informed by a review on information visualisation in and on existing visualisation dashboards. Some features of the prototypes are borrowed from existing systems whereas others are developed from scratch. This paper presented a case study with findings from a stakeholders' workshop that mainly demonstrated the need for visualisations that are as simple as possible and provide the maximum information in easy-to-read interfaces. While this may be retrospectively expected, the workshop emphasised the need for accompanying visualised findings with recommendations that move beyond interpretation and help stakeholders make meaningful fact-based decisions. To cover different needs of teachers, educators and other stakeholders, a learning analytics system should be flexible to give them the ability to choose the information they need to see as well as the depth and the breadth of the information presented at different levels of granularity.

With the specific design recommendations we are making above, this work is a step towards an appreciation that data analysis cannot act alone in fulfilling the purpose of communication as it may not convey the intended messages in an actionable manner. While further work is needed to understand how best to communicate learning analytics in a way that helps stakeholders make the most out of these tools, the work presented here demonstrates how an appropriate instrument can lead to design requirements that reflect the actual stakeholders decision-making needs.

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