Case Study

em foco
Revista Científica em Educação a Distância

Development of an Interface for Visualizing Engagement Profiles Created from Educational Data Grouping

Desenvolvimento de uma Interface para Visualização de Perfis de Engajamento Criados a Partir de Agrupamento de Dados Educacionais

ISSN 2177-8310
DOI: 10.18264/eadf.v15i1.1725

Pamella Letícia Silva de OLIVEIRA[1]
Rodrigo Lins RODRIGUES[2]
Alexandre Magno Andrade MACIEL[1]

[1] Universidade de Pernambuco. Rua Benfica, 455 - Madalena, 50720-001 – Recife– PE – Brasil.

[2] Universidade Federal Rural de Pernambuco. Rua Dom Manuel de Medeiros, s/n - Dois Irmãos, 52171-900 – Recife – PE – Brasil.

Abstract

The distance learning modality faces challenges in improving teaching efficiency, reducing student isolation, and enhancing support technologies. Research focuses on student engagement, but large class sizes make individual tracking difficult. This study aimed to develop an interface for visualizing engagement profiles based on clustered educational data. The Design Science Research (DSR) methodology was used, which involved: 1) problem investigation through interviews with teachers; 2) development, selecting engagement variables, clustering algorithms, and visualization metaphors; 3) evaluations, with feedback from teachers and data visualization experts. Key findings include: 1) the need for tracking tools and the importance of forums, as mentioned by teachers; 2) the "what-why-how" structure for selecting the appropriate visualization; 3) features to ensure greater usability in dashboards, such as reducing scroll and grouping visualizations by information type, as pointed out by experts.

Keywords: Distance education. Engagement. Data visualization. Usability.

Received 04 /11/2024
Accepted 04/04/2024
Published 04/14/2025

Responsible Editors:
Daniel Salvador
Carmelita Portela

HOW TO CITE THIS WORK

ABNT: OLIVEIRA,P. L. S. de; RODRIGUES;R. L.; A. M. A. MACIEL. Development of an Interface for Visualizing Engagement Profiles Created from Educational Data Grouping. **EaD em Foco**, v. 15, n. 1, e1723, 2025. doi: https://doi.org/10.18264/eadf.v15i1.1725

Desenvolvimento de uma Interface para Visualização de Perfis de Engajamento Criados a Partir de Agrupamento de Dados Educacionais

Resumo

A modalidade de ensino a distância enfrenta desafios para melhorar a eficiência do ensino, reduzir o isolamento dos alunos e aprimorar as tecnologias de suporte. Pesquisas focam no engajamento dos estudantes, mas turmas grandes dificultam o acompanhamento individual. Este trabalho teve como objetivo desenvolver uma interface para visualização de perfis de engajamento com base em dados educacionais agrupados. Utilizou-se o Design Science Research (DSR), que envolveu: 1) investigação do problema, por meio de entrevistas com professores; 2) desenvolvimento, com a escolha de variáveis de engajamento, algoritmo de agrupamento e metáforas de visualização; 3) avaliações, com feedback de professores e especialistas em visualização de dados. Como resultados, destacam-se: 1) a necessidade de ferramentas de acompanhamento e a importância dos fóruns, mencionadas pelos professores; 2) a estrutura "what-why-how" para escolha da visualização; 3) características para garantir maior usabilidade nos painéis, como reduzir o scroll e agrupar visualizações por tipo de informação, conforme apontado pelos especialistas.

***Palavras-chave**: Educação a distância. Engajamento. Visualização de dados. Usabilidade.*

1. Introdução

Distance education in higher education institutions is familiar to most countries worldwide (AL-ANEME, G. C.; OLAYIWOLA, P. O.; REJU, C. O. 2010). This happens due to some benefits distance learning provides students, such as a flexible schedule, greater geographic access, and often more affordable prices than in-person. However, according to FARAHMAND, A.; AKBER DEWAN, M. A.; LIN, F. 2021), institutions are dealing with a series of related challenges with online learning, such as increasing teaching efficiency, removing the feeling of isolation of students and improving technologies to support teaching and learning online.

Given this scenario, a fundamental strategy for institutions to improve the effectiveness of distance education is through engagement (WIDIATMAKA, T. J. R., I. et al. 2021). Corroborating, in (OLIVEIRA, P. L. S. de et al. 2022), the authors state that engagement is considered one of the main components that guarantee consistency in learning activities and effective online teaching, given that this educational phenomenon is related to student retention and improvements in the quality of their overall experience. Furthermore, the authors also state that recent research on online teaching has begun to focus less on completion rates and more on student participation and engagement.

However, evaluating the online teaching-learning process can be challenging for teachers, as the number of students per classroom can vary from a few students to more than 50, which, in turn, can cause difficulty for teachers to provide equal amounts of attention per student or even be aware of the entire class environment (KONO, M. et al. 2018). For this, educational data mining (EDM) techniques, especially clustering, can be used, given that this technique aims to group elements in such a way that the characteristics of the group elements (called clusters) are more similar to each other than to other groups (LUIS

CAVALCANTI RAMOS, J et al. 2016). Therefore, this could make it easier for teachers to monitor groups of students with similar profiles instead of hundreds of individual students. Although these techniques have existed for a long time, understanding their results is challenging for teachers not accustomed to data analysis knowledge. One solution to this is to use a data visualization interface to facilitate teachers' understanding of clustering results.

Learning analysis interfaces are mainly used to identify different student profiles. Visual analysis is one of the most common techniques for visualizing information related to student engagement. Generally, data visualizations are very useful for students' self-awareness and self-reflection. For teachers or other interested parties, as support for decision-making (MUBARAK, A. A.; AHMED, S. A. M.; CAO, H. 2021). However, in the perception of students and teachers, it is not easy to interpret the data displayed on the panels (BANERES, D.et al. 2021). Therefore, one challenge that panels face is selecting the appropriate visualization technique (JAYASHANKA, R et al., 2022).

2. Methods

This section will delve deeper into the methodological details applied in this work to achieve the proposed objectives. The Design Science Research (DSR)(LACERDA, D. P. et al. 2013) methodology was used for this. This methodology was chosen because the steps correspond to the objective of this project. Therefore, in this work, the three main stages of the method were adapted and used: awareness of the problem, suggestion and development, and validation. Corroborating for authors (SOUTO REINHEIMER, W et al. 2021), DSR focuses on the design and development of solutions and their practical implementation and adoption by users.

2.1. Problem Awareness

To understand the daily challenges of distance learning teachers, we prepared a semi-structured interview consisting of four questions, which was carried out with two pedagogy teachers, a mathematics teacher, and an administration teacher from the distance learning course at Universidade de Pernambuco. This interview was conducted individually in a remote format and lasted an average of 30 minutes.

(1) What tool/method do you use to monitor student engagement?

Different means are used to monitor. One interviewee mentioned that she creates a monitoring spreadsheet; the others mentioned that she monitors it through the environment, email, and tutor feedback. Interviewee 1: "I make a more pedagogical spreadsheet with my tutor, passing on some parameters such as participation, observation, and students' names." Interviewee 2: "I use three forms: the environment, looking to see if there are students online if they are doing activities; email, where I receive communications from the environment; and feedback from tutors, where I receive information about face-to-face meetings and specific activities that tutors give."With these answers, it was possible to notice the absence of a specific tool for monitoring students that can be used by both teachers and even tutors.

(2) How often do you usually accompany students?

We had very varied answers to this question; one interviewee mentioned "daily," another "weekly," and two "monthly." Interviewee 1: I check daily if students are online to study my subject". Interviewee 2: "I follow up with the tutors monthly, because the activities take longer to carry out".

(3) How can you identify students with different engagement profiles?

In this question, three interviewees mentioned that it was due to interaction on the forum, and only one mentioned that it was due to tutor feedback. - Interviewee 1: "For the response and interaction with other students on the forum." -Interviewee 2: "On the forum, I see the same students or groups that are generally the first to participate and that participate more in the first weeks but disappear." These responses highlight the relationship between forums and student engagement through participation with other students and the frequency of access over time.

(4) What do you think about monitoring groups of students instead of them individually?.

When questioned, the interviewees found it important and mentioned factors such as class size and pedagogical proposals for the groups. Interviewee 2: "Very important because it is impossible to carry out individual monitoring due to the class size." Interviewee 1: "It is much better to look in groups to be able to think about proposals and pedagogical aspects of that group."

2.2. Development

This section explains the three steps for building the panel: 1) Chosen Engagement Variables, 2) Choice of Visualization Metaphors, and 3) Grouping.

In the first step, the engagement variables identified in the systematic mapping conducted by (MACÊDO, P. H. et al. 2021) were considered. Their study analyzed articles published between 2001 and 2019, collected from repositories such as IEEE Xplore, ACM Digital Library, ScienceDirect, Springer, and ERIC. The mapping resulted in the identification of engagement variables supported by evidence from more than five different studies. The selected variables are: 1) Number of forum accesses; 2) Number of messages posted on the forum by the student; 3) Number of activities accessed; 4) Number of accesses to the Learning Management System (LMS); and 5) Final grades.

In the second stage, the choice of a visualization metaphor cannot be carried out randomly since, when placing the data, the information can be confusing to the reader. Given this, some authors present structures to assist in the choice of visualizations.

In (SEDRAKYAN, G.; MANNENS, E.; VERBERT, K. 2019), the authors present some concepts that should be considered: visualization objectives, reasons for visualization, adaptation to the public, data characteristics, types of graphs by visualization objectives, effectiveness, expressiveness, readability and interactivity. Corroborating (MUNZNER, T. 2014), a high-level structure is presented to analyze the use of visualization according to three questions: 1) What data will the user see? 2) Why does the user intend to use a visual tool? 3) How are visual coding and interaction constructed in terms of design choices?

Therefore, to choose the visualization metaphors, twenty-six articles were selected that addressed the grouping, seven from the area of education and the others in different contexts. As a result, the five most used visualizations were identified: heatmap, scatter, line, histogram, and area. It is worth highlighting that visualizations that allowed monitoring and analyzing the grouping were considered, and not visualizations were used to analyze the grouping metrics. For example, method graphs Elbow and dendrogram used to identify the correct number of groups were not considered.

In Frame 1, the information on the five metaphors presented above is summarized according to the analysis structure, "What?-Why?" defined by (MUNZER T. 2013) and (SEDRAKYAN, G. MANNENS, E. VERBERT, K. 2019).

Frame 1: Analysis structure of the five visualization metaphors.

Order	View Metaphor	Type of Attribute (What)	Goal/Task (Why)
1st	Heat map	1 quantitative 2 categorical	Findgroups, outlier, summarize
2st	Dispersion	2 quantitative	Visualize trends, outliers, distribution, correlation, find groups, compare, relate
3st	Line	1 quantitative, 1 ordinal	View trends, compare, relate
4th	Bar	1 quantitative, 1 categorical	Search, view trends, and compare values, composition
5th	Area	1 quantitative, 1 categorical, 1 ordinal	compare

Source: Prepared by the authors

Considering what was explained in Frame 1, the results and the discussion regarding the choice of each view for the five engagement variables will be presented in the section results. Finally, to define the value of K for the Kmeans algorithm, the Elbow method was used, which is widely used in the literature due to its reliability and ease of application. Another method used to compare with the Elbow result was the Silhouette Index.

2.3. Validation

According to (VALENTIM, N. M. C. et al. 2014), among the types of evaluations that software companies carry out to improve the quality of applications are Heuristic Assessment and User Experience Assessment.

The heuristic evaluation of this research was carried out considering the usability concepts mentioned by (DOWDING, D.; MERRILL, J. 2018). The authors furthermore mention six usability criteria: spatial organization, coding of information, reduction of the data set, flexibility, consistency, and recognition rather than remembering. These criteria were used to compose the usability questions asked of experts in the area.

In addition, one more question was also prepared to consider the general context: could you give your opinion on whether the variables are being represented clearly? With the questions prepared, the experts were invited to an online interview by email. Therefore, each specialist participated in the meeting individually, where the panel was presented, and general and usability questions were asked.

The user experience assessment was based on studies by (HASSENZAHL, M.; TRACTINSKY, N. 2006), which state that a product should no longer be seen as simply a package of functional features and benefits but rather as providing experiences.

Based on the user experience model proposed by (HASSENZAHL, M.; TRACTINSKY, N. 2006), today, Attrakdiff (https://attrakdiff.de/index-en.html) is commonly used, which allows for the evaluation of four different aspects of an application: (1) Pragmatic Quality (PQ), which describes the quality of an application and indicates the degree of success that users achieve using the application; (2) Quality Hedonic Stimulus (QH-S), this dimension indicates the extent to which the application can support the needs to develop and advance the application in terms of originality, interest and stimulation. (3) Quality Hedonic Stimulus (QH-I), which indicates the extent to which the application allows the user to identify with it; and (4) Attractiveness (AT), this dimension indicates the overall value of the application, based on the perception of quality.

These qualities make up the questionnaire, which has a set of 28 pairs of words, each application consisting of seven items. Each pair of words represents a questionnaire item based on a scale of (-3 to 3). The word pairs used on the scale with semantic differential were placed at the extremes of the scale.

3. Results e Discussion

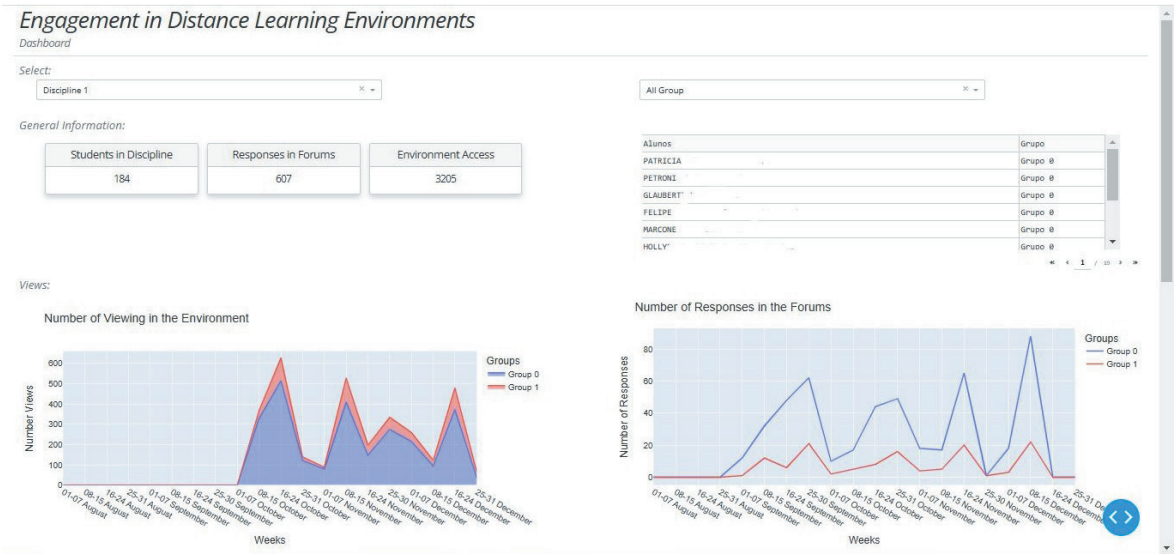
3.1. Clusters

The first results refer to the values obtained for k. According to the Silhouette Index, grouping with two groups is ideal for both disciplines, according to the values found closest to the value 1, which were 0.64 and 0.70, for k=2. Corroborating this, when using Elbow, the value indicated for k was two groups for both disciplines. The average values for the five variables: access to the forum, access to the environment, access to activities, response in the forum, and grade, of group 0 and group 1 of a specific discipline were, respectively: 75.06 and 41.93, 129.75 and 70.37; 15.62 and 7.08; 26.87 and 11.37; 3.66 and 3.17. When analyzing these results, it is noted that “group 0” has higher values in all variables concerning “group 1”. However, it is still not possible to name “Group 0” as “engaged” and “Group 1” as “disengaged,” as this interpretation of each group’s level of engagement may vary from teacher to teacher and according to the particularities of each subject.

3.2. Prototype

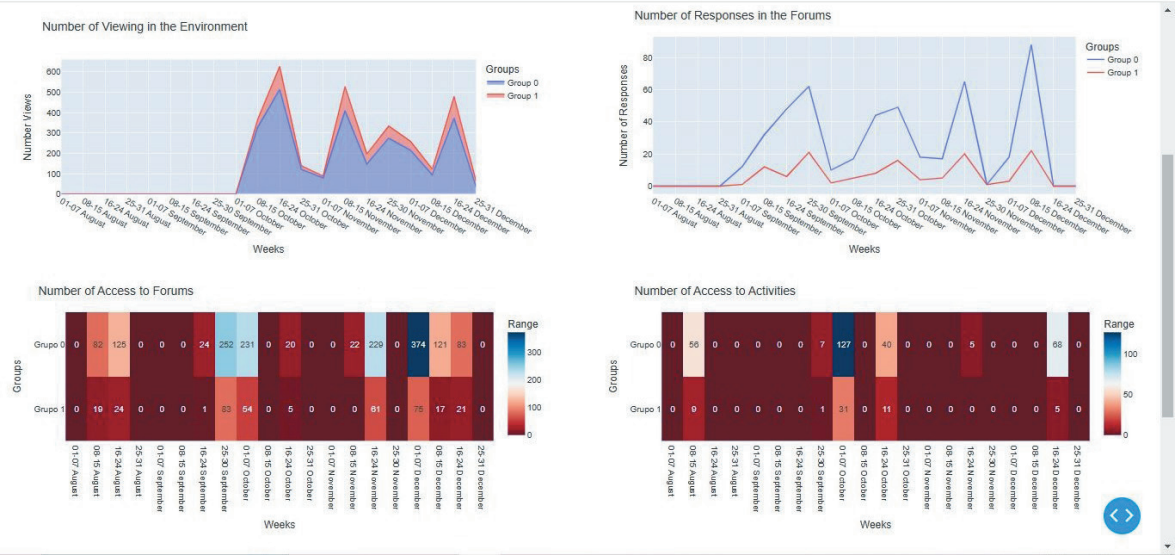
The variables representing engagement were associated with the views that best suited them. As presented below, to carry out this analysis, two questions from the structure proposed by (MUNZER T. 2013) and (SEDRAKYAN, G.; MANNENS, E.; VERBERT, K. 2019) were used, presented in Table 1, when viewing the panel in Figures 1 and 2.

Figure 1: Panel prototype.



Source: Prepared by the authors.

Figure 2: Panel prototype (continued).



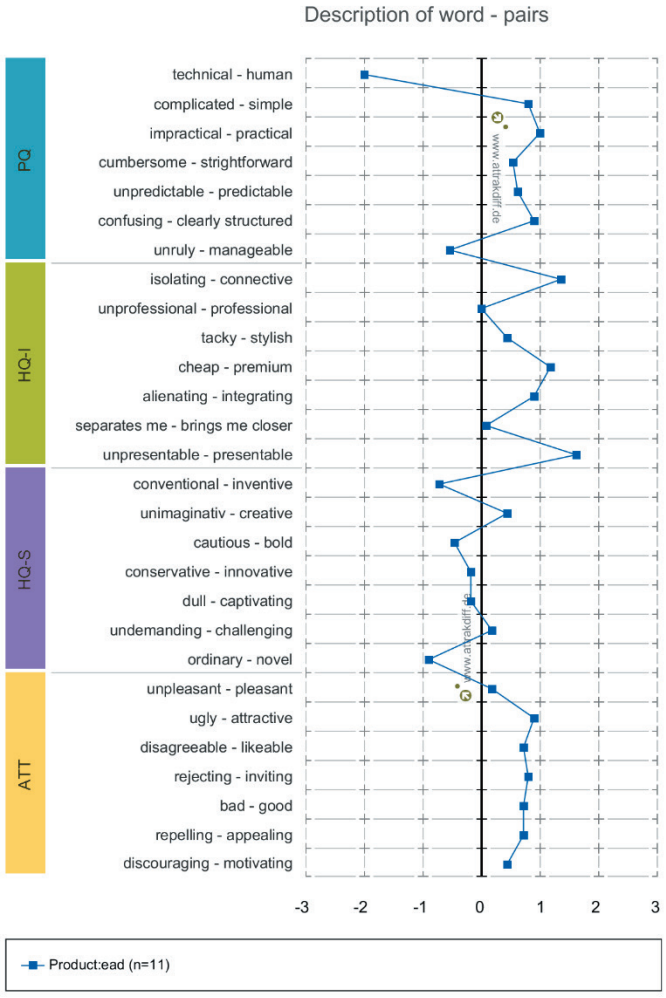
Source: Prepared by the authors.

Therefore, to see the trend in the number of responses on the forums (quantitative and ordinal), we use a line graph; to summarize the information on access to the forums and activities (quantitative, categorical, and ordinal), we use a heat map, to compare the accesses of each group (quantitative, ordinal) we use an area chart. We use scatter and bars to analyze the distribution and composition of the notes (quantitative, quantitative/categorical). Therefore, it is noted that the same type of data can be used for different visualization metaphors, and the "why" must also be considered, that is, the objective intended to be achieved with that visualization.

3.3. User Experience

This section presents the results obtained with the questionnaire adapted from Atrakkidf, which eleven distance learning teachers answered. The questionnaire data were arranged in three graphs: (1) Results portfolio graph; (2) Average Values Diagram; (3) Word pair description chart. The average values for each of the items are also calculated to allow better detailing of user evaluations, as shown in the graph of word pairs in Figure 3.

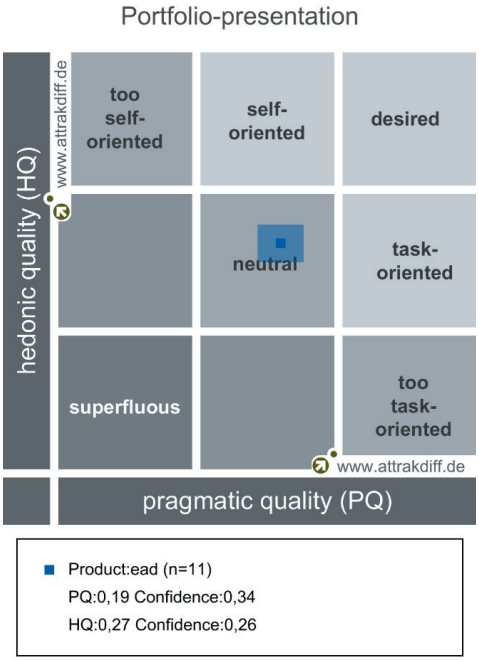
Figure 3: Word pairs.



Source: Prepared by the Attrakidff.

The portfolio graph of AttrakDiff results, presented in Figure 4, visually represents users' perceptions of the pragmatic and hedonic quality of a product or software.

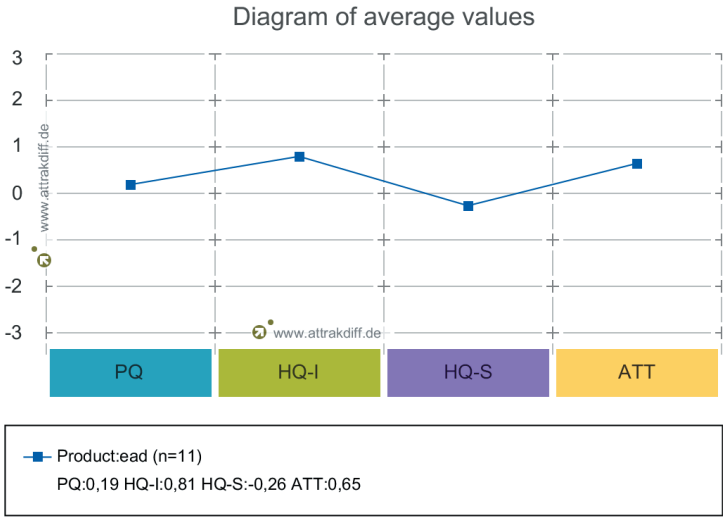
Figure 4: Portfolio graph.



Source: Prepared by the Attrakidff.

The average values of the AttrakDiff dimensions for the panel are plotted in the diagram in Figure 5. In this graph, the scale is considered -3 to 3, with negative points being those below the value of 0.

Figure 5: Average values.



Source: Prepared by Attrakidf

The results of the three graphs allow us to state that the panel was evaluated as attractive and that the evaluators could identify with the product. However, points relating to usability and innovation must be studied. The lower values concerning usability and interaction may be due to the evaluators only having watched the demonstration video. Regarding innovation, we know that there are other panels in the literature. Still, our difference is related to the research involving engagement indicators and visualization metaphors, which still needs to be passed on to the evaluators.

3.4. Heuristic Evaluation

The evaluation process comprised two teachers from the data visualization area and two from the Human-Computer Interaction area. This evaluation took place individually, with each expert, through a video conference. The prototype was presented, and seven questions were answered. After this, the opinions obtained were aggregated.

After completing the opinion elicitation stage, it was possible to condense the statements made by the experts, whose responses are presented below:

(1) What did you think of the layout of the information on the dashboard?

For this question, the experts mentioned a common point concerning how the visualizations were distributed. Interviewee 2: "My suggestion regarding the layout is to group by forum, activity, notes, etc. to help people understand the context of each graph." Interviewee 1: "The graphs should be arranged for their content." - Interviewee 1: "In a dashboard, it is preferable not to scroll too much because you want to relate information from one view to another. So, preferably try to have everything in the same context or minimize the scroll amount".

2) In your opinion, are familiar symbols/phrases/words used to represent data or information elements?

Regarding this question, we obtain three points in common between the answers. The first point is related to the terminology used on the X axis, which, instead of "monthly," would be correct to "weekly" according to the data presented. Interviewee 2: "Maybe even put "per weeks" in the title in all the graphs, even if it would be redundant, but it would help. And on the X axis, I would also change "monthly" to "per week."

The second point concerns the term "grouping," where the ideal would be to have an explanation. Interviewee 2: "It would be good to define how the groups were defined, perhaps in the manual or when presenting. Because people are wary of these automatic decisions, it is good to make it clear."

The third point refers to the naming of the groups. Interviewee 2: "The only strange thing was that the groups were called "0" and "1", a name that represented who they are would be good." Interviewee 1: "Carry out an exploratory analysis and create a nomenclature for the groups according to their profile, to make it more intuitive and closer to the semantics of the title."

3) In your opinion, is there consistency and standardization in the dashboard elements?

For this question, the choice of colors for the panel in general was asked, as well as the use of colors that indicate groups on the heat map to indicate quantity. Furthermore, it was also recommended that the color choices align with accessibility. Interviewee 1: "The colors used in the color maps are inconsistent concerning the categories of other graphics." Interviewee 2: "Regarding colors, it would be interesting to research accessibility because it would be good to put colors that would be safer in terms of contrast and be nice even for those with visual impairments."

(4) Could you give your opinion on whether the variables are being represented clearly?

When analyzing the answers to this question, difficulties were identified in three graphs: dispersion, heat map, and area. Some observations were made regarding the dispersion: Interviewee 2: "The dispersion graph was confusing. It could become a graph just by normalizing the notes into a histogram graph or four histograms because the dispersion is usually a little ball representing an individual and, in this case,

is representing a group". Interviewee 1: "When I look at a scatter plot I think that each point is a student, because generally, these points indicate an entity. You are representing the same data as the bar graph, so I think it is more common to do it with the bar graph; for example, the X-axis, despite being numerical, is categorical because it groups the notes without showing the tenths".

The following suggestions were made regarding the heat map: Interviewee 2: "I liked line graphs more than color maps to see trends. And it was inconsistent to use two different types to show the same type of metric". Interviewee 1: "I do not know why it's a heat map and not a line graph because to show quantity using position is better than using color. Given that, it is unclear how much more red is one than the other".

Finally, we also had some suggestions for the area graph: - Interviewee 1: "In the area and line graphs, the data types are the same, so there is no reason to have a difference in the graphs. Generally, the area graph shows stacking when you want to show the total, not individually. So, the area one raises whether they are stacked, while the line one leaves no doubt. Therefore, whenever there is time, and there is no other reason, use one of the lines". Interviewee 2: "The first two graphs are very similar, and as they are side by side, they represent very similar information, so when you put two different types I think it confuses more than it helps because the person thinks "because one is painted and the other is not ."So as it is the same type of information, the same type of graph would be better since there is no reason".

However, according to experts, to obtain the most accessible and most intuitive panel, some points must be improved, such as:

- Explanation of some terms used to avoid doubts and increase user confidence.
- Group visualizations by type of information so that users understand the context of each visualization.
- Reduce the scroll so the user can relate and compare information from views.
- Change the label of the X axes to be more related to the data presented.
- Implement an accessibility option, making the panel accessible to people with visual difficulties.
- Change graphics that are not clear to guarantee the user greater interpretability in the visualizations.
- Change group names.

3.5. Final Artifact

This section presents the results obtained after implementing the changes suggested by experts in the panel.

The main change was related to the panel scroll. Figure 6 shows the overview of the panel, where it is possible to view all the elements in the same window: title, general information on the cards, filters, three graphs in full, and a good part of the last two graphs. With this, the user will now see all the information that the panel has without the need to scroll to find out what information the panel will present.

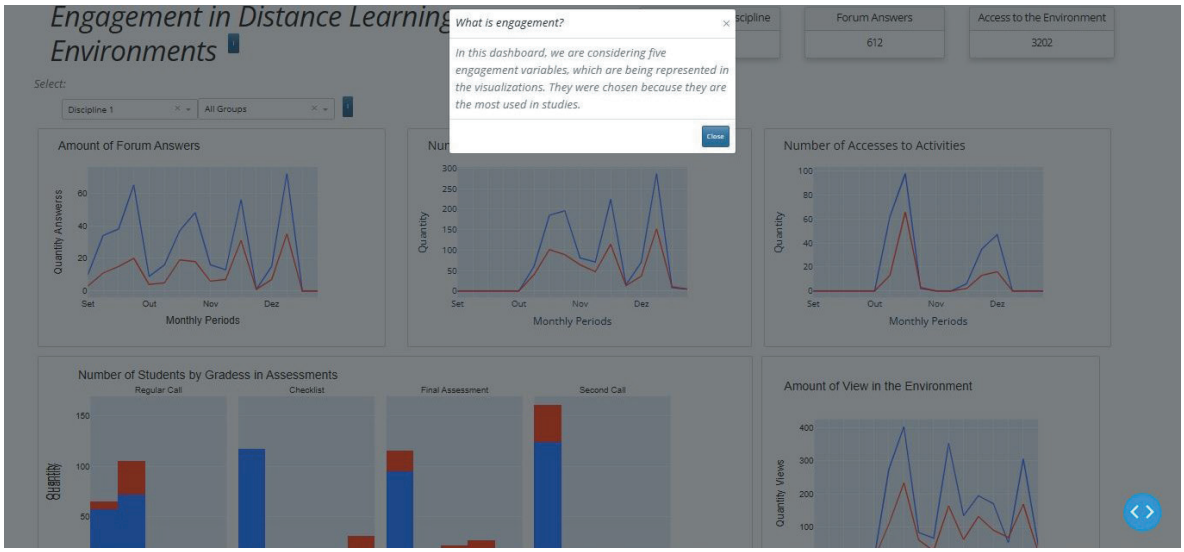
Figure 6: Dashboard overview.

Source: Prepared by the authors

Furthermore, in Figure 6 the filters and all five graphs can be viewed entirely in the same scroll. This modification allows the user to view a greater range of information at the same time and compare the information presented in each graph, facilitating simultaneous monitoring of groups and analysis of groups in the five views. The second modification considered was related to the types of visualization metaphors. Given the question raised by experts about the use of heat, dispersion, and area maps representing the same types of data and with the same objective as the line graph and histogram, we chose to leave the panel with only these two types of data views.

Another modification was made to the terms “engagement” and “groups.” To resolve possible doubts about what we consider engagement and how the groups were formed, buttons were added next to these terms, which, when clicked, will open a pop-up with the respective explanations, as shown in Figure 7.

Figure 7: Pop-up



Source: Prepared by the authors

In general, the suggestions mentioned by the experts were met, except for the one related to the naming of the groups, as it was not part of this project's scope. Therefore, the panel displays five views simultaneously, made up of simple and easy-to-understand graphics. Furthermore, extra information has been hidden but can be accessed when the user needs it. Thus, complete information is provided in the dashboard overview to facilitate engagement monitoring.

Therefore, given the suggested changes, the dashboard is a composite tool with visualizations suitable for monitoring student engagement. Furthermore, by explaining the technical information used in the panel, teachers will understand the information presented and thus feel confident in making decisions. Therefore, it is expected to improve the teaching-learning process in virtual environments.

4. Conclusion

This work addressed the development of visualization metaphors for monitoring engagement in an EaD environment, observing the peculiarities of visualization metaphors, the construction of a panel, and the need to improve the teaching-learning process.

One of the main contributions left by this project is related to the educational context. The results obtained in the interview with EaD teachers show the needs they mentioned from the perspective of the daily life of EaD teachers. With the survey carried out in these interviews, it was possible to find four main points of difficulty:

1. There is a need for a tool to track student data.
2. Data from forums is important in identifying engagement.
3. The large number of students per class.
4. Analyze the responses on the forum quantitatively and qualitatively.

In the area of data visualization, this research presented practical examples of the importance and how to use the structure to choose the correct visualization. Furthermore, another point that was well high-

lighted is that if the data and the objective are the same, we do not need to change them just to change the visualization; we can keep them the same.

In relation to usability, the interviews with experts clearly addressed elements and characteristics that must be followed to create a panel that is easy to interpret and handle for users. Furthermore, the literature also highlighted the stages of planning, design, implementation, and evaluation as important for creating panels.

However, this project leaves its contributions so that researchers can use it as a basis and develop more visual tools, whether in the educational field or other contexts. Furthermore, the panel was created and can be used by teachers to improve the teaching-learning process.

Acknowledgment

This paper was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brazil (CAPES) - Finance Code 001, Fundação de Amparo a Ciência e Tecnologia do Estado de Pernambuco (FACEPE), the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq) - Brazilian research agencies

References

ALANEME, G. C.; OLAYIWOLA, P. O.; REJU, C. O. Combining traditional learning and the e-learning methods in higher distance education: Assessing learners' preference. In: *2010 4TH INTERNATIONAL CONFERENCE ON DISTANCE LEARNING AND EDUCATION*, 2010, [s. l.], . [S. l.]: IEEE, 2010. Disponível em: http://dx.doi.org/10.1109/icdle.2010.5606008 Acesso at: 30 Jul. 2024.

BANERES, D. et al. A Predictive Analytics Infrastructure to Support a Trustworthy Early Warning System. *Applied Sciences*, [s. l.], v. 11, n. 13, p. 5781, 2021. Disponível em: Acesso at: 30 Jul. 2024.

DOWDING, D.; MERRILL, J. The Development of Heuristics for Evaluation of Dashboard Visualizations. *Applied Clinical Informatics*, [s. l.], v. 09, n. 03, p. 511–518, 2018. Disponível em: Acesso at: 30 Jul. 2024.

FARAHMAND, A.; AKBER DEWAN, M. A.; LIN, F. Constructing Intelligent Learning Dashboard for Online Learners. In: *2021 IEEE INTL CONF ON DEPENDABLE 2021*, [s. l.], .Anais [...]. [S. l.]: IEEE, 2021. Disponível em: http://dx.doi.org/10.1109/dasc-picom-cbdcom-cyberscitech52372.2021.00141 Acesso at: 30 Jul. 2024.

HASSENZAHL, M.; TRACTINSKY, N. User experience - a research agenda. *Behaviour & Information Technology*, [s. l.], v. 25, n. 2, p. 91–97, 2006. Disponível em: Acesso at: 30 Jul. 2024.

JAYASHANKA, R.; HETTIARACHCHI, E.; HEWAGAMAGE, K. P. Technology Enhanced Learning Analytics Dashboard in Higher Education. *Electronic Journal of e-Learning*, [s. l.], v. 20, n. 2, p. pp151-170, 2022. Disponível em: Acesso at: 30 Jul. 2024.

KONO, M. et al. Design and Study of a Multi-Channel Electrical Muscle Stimulation Toolkit for Human Augmentation. In: *PROCEEDINGS OF THE 9TH AUGMENTED HUMAN INTERNATIONAL CONFERENCE*, 2018, New York, NY, USA. Anais [...]. New York, NY, USA: ACM, 2018. Disponível em: http://dx.doi.org/10.1145/3174910.3174913 Acesso at: 30 Jul. 2024.

LACERDA, D. P. et al. Design Science Research: método de pesquisa para a engenharia de produção. *Gestão & Produção*, [s. l.], v. 20, n. 4, p. 741–761, 2013.

LUIS CAVALCANTI RAMOS, J. *et al*. A Comparative eStudy between Clustering Methods in Educational Data Mining. *IEEE LatinAmericaTransactions*, [s. l.], v. 14, n. 8, p. 3755–3761, 2016. Disponível em: Acesso at: 30 Jul. 2024.

MACÊDO, P. H.; SANTOS, W. B.; MACIEL, A. M. A. Análise de Perfis de Engajamento de Estudantes de Ensino a Distância. *RENOTE*, [s. l.], v. 18, n. 2, p. 326–335, 2021. Disponível em: Acesso at: 30 Jul. 2024.

MUBARAK, A. A. *et al*. MOOC-ASV: analytical statistical visual model of learners' interaction in videos of MOOC courses. *Interactive Learning Environments*, [s. l.], v. 31, n. 5, p. 3055–3070, 2021. Disponívelem: Acesso at: 30 Jul. 2024.

MUNZNER, T. *Visualization Analysis and Design*. [S. l.]: CRC Press, 2014. 2014.

OLIVEIRA, P. L. S. de *et al*. Identificação de Pesquisas e Análise de Algoritmos de Clusterização para a Descoberta de Perfis de Engajamento. *Revista Brasileira de Informática na Educação*, [s. l.], v. 30, p. 01–19, 2022. Disponível em: Acesso at: 30 Jul. 2024.

SOUTO REINHEIMER, W.; DUARTE MEDINA, R. GAMIEFECTS: A proposta de um framework para apoiar a avaliação de gamificação em contextos educacionais. *RENOTE*, [s. l.], v. 19, n. 2, p. 122–131, 2021. Disponível em: Acesso at: 30 Jul. 2024.

SEDRAKYAN, G. et al. Guiding the choice of learning dashboard visualizations: *Linking dashboard design and data visualization concepts. Journalof Computer Languages*, [s. l.], v. 50, p. 19–38, 2019. Disponível em: Acesso at: 30 Jul. 2024.

VALENTIM, N. M. C. et al. Avaliando a qualidade de um aplicativo web móvel através de um teste de usabilidade: um relato de experiência. In: *ANAIS DO XIII SIMPÓSIO BRASILEIRO DE QUALIDADE DE SOFTWARE (SBQS 2014)*, 2014, [s. l.], . Anais [...]. [S. l.]: Sociedade Brasileira de Computação - SBC, 2014. Disponível em: http://dx.doi.org/10.5753/sbqs.2014.15258 Acesso at: 30 Jul. 2024.

WIDIATMAKA, T. J. R. *et al*. *E-Learning InfrastructureAnd Collective Engagement*: Antecendents And Conclusions In Driving E-Learning Quality. [S. l.: s. n.], 2021. Disponível em: https://zenodo.org/record/4923703