e-Health – For Continuity of Care
C. Lovis et al. (Eds.)

doi:10.3233/978-1-61499-432-9-1163

Big Data in Medical Informatics:Improving Education Through Visual Analytics

Christos VAITSIS[a,1], Gunnar NILSSON[b], Nabil ZARY[a]
[a]*Department of Learning Informatics Management and Ethics, Karolinska Institutet, Stockholm, Sweden*
[b]*Department of Neurobiology, Care Sciences and Society, Karolinska Institutet, Stockholm, Sweden*

Abstract. A continuous effort to improve healthcare education today is currently driven from the need to create competent health professionals able to meet healthcare demands. Limited research reporting how educational data manipulation can help in healthcare education improvement. The emerging research field of visual analytics has the advantage to combine big data analysis and manipulation techniques, information and knowledge representation, and human cognitive strength to perceive and recognise visual patterns. The aim of this study was therefore to explore novel ways of representing curriculum and educational data using visual analytics. Three approaches of visualization and representation of educational data were presented. Five competencies at undergraduate medical program level addressed in courses were identified to inaccurately correspond to higher education board competencies. Different visual representations seem to have a potential in impacting on the ability to perceive entities and connections in the curriculum data.

Keywords. Visual analytics, big data, medical education, data representation, medical informatics.

1. Introduction

There is a constant need to develop the competency of health workers through education, in order to match the demands of healthcare. One approach has been to react to observed deficiencies in healthcare that were linked to unsatisfactory required competencies [1]. An example was given by Cho et al. who highlighted the difficulties the physicians had to keep in pace with the growing medical literature, and therefore proposed to include a journal club in undergraduate medical education to acquire at an early stage the ability to critically review scientific literature, a skill needed as a future physician using evidence-based medicine [2]. While reviewing the literature, we've found limited research reporting on improvement of healthcare education based on educational data [3]. Hege et al. reported how non - previously perceived discrepancies between taught and the assessed curriculum were revealed using a web-based learning objectives database [4].

[1] Corresponding Author: Christos Vaitsis, Department of Learning, Informatics, Management and Ethics, Centre for Learning and Knowledge, Karolinska Institutet, Tomtebodavägen 18A, Stockholm, Sweden; christos.vaitsis@ki.se.

Methods and techniques that can manipulate data in many different disciplines have been developed [5], [6]. Visual Analytics (VA) is a relatively new research field that combines two frequently used techniques, information visualization and data analysis, along with the ability of human perception. The main purpose of VA is to support the manipulation and exploitation of complicated big data, and a holistic view of the data, in order to positively impact on analytical reasoning and decision-making [7]. VA allows the disclosure of previously unknown hidden information and patterns within the data, the use of cognitive strengths like perception and visual pattern recognition, and finally, the presentation of the processed information using visualization techniques [8], [9]. In healthcare education Olmos & Corrin reported how a simple visualization of data, extracted from a healthcare education system, enabled involved stakeholders to instantly review and preview the effects of implemented and future changes [10].

Big data are regularly collected during the evaluation of healthcare education and could, contribute to the continuous improvement of the medical curriculum. However, there is still a lack of empirical data about the use and benefits of VA in healthcare education.

The aim of this study was therefore to explore novel ways of representing curriculum and educational data using visual analytics.

2. Methods

2.1. Collection and sense-making of the educational big data

Big educational data have been collected by the undergraduate medical program at Karolinska Institutet during the preparation for the curriculum review by the Swedish Higher Education Authority (higher education board). This study has access to these curriculum data. Major entities within the curriculum that play important role in healthcare education delivery and quality improvement were identified. Examples are competencies, intended/taught learning objectives and the relation between them. They are defined in three different levels within the curriculum. In first level (higher education board) are the three major competencies (knowledge, skills and attitude) and these are analysed and given to the medical program as sixteen sub-competencies (H1-H16) [11], the students should achieve to learn after graduating from the medical program. In second level, the medical program based on higher education board three and sixteen competencies, developed eight major competencies that should be realized through different learning objectives in the third level of the courses. An example of this structure of competencies and learning objectives is: One sub-competency (H5) that belongs to skills is described as "diagnosing and treating" from the higher education board. According to this, the medical program developed one competency (#4), "system of man in direct contact" and this is addressed in the course level as "patient history". Skills → diagnosing and treating → system of man in direct contact → patient history, correspond to (three major competencies → H1-H16 → eight major competencies → learning objectives).

2.2. Exploration of novel ways of representing curriculum using visual analytics

We performed a review of the literature and found no scientifically validated VA technique or reported appropriate tools for the analysis, visualization and representation of curriculum and educational data. We therefore, explored existing tools and techniques from a plethora of open-source and proprietary software already applied for similar purposes of data visualization. We then examined their appropriateness and ability to represent educational big data from healthcare education. We opted for Cytoscape [11] in our study as a suitable tool because that allows for building a network of different entities and relations between them as they exist within the curriculum and enter it to cytoscape. This is automatically recognized as network with nodes and edges and we could easily rearrange them to preferable representations of shapes and formations. Thereby we built three different visual representations of a part of the curriculum with a focus on previously perceived and non-perceived connections existing in the curriculum. Three approaches were used; competencies mapping, competencies clustering and gap analysis.

3. Results

3.1. Competencies mapping

In Fig. 1 the three major competencies (Grundmål1-3) at the top are depicted with dark green colour and sub-competencies (H1-16) with light green. At the bottom are the eight major competencies of the program level (KI_mål1-8) in dark red and in the middle the learning objectives of the courses level in light red. We represent here how the learning objectives from course level relate to competencies of the program level and to competencies of the higher education board level.

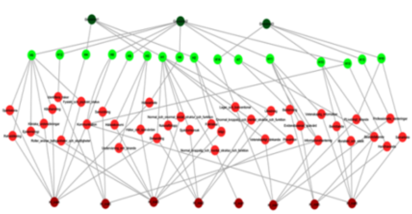

Figure 1 – Map of competencies and learning objectives of all levels. (larger competencies map)

3.2. Competencies clustering

In Fig. 2, entities have the same colours as in Fig.1 aiming to represent what learning objectives are used to address clusters of competencies connecting competencies from both program and higher education board level in the curriculum. Competencies are independent to each other within the clusters. Clusters with light blue background represent competencies from high education board and the cluster with light grey background represents the eight major competencies from medical program.

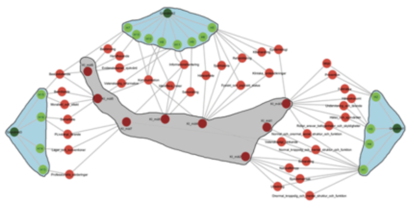

Figure 2 – Clusters of competencies and learning objectives. (larger competencies clustering).

3.3. Competencies gap analysis

In Fig. 3 the eight major competencies are depicted with red colour and have two different names so they can be processed as entities that represent the same information in two different places (KIMål1-8 on the left and KI_mål1-8 on the right). H1-H16 sub-competencies are with dark grey and three indicatively picked courses with light pink, light green and blue colours. We represent here mistakenly connected competencies between KIMål1-8 and H1-H16 as they are addressed in the courses. For example bold light pink line from KIMål3 should be connected to H5 according to intended connections between KI_mål1-8 and H1-H16 and instead is connected to H15. In total, five program level competencies were identified to mistakenly correspond to H1-H16 competencies (three bold blue lines, one light pink and one light green).

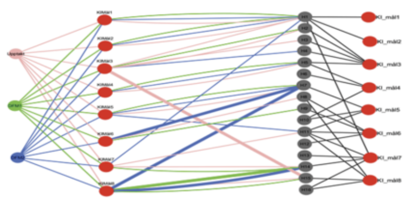

Figure 3. Gaps between higher education board and program's competencies. (larger gap analysis).

4. Discussion

This study reveals that visual analytics has the potential to impact quality improvement decision making. The techniques however were only applied to a snapshot of the curriculum data. The complexity of the curriculum indicates that more analysis must be undertaken to lower levels of learning outcomes and activities, and expand the analysis to represent the curriculum as it is evolved from previous years to today to create a holistic view. VA can be used to explore curriculum and educational data. The five competencies at medical program identified to mistakenly correspond to H1-H16 competencies reveal non-previously perceived discrepancies in competencies connections within the curriculum. The impact of different visual representations on the ability to perceive entities and connections was evaluated with semi-structured interviews with teachers from undergraduate medical education. The figures for relationship perception indicate that the ability to perceive connections between entities within curriculum data increased. The degree of analytical reasoning and data cognition of the curriculum data was also improved but to a lesser extent. Our findings are in line with a study by Corrin & Olmos that used a similar approach to help medical faculties enhance the alignment between clinical experiences and the curriculum [13].

This study therefore opens a new promising direction for medical educational informatics research, with possible implications for quality improvement and decision making in healthcare education.

5. Conclusion

VA can be used to explore and provide novel ways to represent curriculum and educational data. Moreover, different visual representations seem to have a potential in impacting on the ability to perceive entities and connections in the curriculum data thus enhance data perception and cognition. The new direction VA opened in this study for medical educational informatics research, requires further investigation towards both curriculum's structure complexity and ways to represent it, and the role that plays on impacting quality improvement and decision making in medical education.

References

[1] Frenk J, Chen L, Bhutta Z., Cohen J., Crisp N., Evans T., et al. Health professionals for a new century: transforming education to strengthen health systems in an interdependent world. Lancet [Internet]. 2010 Dec 4 [cited 2014 Jan 12];376(9756):1923–58.doi:10.1016/S0140-6736(10)61854-5

[2] Cho N., Gilchrist C., Costain G.Rosenblum N., (2013). Incorporating Evidence-based Medicine in the Undergraduate Medical Curriculum: Early Exposure to a Journal Club may be a Viable Solution, 88(3), 154–155. Available from: http://utmj.org/utmjupload/journals/2/articles/1344/public/1344-1938-1-PB.pdf

[3] Gathright M.M., Thrush C., Jarvis R., Hicks E., Cargile C., Clardy J., O'Sullivan, P. (2009). Identifying areas for curricular program improvement based on perceptions of skills, competencies, and performance. Academic psychiatry: the journal of the American Association of Directors of Psychiatric Residency Training and the Association for Academic Psychiatry, 33(1), 37–42. doi:10.1176/appi.ap.33.1.37

[4] Hege I., Nowak D., Kolb S., Fischer M.R., Radon K. (2010). Developing and analyzing a curriculum map in occupational- and environmental medicine. BMC medical education, 10, 60. doi:10.1186/1472-6920-10-60

[5] Steele J, Iliinsky N, editors. Beautiful visualization. Looking at data through the eyes of experts. O'Reilly Media; 2010. Chapter 10, Finding beautiful insights in the chaos of social network visualizations; p.157-73.

[6] Witten I., Frank E.H., Hall M.A. Data Mining. Practical machine learning tools and techniques. 3rd ed. Morgan Kaufmann series in data management systems; 2011. Chapter 9, Moving on: applications and beyond. p. 375-97.

[7] Keim D.A., Mansmann F., Thomas J., (2009). Visual Analytics: How Much Visualization and How Much Analytics?, 11(2), 5–8. Available from: http://www.hiit.fi/vakd09/vakdsi09keim_final.pdf

[8] Steed C.A., Goodall J.R., Potok T.E., Maness C., Patton R.M., Senter J. Interactive Visual Analysis of High Throughput Text Streams. 2012;1–4.Available from:http://research.microsoft.com/en-us/um/people/shliu/tasmc/paper/Interactive-Visual-Analysis.pdf

[9] Keim D.A., Mansmann F., StoffelA., Ziegler H. Visual analytics. Encyclopedia of Database Systems. Springer, 2009. 3341-3346.

[10] Olmos M, Corrin L. Academic analytics in a medical curriculum: Enabling educational excellence Academic analytics: A timely new field. 2012;28(1):1–15.Available from:http://www.leishman-associates.com.au/ascilite2011/downloads/papers/Olmos-full.pdf

[11] Swedish Higher Education Authority (English version), http://english.uk-ambetet.se

[12] Cytoscape, http://www.cytoscape.org/ (17.12.2013)

[13] Corrin, L. Olmos, M. (2010). Capturing clinical experiences: Supporting medical education through the implementation of an online Clinical Log. In Steel C. H., Keppell M.J., Gerbic P., Housego S.(Eds.) Curriculum ,technology& transformation for an unknown future. Proceedings ascilite Sydney 2010 (pp.231-235). Available from: http://ascilite.org.au/conferences/sydney10/procs/Corrin-concise.pdf.