Learning at Work: Visual Learning Analytics to Upskill Aerospace Engineers in Advanced Manufacturing

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Abstract: The study focuses on how learning sciences and visual learning analytics can be used to design, and to improve, online workforce training in advanced manufacturing. We analyzed the data from a cohort of 900 professionals enrolled in an online training course regarding additive manufacturing. The results inform strategies for instructors to better align the course assignments, learning objectives, and assessment measures and argues for a synchronized data structure for use across online learning platforms.

Introduction

Effective adoption of online platforms for teaching, learning, and skill development is essential to both academic institutions and workplaces (Larson & Miller, 2011). Research on pedagogy and practice for effective online instruction has boomed in recent years, abruptly accelerated by the COVID-19 pandemic. At the same time, educators and trainers are woefully underprepared for the needs of designing for this space, especially for challenging content areas, such as those with specific physical environment needs. What is needed are more systemic approaches to scaffold high-quality online learning outcomes, grounded in the science of how people learn (National Academies of Sciences & Medicine, 2018) and how to design for online skill development for the future of work. This study builds upon prior approaches in learning sciences to support learning in the workforce through research partnerships with industry partners (e.g., Dede, 2006). Particularly, educational data mining (EDM) and learning analytics (LA) as a set of emerging practices have been used to examine learners' trajectories, activities, proficiencies and provide useful information for instructors to understand employees' learning (Ginda et al., 2019). Resultantly, various fields have seen an emerging trend where companies and educational institutions work collaboratively to develop courses to meet specific stakeholder goals.

To combine the latest understandings from the learning sciences with data visualization to scale high-quality learning outcomes to the gamut of online skills development offerings required by rapidly accelerating industry developments, this study illustrates the potential of applying learning design to a course focused on upskilling employees of a large aerospace manufacturer, offered via a leading research university's Massive Open Online Course (MOOC) platform. In line with current learning theory, an iterative approach to design-based educational research was applied to design online certificates and tested a learning objective-based approach to professional online education. Our aims are to support not only the intersection of the learning sciences and workforce training research, but also to the scientific process of exploration, discovery, confirmation, and dissemination. In this study, we ask: How can visual learning analytics (VLA) reflect students' engagement, learning outcomes, and the intersection of both with learning objectives? By answering the research question, we aim to provide a course design guide that incorporates the findings of students' engagement, learning outcomes, and learning objectives to inform the design of online courses.

Methods

A nine-week online course focused on Additive Manufacturing (AM) was developed by aerospace employers as well as experts and scholars in AM and launched in 2017. We worked with the company to examine the learning outcomes and trajectories of 900 engineers to advance the upskilling process. We captured log file data from the course's learning management system (i.e., time an individual spends on videos or assignment), and analyzed employees' performances with course activities from week one to six. In this poster, we removed the data from week seven to nine, because employees used a 3D CAD modeling design platform, OnShape, which provides little information on the course site regarding learning activities and performance. We then qualitatively coded 31 learning objectives from weeks one to six to examine the relationship between the content of course modules and assignment and employees' performances. We then visualized the results to cross compare the performance data and learning objectives. The purpose of the analyses was to examine if the content of the course modules and assignment were well designed to evaluate employees' learning which can be reflected on their performances.

Results

To understand how the instructional design supported employees' learning, the study examined the learning modules with learning objectives analysis, and then applied visual analytics and qualitative coding to investigate the relationships between learning objectives, performance, and engagement. Overall, our linear regression modeling confirms that time spent engaging course content positively correlated to student performance (r^2 =.4527, $p < .01$, n = 880). While these results are not surprising, it is an important measure to run at the end of any course to ensure that students, regardless of background knowledge, can perform well if they invest an adequate amount of time in the course. Examining the intersection of student performance, assessment measures, and intended learning outcomes yielded additional insights into how students engaged with the content. Taking a closer look at the amount of time spent on each learning objective has two primary benefits. First, by providing VLA dashboards, this analysis helps to establish where students spent their time in the course content, as well as establish more accurate estimations of time toward completion of each module. Second, the VLA clarified the amount of time it should take for students to accomplish a specific learning objective. Figure 1.1 presents the time students spent on each learning objective. This view makes salient how much time proportionately is dedicated to a learning objective, either in terms of time each student spent to complete a task, or how much extra time is dedicated in terms of learning activities to specific learning objectives. Furthermore, analyzing overall distribution of student performance within each LO and longitudinally can yield additional insights (see Figure 1.2). For instance, certain LOs produce very low scores, instructors can look for correlation between performance and time spent. If more time spent on a LO leads to a low score, instructors can infer that students are putting forth effort, but the course content could be improved in future iterations.

Figure 1.1
Engagement Time by Learning Objectives

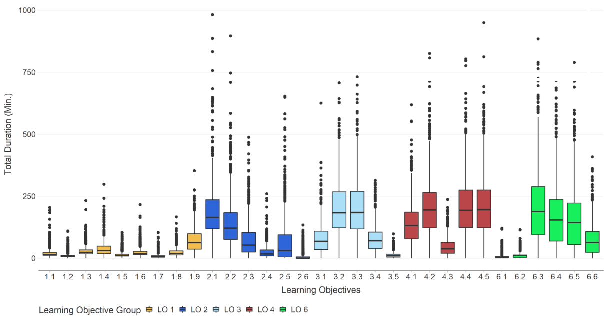
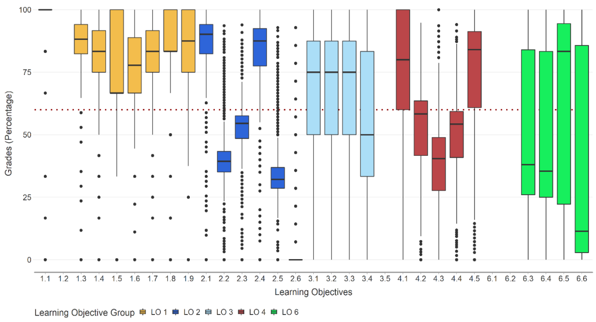


Figure 1.2
Percentage Grades by Learning Objectives



Discussion

This study examined the learning processes and outcomes of aerospace engineers through an online course which focused on the topic of additive manufacturing. Based on the analyses of learning objectives, processes and outcomes, the results informed modifications of future course content and assessment. This work took a fair amount of time to develop the training and courses, and it could be automated if the MOOC platform was designed with simple supporting workflows aimed to articulate learning objectives and tag them in the course assignments and assessment metrics. These key components could be fixed in advance and improve the overall course. Although the data and analyses were drawn from a single case, they provided a springboard to establish field standards across online courses and platforms in using LA and data structure for the purposes of adaptive assessment. To move forward, the process of upskilling employees requires close collaboration of learning scientists, data scientists, security experts, learning platform developers, and industry to design and develop learning materials and environment which lead to measurable improvements in work performance. This study helps to connect learning sciences to the increased focus on the upskilling issue in the workforce by applying EDM and LA approaches through practices. Particularly, the data structure and visualization we developed inform strategies for instructors to better align the course content, assessment measures, and learning objectives.

References

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