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Visualizing course structure: Using course composition diagrams to reflect on design

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We explore an innovative methodological approach called course composition diagrams with course design teams who create online courses. The goal of the research is to understand the potential utility of these representations for enabling curriculum designers to understand and reflect on course structure. Six themes emerged from our qualitative analysis of survey data: 1) affordances of representation, 2) limitations of representation, 3) opportunities for comparison, 4) congruence, 5) reflection on design choices, and 6) utility of representation. We position course composition diagrams within the visual research methods genre. We argue that this approach holds promise for providing curriculum designers with meaningful opportunities to reflect on course design.

Introduction

Massive Open Online Courses (MOOCs) are said to embody a highly traditional portrait of education (Eisenberg & Fischer, 2014). MOOCs that consist of mostly lecture-based videos, machine graded quizzes, and opportunities for social interaction through discussion forums are known as "xMOOCs" and have grown out of a behavioral approach to instruction (Siemens, 2012). They tend to emphasize knowledge transmission and objective assessments, rather than taking a "connectivist" approach to knowledge creation (Siemens, 2012). The pedagogical design of xMOOCs tends to replicate traditional forms of instruction, such as lecture-based instruction, which are able to deliver content to large audiences with efficiency (Eisenberg & Fischer, 2014).

However, in contrast to the way that they have often been portrayed in the literature and in the media, MOOCs are not a single monolithic entity (Major & Blackmon, 2016). Although MOOCs are becoming recognized as their own instructional form, great variation exists between individual courses (Bali, 2014) and groups of courses (Clark, 2013). Such variation includes aspects of pedagogical design, technological affordances of MOOC platforms, and implementation strategies that are employed, such as using MOOCs within "flipped" classrooms in campus-based settings (Blackmon & Major, 2017). With MOOC platform affordances and technical features changing rapidly and new implementation strategies being employed all the time, it is difficult to evaluate MOOCs as a singular genre (Bali, 2014). Indeed, evaluating individual MOOCs may be more productive than considering MOOCs as one entity (Bali, 2014).

Educational researchers have taken several approaches to understanding these variations, including developing MOOC typologies to characterize various dimensions within an overarching concept of interest (Clark, 2013; Conole, 2014; Siemens, 2012), identifying pedagogical patterns that exist in the instructional design of MOOCs (Swan, Day, Bogle, & van Prooyen, 2015), and constructing design representations to depict course elements and their ordering and sequencing within the course (Garcia-Solorzano, Cobo, Santamaria, Moran, & Melechon, 2011; Powers, 2015; Seaton, 2016). It is important for researchers to understand what makes one MOOC different from another and to "know the various shapes and forms a MOOC may take in order to ask meaningful questions about them" (Major & Blackmon, 2016).

In this paper, we posit that it is also vitally important for *MOOC design teams*, including learning designers, instructors, and other professionals who are involved in the design of MOOCs, to understand the structure of the individual MOOCs that they create. MOOCs are usually not designed or taught by an individual; rather they require a coordinated team to develop the structure of the course and to consider how it will be orchestrated (Law, Li, Herrera, Chan, & Pong, 2017). MOOC design teams create course structures by defining the type and frequency of course elements (e.g., assessments, readings, videos), thereby producing learning sequences (arrangements of elements). Understanding the composition of courses and fine-tuning their structures can lead to improved learning outcomes (Freeman, Haak, & Wenderoth, 2011) and increased student satisfaction (Laverty, Bauer, Kortemeyer, & Westfall, 2012).

Consistent with our assertion that there exists great variety in MOOC pedagogical design, MOOC designers do not usually subscribe to templated approaches to design (Seaton, 2016); instead, they draw on a range of known "best practices" for online instruction (e.g., Chickering & Gamson, 1987; Chickering & Ehrmann, 1996; Margaryan, Bianco, & Littlejohn, 2015). Yet, MOOC designers may have limited and infrequent opportunities to reflect on the course structures that they create, and could therefore bypass an important step in the design process. Reflection on design has been shown to improve the effectiveness of the design process (Reyman, 2003) by bringing "unconscious aspects of experience to conscious awareness, thereby making them available for conscious choice" (Sengers, Boehner, David, & Kaye, 2005, p. 50).

In this paper, we explore a means of visualizing MOOC structure that we call "course composition diagrams" (CCDs). These digital and interactive representations present a structural view of the course, and use icons to represent course element types, such as videos and assessments. We hypothesize that by showing course design teams such visualizations of course structure, we can create *opportunities for reflection* that may not otherwise exist, thereby leading to a better understanding of the impact of design choices. We begin by reviewing literature on approaches that aim to characterize the variation that exists in MOOCs (typologies, pedagogical patterns, and design representations) and also literature on the role of reflection in the design process. The present work is situated within the tradition of design representations, although it is also related to categorizing MOOCs through other means such as by using typologies and through understanding pedagogical patterns that exist within curriculum designs.

Literature Review

Because MOOCs are varied, scholars have sought ways to understand these differences through developing typologies that capture constructs of interest, identifying pedagogical patterns, and through constructing design representations to depict underlying structures.

MOOC typologies for understanding variance in course design

Scholars have tried to capture variations in MOOCs through the creation of typologies in order to make MOOCs more accessible as an instructional form (Major & Blackmon, 2016, p. 20). MOOC typologies have been organized around various overarching concepts of interest including orientation to knowledge (Siemens, 2012), pedagogical dimensions (Swan et al., 2015), learner interactions with content and other learners (Conole, 2014), platform type and institutional origin (Moessinger, 2013), technology (Clark, 2013), organizational constructs (Pilli & Admiraal, 2016), and issues surrounding the development of MOOCs (Koutropoulous & Zaharias, 2015). Major and Blackmon (2016) developed a typology which builds on existing MOOC typologies, organized around dimensions such as organizational constructs (e.g., affiliation, size, accessibility, and duration), technology (i.e., synchronous or asynchronous timing, linear or adaptive structure), and pedagogy (e.g., relation to knowledge, content, authority and control).

Swan et al. (2015) developed the Assessing MOOC Pedagogies (AMP) tool to characterize MOOC pedagogies on ten dimensions: epistemology, role of the teacher, focus of activities, cooperative learning, accommodation of individual difference, user role (adapted from Reeves, 1994), structure, approach to content, feedback, and activities/assessment. Each dimension (e.g., role of teacher) corresponds to a pair of diametrically different constructs (e.g., teacher centered and student centered for “role of teacher”). Using the AMP tool, researchers can plot their ratings on a five-point scale that indicates whether a dimension falls closer to one end of the spectrum or another). Use of this tool results in a zigzag line, which when clustered can denote a particular pedagogical type: (1) acquisition, (2) a participation, and (3) self-directed (Swan, Day, & Bogle, 2016).

Typologies allow researchers to distinguish differences among different dimensions and to identify potential relationships among two or more dimensions (Major & Blackmon, 2016). Some scholars have noted that categories of many MOOC classification systems do overlap and interconnect, are not necessarily mutually exclusive, and may directly or indirectly enhance each other’s effects (e.g., Clark, 2013; Koutropoulos & Zaharias, 2015). While typologies are useful for helping researchers to characterize MOOCs across a variety of dimensions of interest, they may be less useful for understanding pedagogical patterns that may exist within MOOC designs and for scrutinizing the *structure* of individual courses. We posit that the next two approaches that we will describe may be more valuable for understanding these underlying pedagogical structures: identifying pedagogical patterns and constructing design representations.

Identifying pedagogical patterns

Laurillard (2012) offers the intriguing idea of “design patterns” for describing, at its most basic level, an educational context, a pedagogical problem, and a pedagogical solution. Design patterns are rooted in the field of architecture, and originate with Christopher Alexander’s (1977) work on town planning where he recognized that patterns can be used to describe a frequently recurring problem and to describe a core solution to the problem. The idea is that the solution is presented in such a way that it can be used “a million times over, without ever doing it the same way twice” (Alexander, 1977, p. x). The basic components of a design pattern are the ‘problem’, the ‘context’, and a description of the solution. Such patterns can be used to guide architects by describing the components of a design along with the rationale and motivation for their use, the context in which they should be used, and the user behavior that results from their implementation.

Design patterns are not intended to be used prescriptively; rather they are meant to provide the learning designer with 'rules of thumb' as they develop a collection of resources, tools, and materials to be considered when they identify a particular pedagogical need (McAndrew, Goodyear, & Dalziel, 2006). In the context of the design of educational technologies, Quintana, Krajcik, and Soloway (2003) relate the concept of design patterns to describing scaffolding patterns to be used within software design, which can be used when a particular learner need has been identified (e.g., learners may require support with sense-making and need support to analyze and make sense of their work products) to inform the type of scaffold that is used within the software (e.g., a graphic organizer). Design patterns can capture three important aspects of teaching: (i) contextual information, such as summary, rationale, and learning outcomes, (ii) pedagogical information, such as sequence of activities, roles, methods of assessment, and (iii) reflections on teaching, such as an evaluation of how well the pattern worked and a proposal for how the pattern could be improved (Laurillard, 2012). Formalized pedagogical patterns can represent design decisions and facilitate the transfer of useful pedagogical ideas. These patterns are of use to the original creators of the pattern and to learning designers who desire to re-use or adapt them (McAndrew et al., 2006). As Law et al. (2017) emphasize, the need for formalizing representations of pedagogical design patterns is greater than ever, because much of the work done in the design of online learning experiences (e.g., MOOCs) is done by course design teams (rather than individual instructors). Of particular interest to the present study, is creating design representations that encapsulate the second aspect of teaching that Laurillard (2012) outlines, that of pedagogical information, such as sequence of activities, roles, and methods of assessment.

Supporting reflection on design through design representations

The emerging research field of learning design offers tools and methods for both articulating and representing the outcome of educational design processes, allowing these processes to be made more explicit and shareable (Conole, 2009). *Design representations* are one tool from this field that can support MOOC design teams within the design process. Design representations describe and represent pedagogical processes and outcomes, including discrete learning activities, entire activity sequences, and whole curricula (Conole, 2010). Design representations portray an abstraction of course elements and sequences. Using design representations, it is possible to codify learning activities—tasks that learners engage in, in order to make progress on and meet learning goals—and make them available for review and critique to the entire design team. Different kinds of design representations (e.g., practice-focused narratives, conceptual representations such as mind maps, and technical-focused representations such as Unified Modeling Language diagrams) may have unique strengths and may be well-suited for a particular purpose, serving to foreground particular aspects of the learning design (Conole, 2009). For instance, Conole (2010) suggests that the "swim-lane" format (see Garcia-Solorzano et al., 2011 for an example) is particularly useful for representing curriculum at the activity level during the course design phase. Diagrammatic or iconic representations of curriculum designs can be valuable, because they can highlight relationships among learning activities, and can give the viewer a sense of flow and movement (Conole, 2009).

Design representations also have the potential to support reflective activity. Without a mediational tool or aid, it can be a challenge for designers to get a sense of the "big picture" (Arias, Eden, & Fischer, 1997). Design representations can serve as mediating artifacts to communicate and facilitate shared understandings, such as facilitating professional discourse around pedagogical patterns (Law et al., 2017). They can also stimulate "design conversations" between a designer and their materials (Fischer & Otswald, 2005).

Educational researchers and designers have only recently begun to make forays into developing design representations that depict MOOC curriculum designs, with some intended to represent designs in progress and others meant to represent finalized designs, MOOC design representations are also intended to be used by various audiences (e.g., researchers, designers, and learners). Alario-Hoyos, Pérez-Sanagustín, Cormier, & Delgado-Kloos (2014) present a visual framework to guide MOOC designers during the *design phase*, which is designed to encourage them to focus on important dimensions such as target learners, objectives and competencies, and pedagogical approaches. Seaton (2016) developed methods that use iconic representations of MOOC elements (e.g., videos and textual readings) to depict the final structure and sequence of activities within a MOOC, allowing researchers and designers to see similarities and differences in MOOC designs. Garcia-Solorzano et al. (2011) visualized the structure of an online course to provide wayfinding support for learners, by visually mapping learning goals to specific elements within the course. Powers (2015) visualized the course structure of MOOCs as a tree diagram, to expose course layout to students to enable self-regulation.

Objectives

The preceding examples of MOOC design representations focus on methods for visualizing MOOC design and structure, but do not report on testing their designs with users, revealing an opportunity for research. The present work aims to contribute a deeper analysis of an approach to visualization that can support MOOC design teams in reflecting on finalized curriculum designs. We follow the methods outlined by Seaton (2016) and his colleagues at Harvard University to visualize the structure of MOOCs. We hypothesize that by showing course design teams visualizations of course structure, we can create *opportunities for reflection*, thereby leading to a better understanding of the impact of design choices.

Our objectives led to the following research questions:

1. What do CCDs reveal to course design teams about the design of an online course?
2. What do CCDs obscure about the design of an online course?
3. Do CCDs allow course design teams to reflect on the design of an online course? If so, how?

Methodological Perspectives

Additionally, our work makes a contribution to the field of visual methodologies, a growing area within educational research. Although visual methods have historically been met with resistance (Fischman, 2001), contemporary scholars have called for the thoughtful inclusion of "visuality" in a variety of ways, including as sources of data, as the object of study within educational contexts, and to communicate research results (Fischman, 2001; Galman, 2009). For example, some educational researchers have used timelines as part of their methodologies (Sheridan, Chamberlain, & Dupuis, 2011), to represent data in an analyzable format (Quintana & Slotta, 2016), and to promote reflection on activity (Barry, 1997).

Techniques

Materials

The CCDs we developed visualized the course structure for ten MOOCs that are on the Coursera platform (Coursera, n.d.). Courses ranged in topic, including three data science courses, three social impact courses, and four professional development courses. Courses varied in length, from 4-7 weeks, with each week including a 1-3 lessons (i.e., related groupings of resources and activities). We created rows in a spreadsheet that mapped to the element types defined on Coursera's course outline pages: 1) section heading, 2) video, 3) assessment, 4) discussion prompt, and 5) reading. We manually scraped course data from each page within the course (e.g., video titles, video length, number of in-video questions in a video) and from Coursera's administrative analytics pages (e.g., average quiz scores), and added these data to the corresponding columns in the Excel spreadsheet. We exported the spreadsheets (n=10) with the course elements and corresponding data to Plot.ly (Plot.ly, n.d.), a web-based tool for creating infographics, to create the course composition diagrams (following Seaton, 2016).

We used abstract icons to represent the elements of each course, displaying them in chronological order. We used a legend to explain the correlation between the icon's symbol and its meaning (e.g., blue diamond = quiz) (see Figure 1). CCDs were interactive, allowing users to "hover" over an element to view additional information. For example, as users hovered over a video element (depicted by an orange triangle), additional information, such as the video's title, length, style (e.g., lecture), and the number of in-video quiz questions was displayed (see Figure 2).

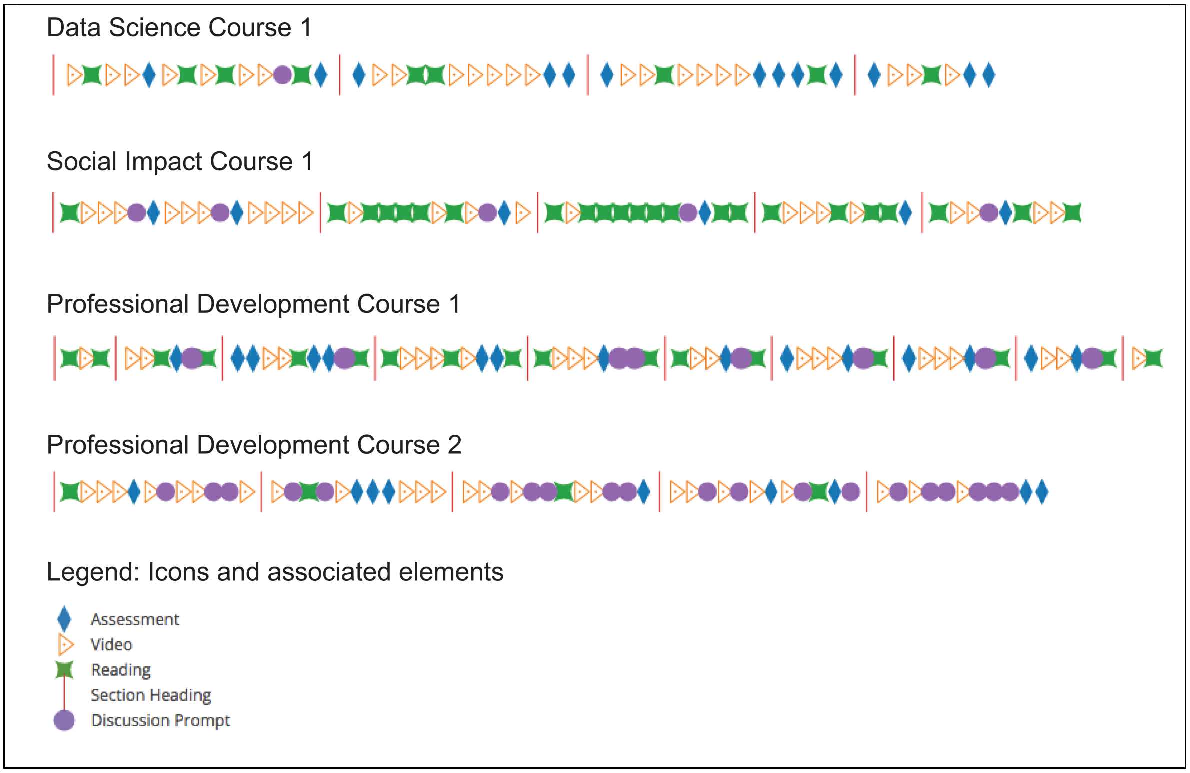

Figure 1: Course composition diagrams for four MOOCs, including legend for icons

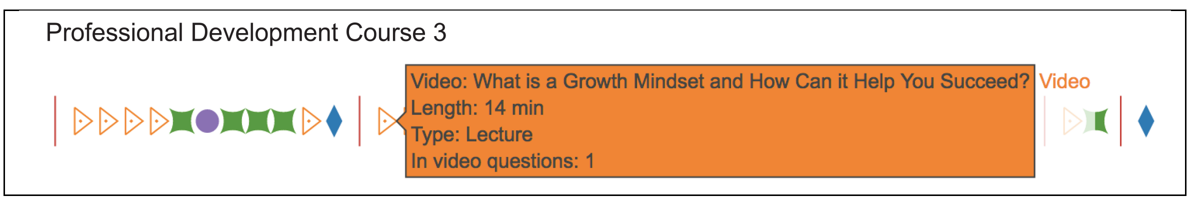

Figure 2: Course composition for one MOOC. The orange box shows additional information that is visible when users hover over a video element

Participants

We recruited participants (n=15) from a large mid-western public university who are staff or faculty at the University's digital education and innovation lab. We invited participants to view CCDs of one or more MOOCs for which they had provided pedagogical and technological expertise within the past year. Participants' roles are summarized in Table 1.

Table 1: Summary of participants' roles and numbers

Role name	Description of role	Number of participants
Faculty	Leads the development of curriculum materials; subject matter expert	1
Project manager	Coordinates the efforts of all design team members to keep project on track	6
Learning experience designer	Works closely with faculty to design learning goals, assessments, learner-centered activities, and instructional content	3
Course design assistant	Works closely with course team to support the curriculum development process	2
Course advocate	Interacts with learners once the MOOC is "live" to support and monitor discussion fora, and to act as a liaison between learners and faculty	1
Media specialist	Works closely with faculty to produce instructional videos for the course.	1
Marketing specialist	Works with course team to develop strategies for marketing the course to a global audience	1

Data collection

We administered a web-based questionnaire to our participants (see Table 2). In it, we stated the goal of the research ("to understand the utility of course composition diagrams for allowing course design teams to reflect on design") and provided a hyperlink to the CCD for a course that each participant had worked on. We sent a follow-up (shorter) version of the survey to participants who had responded to the first survey, with a link to a different CCD. The survey response rate was 66%.

Table 2: Initial questionnaire and follow-up survey

Initial survey questions	Follow-up survey questions
1. Describe your experience using the interactive timeline graphic. What did you enjoy about the approach? 2. What aspects of using the interactive timeline did you find challenging? 3. What did you notice about the flow and sequence of instructional content? 4. What did you notice about the types of content contained within the course? 5. What were the patterns you observed? 6. How does the final course design relate to your experience of working on the course? (For example, were elements missing that you expected to be there? Were elements present that you did not expect? Did assessment results align with your expectations?) 7. Do you have any final thoughts concerning the interactive timeline approach?	1. What were the similarities and/or differences between the first course you viewed a timeline for and this course, in terms of structure, patterns, or elements within the course? 2. Do you have any further observations or comments about the interactive timeline approach? (e.g., was the timeline more useful for one course vs. another?)

Approach to analysis

Following the coding process outlined by Creswell (2015), we 1) read through the textual responses (n=22 surveys), 2) divided the text into discrete segments of information or "excerpts" (n=174), 3) created descriptive labels or codes to describe related segments, 4) worked through an iterative process of grouping segments and refining labels to reduce redundancy (n=32) and 5) and derived themes or major ideas from groups of codes (n=6). We used Dedoose (n.d.), a web-based application that allows researchers to analyze data using qualitative or mixed methods approaches, to analyze the surveys, using the inductive approach described above.

Results

Our analysis of the survey data revealed six themes: 1) affordances of representation, 2) limitations of representation, 3) opportunities for comparison, 4) congruence, 5) reflection on design choices and 6) utility of representation.

Theme 1: Affordances of representation

Participants noted how CCDs surfaced quantitative aspects of the course, including the quantity of one element type (especially when it existed high or low numbers), the length of a course, and the length of modules in relation to other modules (see Table 3). Participants described how CCDs provided a high-level overview of course structure, which revealed the proportion of one element type to another. Participants appreciated that CCDs allowed them to retrieve additional details about each course element through interactivity.

Participants described the way that course elements related to each other (see Table 3):

- Balance – even distribution of course elements
- Variety – mix of course elements across the course
- Repetition – recurrence of a single element at various points in the course
- Pattern –repetition of a sequence of elements
- Rhythm – repetition of a sequence of elements, with some variation
- Emphasis – impression of prominence of one or more elements
- Movement – relates to the progression or flow through a sequence of elements

Table 3: Overview of themes and codes associated with the first research question

Q1: *What do course composition diagrams reveal to course design teams about the structure of an online course?*				
Theme	**Code**	**# of excerpts**	**Code description**	**Quote**
Theme 1: Affordances of representation	Quantitative aspects	27	Number of different element types or length of grouping of elements	*"It allows us to get a much more quantitative view of the content."*
	Bird's eye view	13	High level overview of course structure	*"I could get a feel for the distribution of various elements in the course."*
	Additional details	3	Additional information and detail	*"I enjoyed the 'interactive' element, and being able to see additional information by hovering over each element."*
Affordances of representation – related to principles of design	Balance	20	Distribution of one or more element	*"Each module was relatively 'even' in terms of the number of content types."*
			Balance with respect to weight, or a preponderance of an element type within a specific part of the course	*"I see a similar trend of very heavy reading modules in the middle/end of the course."*
	Variety	15	Diversity of elements	*"I observed the diversity of content type."*
	Rhythm	13	Repeating pattern with some variation	*"Each module has a relatively familiar flow, even if they're not identical to each other."*
	Pattern	11	Repeating sequence of elements	*"Each section of the course is structured almost like a sentence."*
	Emphasis	12	Impression of prominence	*"There was a heavy representation of discussion prompt activities/content types."*
	Repetition	7	Regular recurrence one element	*"I like that I'm able to isolate the different components (assessments, videos, etc.) to see how they are distributed across the course."*
	Movement	6	Suggestion of direction, flow, and progression	*"I was easily able to see the content mix and progression."*

Theme 2: Limitations of representation

Participants reported three major limitations of CCDs: 1) lack of differentiation within element types, 2) lack of precision in the display of quantitative information, and 3) lack of precision in qualitative information (see Table 4). Participants wanted to see more precise differences within an element type (e.g., representing quiz types – formative or summative – instead of simply seeing an assessment icon in a CCD). Participants also wanted quantitative aspects of course elements to be represented visually (even though they were available by hovering over an element). For example, videos ranged from 5 to 30 minutes, but this difference was not shown in the representation (i.e., by icon width). Similarly, several participants noted that qualitative dimensions such as difficulty level and required effort were not represented.

Table 4: Overview of theme and codes associated with the second research question

Q2: *What do course composition diagrams obscure about the structure of an online course?*				
Theme	**Code**	**# of excerpts**	**Code description**	**Quote**
Theme 2: Limitations of representation	Lack of differentiation within element type	6	Lack of differentiation within an element type obscured information about some elements	*"I know from working on the course that a lot of 'readings' are actually videos from external sources that we couldn't embed and so they're linked from readings. That skews a little bit of the perception of the amount of text vs. videos."*
	Lack of precision in display of quantitative information	4	Lack of precision in display of quantitative information (i.e., all icons to represent videos are the same width, regardless of video length)	*"If I were comparing these side by side I don't think I could say which was longer (in minutes)."*
	Lack of precision in display of qualitative information	3	Lack of precision in representation in display of qualitative information (e.g., required effort, or difficulty level)	*"It was difficult to get a sense of required effort over a module."*

Theme 3: Opportunities for comparison

Participants reported that CCDs allowed them to make comparisons between courses, such as comparing quantitative dimensions among courses, and comparing the number of an element type or the length of two or more courses (see Table 5). Participants also made comparisons from CCDs to the course outline view available in Coursera.

Theme 4: Congruence

Participants spoke about the congruity of the CCDs with the "actual" course and how it impacted their reflection on the course. Some participants stated that CCDs provided confirmation of expected outcomes (i.e., congruence) (see Table 5). Others stated that

CCDs helped them see that the course structures that they had developed were incongruent with what they had originally envisioned.

Table 5: Overview of themes and codes associated with the third research question

Q3: *Do course composition diagrams allow a course team to reflect on the design of an online course? If so, how?*				
Theme	**Code**	**# of excerpts**	**Description of code**	**Quote**
Theme 3: Opportunities for comparison	Comparison	20	Comparison to other courses or representations	*"This course, like the first one, still only has one discussion prompt."*
Theme 4: Congruence	Congruence	7	Representation was consistent with expectations	*"This outline reinforces my expectations/ knowledge of the course."*
	Incongruence	11	Representation was inconsistent with expectations	*"Since [pre-lecture reflections] fall under the 'assessment' symbol, it seems like students are being quizzed more than they really are and in spots in the course that do not necessarily make sense for quizzes."*
			Incongruence was also associated with new perspectives that emerged by viewing CCD	*"It allowed me to realize that this was a very reading-light course (and I think we knew this all along), but it's even more clear that that's the case when I use this visualization."*
Theme 5: Reflection on design choices	Affirming design choices	2	Evaluative statements that affirm design choices	*"I would say that this course has a good amount of interactive activities."*
	Questioning design choices	6	Tentative statements that question design choices	*"I'm worried about having a peer review in the first week of a course."*
	Speculating about design choices	8	Speculative statements that hypothesize about the impact of design choices	*"Each unit has its signature beginning and ending so your surroundings in the course might stay familiar."*
Theme 6: Utility of representa-tion	Potential for future use	7	Consideration of how approach could be used in future processes	*"I think this would be most useful when I have additional data, including data from the platform and potentially conversations from learners within the course."*
	Reservations about future use	5	Expression of uncertainty of meaning, interpretation, significance, and utility of visualization	*"I don't know which is 'better' or which just "looks better" so I am not really sure what I would do with the information."*

Theme 5: Reflection on design choices

Participants used CCDs to reflect on their course design choices in three ways: by providing: 1) evaluative statements that affirmed design decisions, 2) tentative statements that questioned design choices, and 3) speculative statements that hypothesized about the impact of design decisions (see Table 5).

Theme 6: Utility of representation

Participants considered how CCDs could be used in future course design processes, such as to complement other data sources, to inform evaluation and iteration processes, in conversation with faculty, and as a tool for answering research questions (see Table 5). Some participants questioned the utility of the representation and had reservations about its future use, including expressions of uncertainty of meaning, interpretation, and significance.

Discussion

The first two themes that emerged from our analysis address our research questions on CCDs as tools to represent course structure, including what CCDs *reveal* and *obscure* about MOOCs to their design teams: the affordances and limitations of the representations. These findings relate most closely to the literature on design representations, and how they have the potential to foreground certain aspects of a design, bringing various dimensions into clearer focus (Conole, 2010). Similarly, they also echo the challenge that Conole (2009) articulates, that of balancing readability with utility.

Participants commented that one of the affordances of the CCD design representation was that it allowed them to perceive the entire course at a glance. This finding is consistent with Conole's (2009) view that diagrammatic or iconic representations are particularly useful for providing a quick overview or "bird's eye view" of a course. Quantitative aspects of individual elements were also immediately apparent, especially when there was extreme variation in the quantity of an element, such as "a lot" or "a little" of one element type (e.g., videos). Surfacing quantitative aspects of a course design could allow designers to see how their pedagogical design relates to MOOC typologies. For instance, MOOCs associated with typologies that relate to the orientation to knowledge (e.g., content acquisition), might have CCDs with a high proportion of elements such as videos and readings.

Participants also remarked that they could see how course elements related to each other. Participants used descriptive language that had semantic connections to the visual language of design. They used terms and phrases that very closely mapped to the principles of design: balance, variety, rhythm, pattern, emphasis, repetition, and movement. In visual art, the principles of design describe the way that the individual elements of design (such as line, color, and shape) are arranged and their relationship to each other (DeWitte, Larmann, & Shields, 2015; Ragans, 2005). CCDs not only enabled members of course design teams to see "what was there" from an objective point of view, they allowed participants to see the relationship of individual elements to the whole course "composition." This finding suggests that participants were able to comprehend course structure in a nuanced way. The CCD provided a visual means of representing pedagogical patterns (Laurillard, 2012) and allowed participants to identify when these patterns were quite regular and when there was some variance within the pattern.

With respect to the limitations of the design representation, many participants wanted to see differentiation of elements through specialized icons, such as showing the difference in video length visually. This finding is interesting, because participants could have obtained additional information (such as video length) by hovering over an element, but it appears that they wanted to be able to obtain this information without performing the hovering action. This finding reveals an important tension, that of wanting to provide design practitioners with a representation that is easily understood, without creating a representation that is so simplistic that it ceases to be useful (Conole, 2009). These findings suggest possible future directions for CCDs, but we should proceed with caution: if we further differentiate element types, we risk increasing the visual noise and could potentially obscure the representation's meaning. Participants were able to identify patterns in the CCDs used in this study. The addition of more icons could make this task more challenging. One participant remarked that the representation was already "visually noisy" and that it took them some time to *"acclimate to the different icons being used, especially since they didn't intuitively signify the element they represented."*

The remaining four themes address our research question about how CCDs might serve as reflective supports for MOOC design teams: comparison among courses, congruence of representation with experience, reflection on design choices, and utility of the design representation. In reviewing these themes, we saw evidence of reflection when participants referred to CCDs in relation to other CCDs. We also saw evidence of reflection related to participants' design experiences.

The variation in the designs of individual MOOCs in this study is apparent when the CCDs are viewed side by side (see Figure 1). Participants who viewed multiple CCDs (i.e., those who were involved in more than one design process and were shown two or more CCDs) noted that the CCDs allowed them to make comparisons between courses. Although comparison was not central to our methodology, this finding resonates with Major and Blackmon's (2016) assertion that the differences among MOOCs may be as important as their similarities. It also gives credence to the claim that xMOOCs are not monolithic entities (Major & Blackmon, 2016). Following Conole's (2014) call for methods and tools that give a more nuanced view of MOOC design, the findings of this study show that CCDs can expose variation in the design of MOOCs.

The CCDs also allowed participants to reflect on their design experience and to evaluate if the representations were congruent with their perception of the course, with some participants declaring that the CCDs provided confirmation and others stating that CCDs surfaced aspects of the design that were previously unknown to them. In this way, the CCDs acted as a mediating artifact, allowing the participants to have a "conversation" with the representation and to listen to the "talk back" of the situation (Fischer & Otswald, 2005). Although mediating artifacts are usually discussed in the context of collaborative design, they can also mediate a design conversation between the designer and their materials (Fischer & Otswald, 2005). Similarly, the CCDs enabled participants to reflect on their design choices, causing participants to affirm, question, or hypothesize. As Sengers et al. (2005) observed, this is important an important step in the design process, because by bringing aspects of experience that were previously unconscious to the surface, they become "available for conscious choice" (p. 50) for future processes.

Future Work

The final theme (utility of the design representation) relates to opportunities for future work. Participants considered how CCDs could be incorporated into the design processes. For example, we might want to consider using CCDs as a tool to stimulate discussion earlier in the design process with faculty, thereby opening up "new design spaces" (Sengers et al., 2005). Participants also noted that CCDs could be useful as a tool for answering research questions. While our focus has been on the role of CCDs for use by course design teams, we can see the potential for such approaches to be used by researchers. For instance, researchers might be interested in connecting related CCD design representations to various MOOC typologies. Further, the representational affordances of CCDs are currently limited to the type of resource or element that can be published on the platform. The rationale underpinning pedagogical choices is not represented, nor are the other aspects related to pedagogical design patterns (Laurillard, 2012). Future work could consider how to represent contextual information and reflections on the pattern, in addition to pedagogical information, such as sequence of activities, roles, methods of assessment.

In our immediate future work, we intend to explore a novel and *tangible* approach to visualizing course structure, using strings of beads to represent MOOC course structures (see Figure 3). This approach relates to Gaver et al.'s (2004) work on ludic design, which offers participants the opportunity to examine a familiar phenomenon through an unfamiliar medium, provoking curiosity and exploration.

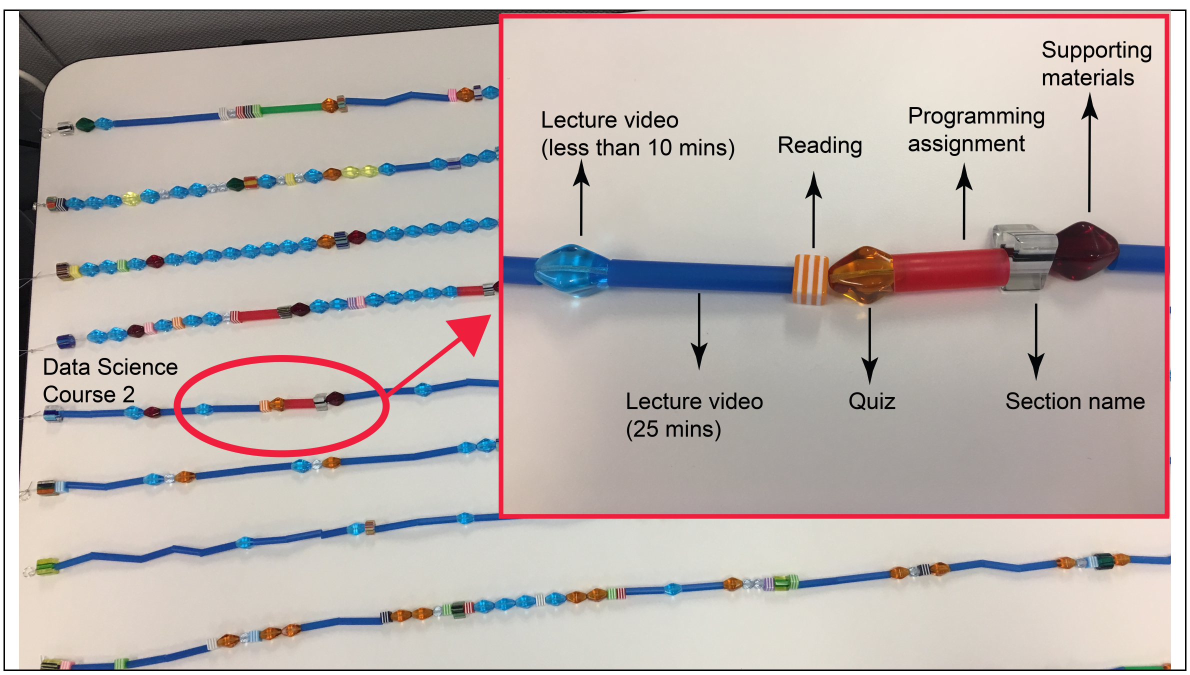

Figure 3: Future directions include showing course design teams tangible versions of course composition diagrams

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