Analyzing Large Collections of Open-Ended Feedback From MOOC Learners Using LDA Topic Modeling and Qualitative Analysis

Gaurav Nanda, Kerrie A. Douglas, David R. Waller, Hillary E. Merzdorf, and Dan Goldwasser

***Abstract*—There is a large variation in background and purpose of massive open online course (MOOC) learners. To improve the overall MOOC learning experience, it is important to identify which MOOC characteristics are most important for learners. For this purpose, in this article, we analyzed about 150 000 open-ended learner responses from 810 MOOCs to three postcourse survey questions about their learning experience: (Q1) What was your most favorite part and why? (Q2) What your least favorite part and why? (Q3) How could the course be improved? We used the latent Dirichlet allocation topic model to identify prominent topics present in learner responses to each question. We determined the theme of each identified topic through qualitative analysis. Our results show that the following aspects of MOOCs can significantly impact the learning experience: quality of course content, accurate description of prerequisites and required time commitment in course syllabus, quality of assessment and feedback, meaningful interaction with peers and educators, engaging instructor and videos, accessibility of learning materials, and usability of platform.**

***Index Terms*—Classroom feedback systems, distance learning, large text archives, machine learning.**

I. Introduction

OVER the past few years, massive open online courses (MOOCs) have increasingly become a popular medium for learning due to their easy access to interested learners and growing recognition by universities and employers [1], [2]. Learners enroll in MOOCs with different motivations such as fulfilling current needs, preparing for the future, satisfying curiosity, and connecting with people [3]. MOOCs have been successful in providing access to content to many learners. However, many learners who start a MOOC indicating an intent to complete the MOOC do not finish the MOOC dropping out after few weeks [1], [4]. As there is a large variation in the background and learning objectives of MOOC learners, the definition of success in a MOOC varies considerably for different learners [5]. While it may be difficult to build a fit-all design for a MOOC for different types of learners, there are certainly broader improvement opportunities in MOOCs, through which the learning experience can be enhanced for most learners. To identify these opportunities, it is important to understand which MOOC characteristics matter the most to different types of learners and prioritize improvement efforts accordingly. Learner-generated MOOC reviews are an important source of information to understand what is working well in the current system and what could be improved [6].

Therefore, to identify the most significant pedagogical and technical aspects of MOOCs from learners' perspective, we analyzed their open-ended responses to three questions from the postcourse evaluation surveys of 810 courses offered on a popular social learning platform. These questions, which asked learners about their MOOC learning experience, were as follows:

Q1) what was your most favorite part of the course and why?
Q2) what was your least favorite part of the course and why? and
Q3) how the course could be improved?

It is very likely that the postcourse evaluation survey would be completed by learners who completed the MOOC, but it was not possible to confirm it as the survey responses were collected through a third-party survey platform and were completely anonymous. While many previous studies on MOOC learners have focused on learners overall or those who disengaged early [7]–[9], they have not analyzed feedback from different types of learners enrolled in different types of MOOCs. This study attempts to fill this gap in MOOC literature by analyzing open-ended survey responses from a very large number (about 150 000) of MOOC learners from 810 MOOCs in different subject areas, to identify the MOOC characteristics that had majorly impacted their learning experience.

We used the latent Dirichlet allocation (LDA) topic model to identify prominent underlying topics in the large collection of learners' responses. We then used a formalized qualitative approach to determine the theme of each topic generated by the LDA model. Corresponding to Q1, Q2, and Q3, the topics identified from learners' responses indicated which aspects of MOOCs were most liked, least liked, and could be improved. At a broader level, these topics were indicative of MOOC characteristics that mattered most to a considerably large

Manuscript received October 31, 2019; revised October 1, 2020 and February 24, 2021; accepted February 26, 2021. Date of publication March 9, 2021; date of current version June 4, 2021. This work was supported by the National Science Foundation (NSF) under Grant PRIME 1544259. *(Corresponding author: Gaurav Nanda.)*

Gaurav Nanda is with the School of Engineering Technology, Purdue University, West Lafayette, IN 47906 USA (e-mail: gnanda@purdue.edu).

Kerrie A. Douglas, David R. Waller, and Hillary E. Merzdorf are with the School of Engineering Education, Purdue University, West Lafayette, IN 47906 USA (e-mail: douglask@purdue.edu; wallerd@purdue.edu; hmerzdor@purdue.edu).

Dan Goldwasser is with the Department of Computer Science, Purdue University, West Lafayette, IN 47906 USA (e-mail: dgoldwas@purdue.edu).

Digital Object Identifier 10.1109/TLT.2021.3064798

number of learners who completed MOOCs on different topics. In the next section, we discuss some of the previous studies that have also tried to identify important aspects of MOOCs.

II. Related Work

A. MOOC Characteristics Impacting Learning Experience

Previous studies have tried to identify MOOC characteristics that have a major impact on learning experiences by investigating reasons behind high dropout rates. Zheng *et al.* [3] identified eight factors associated with low MOOC retention rates: 1) high workload; 2) challenging course content; 3) lack of time; 4) lack of pressure; 5) lack of awareness features; 6) social influence; 7) lengthy course start-up; and 8) learning on demand. Eriksson *et al.* [10] found that the main factors influencing MOOC dropouts included the following:

1) mismatch between learner's perception and actual course content and design;
2) learner's ability to manage time as the course needed more time than expected or the difficulty level was more than expected;
3) social aspects of having a learner community feeling; and
4) language-related issues such as proficiency in English, video subtitles, and clarity of instructor.

Yang *et al.* [11] identified five exogenous constructs that have direct or indirect influence on the continuance decision of MOOC learners: 1) system quality; 2) course quality; 3) service quality; 4) perceived ease of use; and 5) perceived usefulness. Yousef *et al.* [12] identified the following challenges associated with the MOOC environment, which make it hard for learners to complete the MOOC: 1) lack of human interaction; 2) different levels of language proficiency; 3) and 4) different cultural background.

In summary, based on learners' feedback, previous studies have identified following MOOC characteristics that can lead to low learner engagement and drop-out: difficult course content [3], [6], [10]; high workload and lack of time [3], [6], [10]; mismatch between a learner's perception and actual course content and design [10]; absence or poor quality of social interaction [6], [10], [12]; issues related to language proficiency and differences in cultural background [3], [10], [12]; hard-to-follow or nonengaging instructors [6], [10]; issues related to lecture videos [10]; usability of the platform [4], [11]; quality of assessment and feedback [6]; and perceived utility of the course [11]. These are also presented later in conjunction with the findings of this study in Table V.

In addition to identifying factors that lead to drop-outs in MOOCs, previous studies have also tried to break down the MOOC learning experience into various components for assessing MOOC quality. Yousef *et al.* [4] developed 74 indicators for evaluating MOOC quality based on survey responses of learners and educators, which were grouped into two broad dimensions: pedagogical and technical. The pedagogical dimension included instructional design, consisting of lecture organization and culture, and assessment, consisting of e-assessments and peer assessments. The technical dimension included user interface, video content, learning and social tools, and learning analytics. Similarly, Gamage *et al.* [1] identified the following indicators that determine the quality of MOOCs based on survey responses and interviews of learners: interactivity, collaboration, pedagogy, motivation, network of opportunities/future directions, assessment, learner support, technology, usability, and content.

B. Methods Used

Methodologically, most of the aforementioned studies performed qualitative analysis on submitted surveys [1], [4], [11] and in-depth interviews [1], [3], [10] of learners and educators to identify the significant aspects of MOOCs. For data analysis, these studies used approaches such as grounded theory [1], [3], [6] and structural equation modeling [11].

The sample size of collected data varied between studies, as discussed in the following. Eriksson *et al.* [10] conducted a qualitative case study based on in-depth interview of 34 learners in different stages of completion from two MOOCs. Zheng *et al.* [3] also conducted in-depth interviews of 18 learners who had taken MOOCs from different areas and analyzed the interviews using grounded theory. Yang *et al.* [11] used structural equation modeling on survey data collected from 294 learners who had completed at least one MOOC. Yousef *et al.* [4] analyzed survey data collected from 98 professors who taught MOOCs and 107 MOOC learners. Gamage *et al.* [1] also used grounded theory to analyze survey and in-depth interview data collected from 41 very active MOOC learners. Adamopoulos [6] used a different data source and analyzed 1163 online textual reviews submitted by 842 learners using grounded theory methodology.

To summarize, these studies identified important aspects of the MOOC learning experience based on data collected from a decent number of MOOC learners and educators, with the largest sample size being about 1200. In this study, we have analyzed about 150 000 open-ended postcourse survey responses from MOOC learners from 810 courses, which is much larger in size as compared to any of the previous studies. By analyzing such a large collection of feedback from thousands of learners who had completed the MOOC, we aimed to examine their opinion about important MOOC aspects identified in earlier studies and discover additional significant aspects of the MOOC learning experience.

Manual analysis of a large number of open-ended survey responses can be extremely tedious and time-consuming as it involves multiple steps such as developing a coding scheme, manual coding of open-ended responses, and statistical analysis of coded data [13]. With development of advanced data mining methods, it is becoming easier to analyze a large amount of textual data such as discussion forums and open-ended survey responses [14]. Application of data mining in the area of education is an emerging field, and various approaches such as classification, clustering, text mining, and association rules have been examined by researchers to obtain insights about learner behavior [15]–[17]. A good review of data mining applications in education is available in [18] and [19].

LDA topic models can identify emerging themes from a large collection of documents such as open-ended survey responses [20]–[22]. They have been widely used for

exploratory analysis of large textual collections for various purposes, such as analyzing educational blog posts [23], identifying topics of history research from old newspapers [9], and grouping drugs with similar properties based on FDA drug labels [24]. LDA topic models have also been used for analyzing MOOC data such as understanding learners' perception about MOOC participation certificates from open-ended feedback from learners [25], analyzing MOOCS discussion forums [26]–[28], understanding learner behavior and predicting course outcome [29], and identifying MOOC-related topics being reported in media [30]. Previous studies have found the approach of determining the themes of topics generated by the LDA model using qualitative analysis to be effective for analyzing open-ended survey responses [21], [22], [25]. We used a similar approach in this study as explained in Section III.

III. Methods

In this section, we first provide information about the data, followed by a brief summary of the LDA topic model, and then discuss the qualitative analysis methodology used in this study.

A. Data

We analyzed open-ended responses to three postcourse survey questions from 810 courses offered in the period January 2014–March 2016 on a popular online learning platform. Among these 810 courses, there were 575 unique courses with multiple runs of some courses. The MOOCs were broadly categorized into 13 different categories based on the topic of study. These categories with associated number of unique MOOCs were: 1) Creative Arts and Media (36); 2) Study skills (14); 3) Teaching (25); 4) Politics and Modern World (25); 5) History (38); 6) Languages and Culture (43); 7) Literature (12); 8) Business and Management (138); 9) Law (9); 10) Health and Psychology (125); 11) Nature and Environment (45); 12) Science, Engineering, and Math (50); and 13) Technology and Coding (15).

The postcourse surveys were sent out to course participants through the Survey Monkey platform to be submitted voluntarily. As the postcourse survey data were collected through a third-party platform anonymously, the user identification fields such as name or user ID were not captured. Additionally, the enrollment information, precourse survey data, and the course participation data for these MOOCs were not available. Therefore, it was not possible for us to link the survey responses of learners with their background, precourse survey responses, course participation, engagement level, or assessment outcomes in the MOOC.

The responses to postcourse surveys were provided to us by the platform in the form of separate csv files for each course. Some questions in the postcourse surveys were common across all courses and some were specific to the course. Among the postcourse survey questions common across all courses, we identified three open-ended questions that asked learners about their MOOC learning experience, as listed in Table I.

TABLE I
List of Postcourse Survey Questions Analyzed

ID	Post-Course Survey Question	Number of Responses	Average Length of Responses in Words
Q1	What was your favorite part of the course, and why?	158,000	17
Q2	What was your least favorite part of the course, and why?	130,500	16
Q3	How could the course be improved?	137,000	16

We preprocessed the survey data to collate nonblank responses from all the courses for each question. As shown in Table I, each question had thousands of responses. We then used the LDA topic model to identify major underlying topics from the responses for each question.

B. LDA Topic Model

LDA topic modeling, which is a widely used method for exploratory analysis of large collections of textual data, was performed on the collated responses to each question using the MALLET library [31], as used in some previous studies analyzing open-ended feedback [25], [21]. LDA is a generative statistical model that considers each document as a mixture of underlying topics. A topic is a concept or theme that is constituted of words that frequently co-occur together in the dataset and are used by the LDA model for learning the topics. The LDA model tries to identify these topics iteratively based on the co-occurrence of words in documents and represents each document as a composition of different topics with associated weights. A good explanation of the LDA algorithm can be found in [32].

Since LDA is an unsupervised method (i.e., the data are not hand labeled), it is difficult to judge the quality of topics identified by the model. Measures such as perplexity or probability of held-out documents [33] have been proposed for evaluating the quality of topic models, but they have not been found to correlate well with human judgment of topic quality as they do not capture whether the topics generated are coherent or semantically interpretable [34], [35]. "Topic coherence" measures have been found to be better correlated with human judgment as compared to other measures of topic model performance such as perplexity [36]–[38]. LDA needs the number of topics as an input to the algorithm. The interpretability of generated topics varies depending on the number of topics provided as input to the LDA topic model. As "topic coherence" measure is well correlated with human judgment of topic quality, we used the CV coherence measure to find the optimal number of topics as input to LDA, as recommended by Röder *et al.* [36] .

The CV coherence measures how often the words in the topic co-occur together in the dataset [36], [39]. For each question, we calculated the CV coherence of LDA models with different number of topics as input ranging from 10 to 30 using the Python libraries gensim [40] and pyLDAvis [41]. This range was considered based on an initial assessment of

the topics generated with very few (5) topics and a large number of topics (50). The LDA model with five topics generated too broad topics and the LDA model with 50 topics generated many overlapping topics. Within the range of 10–30 topics, the number of topics corresponding to highest CV coherence was considered as optimal. The MALLET library used for developing the LDA model in this study provided the following output with default parameter setting.

(1) A topic is defined by its probability distribution over words. MALLET provided a list of the top 20 words that constitute each topic. For example, for topic T_i, the list of the top k words, $W_i = \{w_i^1, w_i^2, \ldots, w_i^k\}$, that constituted the topic were outputted. The default value of $k = 20$ in MALLET was used for this study.

(2) The composition of each document (open-ended responses, in our case) was outputted in terms of topics and associated weights. For example, for a given topic model with n topics $\{T_1, T_2, \ldots, T_n\}$, the composition of a response R_i can be represented as

$$C(R_i) = p_i^1 T_1 + p_i^2 T_2 + p_i^3 T_3 + \cdots + p_i^n T_n$$

where p_i^j represents the relative weight associated with topic T_j and the sum of all topic weights for a document is 1, i.e., $\sum_{j=1}^{n} p_i^j = 1$. Therefore, documents composed of multiple topics were expected to get assigned smaller weights for multiple topics, and documents composed of a single topic were expected to have a high weight associated for that topic. This MALLET output for the LDA topic model with an optimal number of topics was then analyzed qualitatively to interpret the theme of the topic, as described in the next section.

C. Qualitative Analysis

While LDA topic models can identify topics from the data based on word co-occurrence, the interpretability of topics generated by LDA is not guaranteed [36]. Determining the exact meanings of the topics requires additional information and domain knowledge [24]. Therefore, we conducted qualitative analysis on the MALLET output generated by the LDA topic model with the objective of inferring whether a coherent, interpretable, and relevant theme was associated with each generated topic. In order to determine the theme of each topic, we followed an approach similar to that in [25] and [42], where we qualitatively analyzed the top words of the topic and the responses that had highest weight associated with that topic. We selected the highest weighted responses for determining the topic theme as these responses were expected to be composed mainly of a single topic and, hence, would be most representatives of the topic.

The various steps involved in the qualitative analysis approach are described in a flowchart form in Fig. 1. Three researchers carried out the qualitative analysis, in which they first developed an initial theme of the topic by examining the top 20 words of the topic and then refined and validated

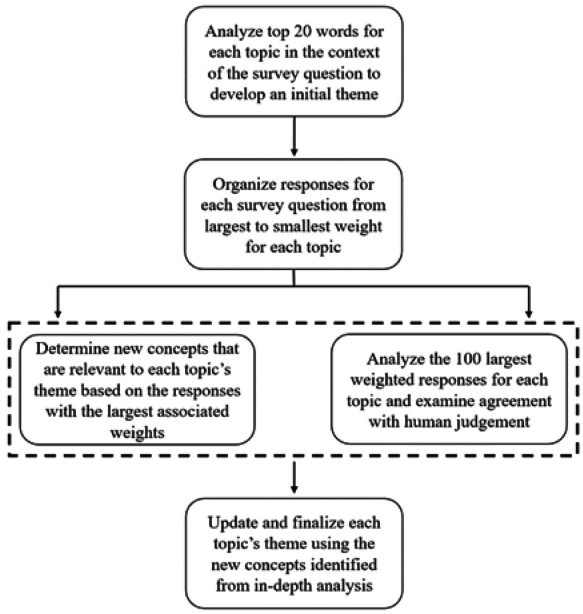

Fig. 1. Qualitative analysis methodology for topics identified by LDA.

the theme based on the top 100 responses associated with the theme based on topic weight.

As shown in Fig. 1, after determining an initial theme for each topic by examining the top 20 topic words in context of the question asked, the responses were sorted in order of decreasing weight associated with the topic (shown as p_i^j in MALLET output). Then, the top 100 responses with the largest weights were manually examined by each researcher to check whether the responses corresponded to the initial theme. The researchers updated the topic theme with additional aspects if any recurring subthemes were found consistently in the top 100 responses. During this process, the researchers also identified the number of cases in the top 100 responses, where the response did not correspond to the theme of the topic. While determining the topic themes, we also found some topics that pertained to specific courses; we did not perform qualitative analysis on these topics as they were not useful for MOOCs overall and, thus, did not align with the focus of this study.

To illustrate the qualitative analysis process with an example, one of the topics that emerged from the responses to Q2 (What was your least favorite part of the course and why?) comprised the following top 20 words: *comments, discussion, discussions, people, read, students, time, learners, didn't, participants, comment, find, felt, reading, feel, online, don't, found, lot*, and *interaction.*

By inspecting these words in context of the question asked, we developed an initial theme for this topic that "the learners did not like the nature of comments and discussions on the discussion forum." Then, by examining strongly associated responses with this topic, such as, "The comments section. There was simply far too many comments to read and interact with At times there were over statements written for each section and I simply didn't have time to read them all. I would have appreciated if we had been split into smaller groups

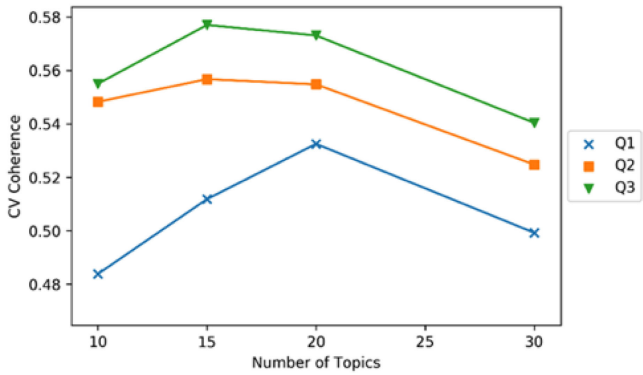

Fig. 2. CV coherence for different number of topics for Q1, Q2, and Q3.

which I believe would have allowed a more meaningful engagement with other students," and "I didn't like the lack of discussion monitoring. Many people cluttered up the discussion area with comments such as looking forward to trying this out and screened and deleted such comments. Also, the educators didn't respond to valid questions and comments," we could confirm that the theme we developed for the topic was appropriate and should include following additional aspects:

1) learners were overwhelmed by the number of responses on the discussion board;
2) wanted better organization of comments; and
3) more meaningful interaction with peers and educators.

As shown above, we refined the topic themes after an in-depth analysis of the highest weighted responses for each topic. Through this process of qualitative analysis, we were able to capture the finer aspects of the theme of each topic.

IV. Results

In this section, we present the prominent themes identified through qualitative analysis of results from LDA topic modeling on the responses to the three postsurvey questions considered in this study. As mentioned before, we determined the optimum number of topics for the LDA topic model using the CV coherence measure. For Q1, Q2, and Q3, the CV coherence values for different numbers of topics are presented in Fig. 2.

As shown in Fig. 2, the CV coherence values were highest for following number of topics for each question: 20 for Q1, and 15 for Q2 and Q3. Therefore, we developed the LDA topic model with 20 topics for Q1 and with 15 topics for Q2 and Q3. The prominent themes identified for each postcourse survey question through qualitative analysis are discussed as follows.

A. *Q1: What Was Your Most Favorite Part of the Course, and Why?*

The 20 topics identified by the LDA model from Q1 responses are listed in Table II, including the following:

1) the themes of each topic derived from the qualitative analysis;
2) top ten words associated with the topic as outputted by the LDA model;
3) the weight of each topic as outputted by the LDA model (which indicates how frequently the topic was present in the collection of responses); and
4) "qualitative analysis agreement level," which represents how many of the top 100 responses fell into that topic based on qualitative analysis.

A higher level of agreement in qualitative analysis indicates that the theme of the topic was more coherent, and a lower level indicates that there were other themes present in the top 100 responses strongly associated with the topic.

Q1 topics indicate those aspects of MOOCs that learners liked the most. In Table II, the Q1 topics are ordered by decreasing order of LDA topic weight—indicating that the topics listed in the beginning were more widely present in the responses. Topics Q1T7, Q1T10, Q1T12, Q1T13, Q1T16, Q1T17, Q1T18, and Q1T19 were related to specific aspects of certain MOOCs that were learners' most favorite part. We did not conduct qualitative analysis for these content-specific topics as our focus was to identify the things that learners liked across different courses. Hence, the qualitative analysis agreement level is blank for content-specific topics in Table II.

The qualitative analysis agreement level for most of the topics was fairly high indicating that the topic theme identified was relatively coherent. For topics Q1T4 and Q1T5, the agreement level was comparatively low, 58% and 51%, respectively. In case of Q1T4 (link to further reading materials), the reason was that among the top 100 associated responses, a many responses referred to internal reading materials and other learning resources of the MOOC, which did not qualify as "further reading materials." In case of Q1T5 (flexibility with time), the agreement level was found to be low because some other related themes were present in the top 100 associated responses, such as length of lecture videos and learners liked all aspects of the MOOC.

Topic Q1T2's theme indicated that some learners enjoyed the MOOC overall, but it was hard for them to identify a specific aspect of the course that they liked the most, as asked in Q1. The themes of the other topics that emerged from Q1 responses are discussed in next few subsections along with representative responses that were composed primarily of that topic. Topics that were thematically linked are discussed together.

1) Interaction With Other Learners and Educators (Q1T1): Q1T1 response—"My favorite part of the course was engaging with others replying to comments and reading other participant's points of view because doing this helped me with my thinking and judgments on points raised."

As indicated by the high topic weight for Q1T1 in Table II, the most favorite part of the MOOC for a lot of learners was interaction with other learners and educators in various forms, such as content-related discussion and receiving and providing feedback. Learners mentioned that:

1) the interaction added a lot of value to their learning experience;

TABLE II
LIST OF TOPICS IDENTIFIED BY THE LDA MODEL FOR Q1:WHAT WAS YOUR MOST FAVORITE PART AND WHY?

Topic ID	Topic Theme	Top-10 Topic Words	LDA Topic Weight	Qualitative Analysis Agreement Level
Q1T1	Interaction with peers and educators	comments, students, learners, reading, people, participants, discussions, ideas, videos, discussion	0.09	85%
Q1T2	Enjoyed everything in the course	part, interesting, week, favourite, enjoyed, found, parts, weeks, lot, favorite	0.09	64%
Q1T3	Clear and engaging presentation	videos, engaging, interesting,subject, experts, video, informative, excellent, clear, presented	0.07	92%
Q1T4	Links to further reading materials	information, links, research, provided, material, resources,knowledge, subject, sources, articles	0.07	58%
Q1T5	Flexibility with time	time,work, learn, week, made, courses, didn't, great, learning, feel	0.07	51%
Q1T6	Quizzes	knowledge,quizzes, understanding, learning, helped, test, learned, tests,learnt, practice	0.07	77%
Q1T7	Content-Specific	part, learning, business, work, tools, social, management, future, ideas, idea	0.07	-
Q1T8	Video and Transcripts	videos, video, reading, articles, easy,read, information, transcripts, learn, learning	0.06	95%
Q1T9	Real world examples	real,life, people, case, studies, examples, gave, videos, practical,story, experience	0.06	93%
Q1T10	Content Specific	health, brain, mental, disease, people, work, cancer, treatment, care, exercise	0.05	-
Q1T11	Clear Explanation in Videos	understand, easy, clear, explained,videos, made, concepts, follow, explanations, helped	0.05	90%
Q1T12	Content Specific	history, people, war, richard, life, week, time, period, interesting, food	0.05	-
Q1T13	Content-Specific	science, interesting, climate, change, deep, forensic, ocean, learning, sea, future	0.04	-
Q1T14	Peer review	feedback, writing, essay, review, work, research, assignment, ideas, peer, write	0.04	84%
Q1T15	Language Related	part, language, english, videos, grammar, learn, skills, writing, improve, words	0.03	72%
Q1T16	Content-Specific	wall, learning, life, roman, inscriptions, people, enjoyed, latin, read, museums	0.03	-
Q1T17	Content-Specific	plays, books, read, reading, literature, shakespeare, enjoyed, life, poems, context	0.03	-
Q1T18	Content-Specific	film, actors, play, films, production, editing, music, video, part, director	0.03	-
Q1T19	Content Specific	food, foods, diet, nutrition, information, health, medicine, healthy, gut, eating	0.03	-
Q1T20	Instructor feedback sessions	questions, week, videos, end, feedback, answer, richard,weekly, craig, answers	0.02	76%

2) receiving feedback from peers and instructors validated their understanding and methods of solving assignment problems, helped them understand the topics better, and provided new information and different perspectives beyond the course material; and
3) providing feedback and participating in discussions made them feel valued, less isolated, and connected with instructors and peers.

2) Effective Lecture Videos (Q1T3, Q1T8, Q1T11, and Q1T15): Q1T3 response—"The course contributors are clearly experts in their field who know how to explain the subject in a clear and understandable way."

In responses mainly composed of Q1T3, learners' most favorite aspect of the course was easy-to-understand and clear lecture videos by expert instructors. These lectures helped them learn the content in an intuitive and structured manner, which would not have been possible by reading the course material on their own.

Q1T8 response: "Videos were very interesting and interactive. Articles were sometimes a bit too long."

In Q1T8-related responses, learners mentioned videos as their favorite part of the MOOC and felt that compared to reading text, videos were more engaging and enabled them to understand the course content better and at a faster speed. Learners who were nonnative English speakers mentioned that they were able to follow the videos with the help of subtitles. Learners also valued video transcripts being available as it helped them to go through the material when the Internet connection was weak for video streaming and provided them the ability to refer to or revise the course topics quickly.

Q1T11 response: "*My favorite part was animation to illustrate clarify and simplify the subject.*"

In Q1T11 responses, learners discussed how animation and visuals used in the videos helped them understand the course material better, which highlights the strength of video as a medium of learning.

Q1T15 response: "The conversation videos. We could learn a lot of new vocabulary, and we could see the grammar in context."

In responses primarily composed of Q1T15, learners who took language-related courses (such as courses in Italian or Dutch) appreciated that they were able to understand the videos in different languages with the help of subtitles as well as learn the grammar, pronunciation, and other nuances of those languages by listening to native speakers.

Videos are one of the primary aspects of MOOCs and provide an effective medium to learn from instructors beyond the reading material in a structured and consolidated manner. The quality of lecture videos is instrumental in determining the learning experience and outcome of learners, as reflected in learners' responses related to topics Q1T3 (clear explanation and engaging presentation by instructors), Q1T8 (video and transcripts), and Q1T11 (clear explanation in course videos) that covered different aspects of lecture videos which learners liked the most.

3) Q1T9 (Real-World Examples): Q1T9 response—"I enjoyed the case studies as they helped to illustrate the concepts that were being discussed. It is always helpful to see what is being discussed applied to real world scenarios."

Learners mentioned that providing more real-life case studies and practical examples during teaching helped

learners understand the course material better, as they were able to relate to their surroundings and learn the utility and applicability of theoretical concepts and models.

4) Further Reading Material (Q1T4): Q1T4 response—"I enjoy the extra resources provided. They introduced me to new sites and offered valuable information."

Learners valued information and access to further reading material and resources in form of links to various scientific articles, online databases, and other resources beyond the course syllabus, being provided to them for further reading. They mentioned that it provided them the opportunity to explore further on the topics covered in the course, know more about the applications, and plan for next level courses.

5) Flexibility With Time (Q1T5): Q1T15 response—"It was broken down into small sections, which could be viewed studied in a few minutes. This made it easy to fit into other commitments as: When I had a few spare minutes. You did not have to commit to an hour or two at a time."

Many MOOC learners have other commitments such as studies, work, and family. Therefore, the time commitment associated with a MOOC is an important factor for their course participation and completion. In responses closely associated with the topic Q1T5, learners mentioned that they greatly valued the time-related flexibility that the course offered as they were able to accommodate the MOOC in their busy routines. Learners mentioned that they were able to finish the course (and did not drop out) because of the flexibility that the course offered. This indicates that a well-structured MOOC considering the time commitments of learners is likely have a lower dropout rate and more satisfied learners.

6) Assessment (Q1T6): Q1T6 response—"I enjoyed the quizzes as it gave me a chance to reflect and test what I'd learned."

Learners listed quizzes, tests, and course assignments as their favorite part of the course and mentioned that it helped them to verify their understanding of the subject matter, reinforced their learning, and provided them an opportunity to consolidate different topics covered in the course and apply them to solve problems asked in the quizzes.

7) Feedback From Instructors (Q1T20): Q1T20 response—"I really like that the mentors responded to the comments and brought questions up for discussion at the end of each week. I've done a few MOOC without active graders and this is much more engaging."

Topic Q1T20 was focused on the interaction with educators related to providing feedback on discussion forums and answering questions. In some courses, instructors created a weekly feedback video covering the most discussed topics on the discussion forum for that week. These weekly feedback videos were highly liked by the students as mentioned in their responses. Learners valued the fact that their comments and questions were being viewed by instructors and their questions were being answered by instructors or teaching assistants.

B. Q2: What Was Your Least Favorite Part of the Course, and Why?

The topics resulting from the LDA topic model from Q2 responses are presented in Table III, along with the theme of the topic, top ten words associated with the topic, LDA topic weight, and agreement level from qualitative analysis. Similar to Table II, topics are ordered by decreasing LDA topic weight.

As shown in Table III, there were a few topics that corresponded to specific course content. Q2T11, Q2T13, and Q2T15 were not considered for qualitative analysis and, thus, do not have an associated qualitative analysis agreement level. The qualitative analysis agreement level was fairly good for all the other topics except Q2T12. In case of Q2T12, a large portion of the top 100 associated responses were not in English, so they could not be counted to be in agreement with the theme of the topic, resulting in a relatively low agreement level (28%).

One of the prominent topics Q2T3 (enjoyed all parts, did not have any least favorite) indicated that there were a considerable number of learners who were very satisfied with the current offering of the MOOC and did not have any least favorite part. The other topics from Q2 responses that corresponded to different aspects of MOOCs that were disliked by learners are discussed in next subsections along with representative responses for each topic.

1) Discussion Forum (Q2T1): Q2T1 responses—"The comment section was way too overwhelming. I found it pretty impossible to sort through the several thousand comments to find a discussion it seems like it would be great if we were broken into smaller groups."

"Reading other participant comments, lots of biased ill-informed comments and at times people were rude and dismissive of others."

Q2T1 was the most heavily weighed topic that emerged from Q2 responses. Learners mentioned that they found it hard to navigate through the large volume of discussion forum posts and comments and keep up with the several ongoing discussion threads in the course. This led to some frustration as they felt they were not able to participate in the course and were not able to gain knowledge from the discussion forums. Learners also mentioned that many of the comments on discussion forums were not relevant to course material and were also not professional in nature. Some learners expressed their displeasure about nonparticipation from other learners in discussion forums and there were also learners who did not like online discussion forums as a medium for interaction altogether.

2) Expectation Mismatch: Course Syllabus, Prerequisites, and Time Commitment (Q2T2, Q2T4, and Q2T6): Q2T2 response—"I wish many of the topics had been discussed in more depth. Found that was a very broad overview of most topics."

In responses mainly composed of topic Q2T2 (different expectation of depth and breadth of content covered), learners mentioned that the course content was different from what they had expected based on the course description, and that the course syllabus and outline should have clearly listed the topics to be covered in the course in a detailed manner.

TABLE III
LIST OF TOPICS IDENTIFIED BY THE LDA MODEL FOR Q2: WHAT WAS YOUR LEAST FAVORITE PART AND WHY?

Topic ID	Topic Theme	Top-10 Topic Words	LDA Topic Weight	Qualitative Analysis Agreement Level
Q2T1	Issues related to discussion forum	comments, discussion, discussions, people, read, students, time, learners, didnt, participants	0.14	87%
Q2T2	Different expectation of depth and breadth of content covered	week, bit, felt, information, content, short, basic, subject, weeks, material	0.13	91%
Q2T3	Enjoyed all parts, didn't have any least favorite	part, favourite, enjoyed, interesting, favorite, parts, didnt, found, good, enjoy	0.12	89%
Q2T4	1) Time commitment more than stated or expected 2) Course length not appropriate	time, week, weeks, work, didnt, complete, lot, end, longer, long	0.09	86%
Q2T5	Long and hard to understand reading material or videos	long, articles, videos, read, reading, bit, time, links, information, material	0.09	71%
Q2T6	Difficult to follow content	difficult, understand, found, bit, hard, technical, language, follow, terms, remember	0.09	93%
Q2T7	Issues related to videos such as subtitles and audio quality	videos, video, talking, english, read, subtitles, difficult, found, understand, bit	0.07	78%
Q2T8	Content-specific	interesting, didnt, found, interest, section, relevant, interested, week, history, pregnancy	0.05	-
Q2T9	Didn't like the quizzes and exams	questions, answer, test, quizzes, question, answers, tests, quiz, end, wrong	0.05	87%
Q2T10	Did not like peer review	work, didnt, review, assignment, feedback, write, peer, assignments, writing, feel	0.05	69%
Q2T11	content-specific	interested, business, history, information, wall, important, case, interesting, people, interest	0.05	-
Q2T12	Not getting a free certification	courses, learning, social, learn, media, certificate, people, university, students, future	0.05	28%
Q2T13	Content-specific	people, view, point, made, felt, issues, political, world, health, art	0.04	-
Q2T14	Issues related to videos such as internet speed, ability to download, and system compatibility	videos, work, download, internet, computer, video, access, couldnt, watch, transcripts	0.04	89%
Q2T15	Content-specific	food, information, health, medicine, foods, people, nutrition, diet, eating, healthy	0.03	-

Q2T4 responses: "Similar to other courses the quoted time needed per week significantly underestimates the time needed to engage fully with the course" and

"I found it too intense. There was a lot to take in in a short space of time I would have preferred it to be more diluted over weeks perhaps."

In responses related to Q2T4, learners mentioned that the actual time they had to spend on the course was much more than the weekly time commitment estimated for the course. There were two aspects to this issue that came up in learner responses:

1) the background of these learners was not sufficient for the course, so they had to spend extra time to keep up with the course; and
2) the pace of course was very fast. For pace of the course, lot of learners suggested that either the course length should be increased or the course should be broken down into multiple parts.

Q2T6 response: "I found that the more academic explanations were a little beyond me as I did not have enough background knowledge to understand how ions work for example or how molecules bond together. Some familiarity with the technical language would have been helpful."

In responses mainly composed of topic Q2T6 (difficult to follow content), learners highlighted that the content of the course was difficult to follow due to various reasons such as not having enough prerequisite knowledge for the course, use of highly technical language in videos, and text which they did not understand.

In summary, MOOCs are focused on specific topics in a short period of time. Learners who enroll in a MOOC make adjustments to their busy schedule to complete the course and expect to gain knowledge on those specific topics. Therefore, it is important that before starting the course, learners know clearly about the topics to be covered in the course, prerequisites needed for the course, and a good estimate of the time commitment needed for the course.

3) Assessment Related (Q2T9 and Q2T10): Q2T9 response—"The quizzes I don't like the binary nature of them, and I feel like some of the questions weren't suitable for a right wrong answer."

In responses associated with Q2T9, learners were not happy with the format of the quizzes because of binary or multiple-choice answers for questions that may be open to interpretation and absence of explanatory feedback on quiz attempts.

Q2T10 responses: "Receiving peer review feedback as I felt the person didn't do justice to his role as a peer review person. I didn't get clear feedback."

"Reviewing other people's work. I didn't feel comfortable critiquing other people's work when I am still learning myself."

In responses mainly composed of Q2T10, learners did not like peer review as an assessment method in the course. They felt that the person evaluating the work was not an expert and, hence, would not be able to evaluate accurately or provide any valuable feedback. While many learners mentioned that they did not like the quality of peer review they received, some learners also

mentioned that they were not comfortable reviewing others' work as they did not have enough knowledge on the subject matter.

Assessments are an important aspect of learning. They not only help in validating the understanding of the learning material but also in consolidating different topics together to solve problems. Therefore, the nature of assessments and quality of feedback on assessments is important for learners. This was also reflected in the responses associated with topics Q2T9 (didn't like the quizzes and exams) and Q2T10 (didn't like peer review).

4) Issues Related to Understanding and Engagement Level of Videos and Other Content (Q2T7 and Q2T5): Q2T7 responses—"Some of the videos were a bit long and lacked variation in tone pace and a sense of passion."

"Some subtitles were missing and some words were not correctly translated. This was particularly difficult when the speaker had a strong foreign accent."

In responses related to Q2T7 (issues related to videos—subtitles and audio), learners mostly highlighted the issues with lecture videos such as the following:

1) lectures being very long and monotonous because of which they could not focus properly on the entire content;
2) missing or out-of-sync subtitles, which made the lectures difficult to follow for nonnative language speakers;
3) poor audio quality of videos; and
4) difficult-to-follow speech of the instructor due to a heavy accent.

Q2T5 responses: "Some of the articles were hard to follow and had to be read several times."

"The really long videos hard to keep concentration going for mins plus."

Q2T5 (long and hard to understand reading material or videos) was also related to Q2T7, but it covered videos, as well as reading materials. In responses associated with Q2T5, learners mentioned that they struggled with videos and articles that were long and difficult to understand. It was hard for them to maintain their concentration when videos or articles were too long. In some cases, they had to reread the articles or rewatch the videos multiple times to understand the content because information was not presented to them in a lucid manner. Lecture videos are one of the primary offerings of MOOCs and, in many cases, is the main medium of learning for students. Therefore, it is important that the videos are easy to understand, engaging, and of appropriate duration to hold the learner's attention.

5) Technical Issues (Q2T14): Q2T14 response—"I was unable to view the videos due to a slow internet connection as I am working in a developing country."

In responses associated with the Q2T14, learners complained about technical issues such as poor Internet connection, browser incompatibility for playing videos, and restricted access on workplace computers, due to which they could not participate in the course as much as they expected. It is to be noted that many of the technical issues mentioned by learners were at their end and not on MOOC provider's side. While it may be out of scope for MOOC providers to address such issues, it is perhaps worthwhile to think of providing learning resources that can tackle these challenges, such as providing the option to download the videos transcript to learners with poor Internet connections.

6) Cost of Participation or Completion Certificate (Q2T12): Q2T12 response—"Needing to pay such a high price for a certificate upon completion."

In responses closely associated with Q2T12, learners complained about the high cost of obtaining a participation or course-completion certificate. While a lot of learners stated that the certificate should be free, many learners also mentioned that they would not mind paying for the certificate, but the cost was just too high for them. There seemed to be two aspects associated with the cost of certificate: 1) the value for money for the certificate, which is related to the use of certificate for professional purposes; and 2) personal affordability, which is linked to the economic status of the learner, for example, if the learner is unemployed or lives in a developing country where the currency exchange rate is very high.

C. Q3: How Could the Course Be Improved?

In the postcourse survey question Q3, learners were asked for some suggestions to improve the course. The topics that emerged from responses to Q3 are presented in Table IV with their theme, LDA top ten topic words, LDA topic weight, and qualitative analysis agreement level.

As shown in Table IV, topics Q3T11, Q3T12, and Q3T14 corresponded to specific course content. Therefore, these topics were not considered for qualitative analysis and, thus, do not have an associated qualitative analysis agreement level. The qualitative analysis agreement level was fairly good for all the other topics except Q3T13 (20%) and Q3T15 (53%). For both Q3T13 and Q3T15, the relatively low agreement level was due to a lot of non-English responses being among the top 100 associated responses, which were not counted to be in agreement with the topic theme.

As shown in Table IV, the topic Q3T1 (enjoyed everything, no improvements suggested), which had the highest weight, indicates that a considerable number of learners were extremely satisfied with the current offering and did not suggest any improvements. An example response was: "No suggestions–the course was excellent as it was."

It is to be noted that in many responses associated with other Q3 topics, learners mentioned that they were happy with the current MOOC but suggested some improvements because they were asked to do so. An example response is: "As for me, this course is excellent and hardly needs any improvements. But it would be great to add more quizzes."

Next, we discuss other topics that emerged from learners' responses to Q3 with some representative responses. It was intuitively expected that many topics that emerged from responses to Q3 (what to improve in the course) would be similar to the topics that emerged from responses to Q2 (what they did not like in the course).

TABLE IV
LIST OF TOPICS IDENTIFIED BY THE LDA MODEL FOR Q3: HOW COULD THE COURSE BE IMPROVED?

Topic ID	Topic Theme	LDA Top-10 Topic Words	LDA Topic Weight	Qualitative Analysis Agreement Level
Q3T1	Enjoyed everything, no improvements suggested	good, improved, excellent, great, fine, perfect, improve, improvement, dont, thought	0.15	85%
Q3T2	More meaningful interaction with educators and peers-educator involvement, better features on discussion board	comments, discussion, students, questions, discussions, educators, participants, people, learners, feedback	0.11	94%
Q3T3	Provide more real-life examples	examples, practical, real, case, studies, videos, work, life, exercises, people	0.1	81%
Q3T4	Cover topics in more depth and detail	longer, depth, subject, topics, information, bit, detail, good, courses, study	0.09	84%
Q3T5	Increase length of course, reduce per-week load, more even distribution of content over weeks	longer, weeks, week, bit, time, content, material, information, videos, depth	0.09	87%
Q3T6	Improving audio and video quality. Making videos more engaging	videos, video, subtitles, bit, english, talking, audio, reading, speakers, read	0.09	85%
Q3T7	More accessible learning resources-videos and reading materials	links, videos, reading, articles, material, video, download, read, materials, information	0.08	73%
Q3T8	Better and more quizzes. Better assessment	quizzes, questions, test, tests, end, quiz, week, answer, assignments, feedback	0.08	90%
Q3T9	Better estimate of the time commitment and length of course	time, week, weeks, work, hours, people, complete, lot, didnt, felt	0.07	81%
Q3T10	Better explanation of difficult technical concepts	terms, concepts, explanation, understand, examples, basic, explanations, language, maths, explained	0.05	72%
Q3T11	content-specific	history, wall, life, information, war, richard, time, countries, people, country	0.05	-
Q3T12	content-specific	people, health, issues, mental, care, social, information, patients, change, aspects	0.05	-
Q3T13	Clearly state the level of prior knowledge required	level, people, knowledge, students, advanced, levels, subject, audience, basic, courses	0.04	30%
Q3T14	content-specific	food, foods, medicine, information, health, specific, nutrition, diet, title, healthy	0.03	-
Q3T15	Reduce the cost of online certificate	certificate, free, university, participation, courses, certificates, pay, online, completion, cost	0.02	53%

1) Interaction With Peers and Educators (Q3T2): Q3T2 responses—"It could have more interaction, chats, and channels to make the participants keep in touch with others."

"I gave up on the discussion forums because no one was really discussing much it was mainly huge numbers of people who had apparently not read anyone else's comment each posting their own separate thoughts."

Learners suggested various improvements for better interaction with peers and educators, which are as follows.

1) Having more moderation and participation from educators in the discussion forums in order to receive feedback on their understanding and get answers for ongoing open questions asked by the learners.
2) Having more avenues to interact with mentors and peers and ask more questions such as webinars and live online sessions with peers and instructors.
3) Improving the layout and organization of the discussion forum based on content so that the ongoing discussion between large numbers of participants does not seem overwhelming.

2) Clear Explanation (Q3T3 and Q3T10): Q3T3 response:—"A variety of case studies used to base the issues around. I think story/real life examples are easier to engage with generally."

Given that there is a large variation in the educational and professional background of MOOC learners, it is important that the new concepts are introduced in the course in a simple and easily understandable manner and that the information presented to them is not loaded with technical jargon. In responses associated with Q3T3 (provide more real-life examples), learners suggested that more real-life examples and case studies would help their understanding of the course material. Many learners mentioned that they work in the industry, and it would have helped them if the theoretical concepts were explained by giving examples from workplace settings. Learners also mentioned that they would have preferred more worked out examples and more practice exercises in the course so that they can learn how to solve problems and apply the course concepts in different situations.

Q3T10 responses: "Use simplified diagrams and animations to explain imaging technologies rather than just have the technician explain the process in his own words."

"I think it could be bit more concise and a bit less technical. I found the medical explanations hard to follow."

In responses associated with Q3T10 (better explanation of difficult technical concepts), learners recommended that complex technical concepts should be explained in simpler language without jargon. Animations and other visual aids would help so that people with less experience in the area or from other backgrounds can also understand easily.

3) Content-Related Expectations (Q3T4): Q3T4 response—"More in-depth information. The subject matter was very general and covered too broad an area."

In responses associated with Q3T4 (cover topics in more depth and detail), learners mentioned that the depth of topics

covered in the course was different from their expectations. While some topics were covered at very advanced levels, other topics were covered at a very introductory level. Many learners suggested that clearly listing the topics and the level of detail in which they would be covered in the course will be very helpful.

4) Accessibility of Learning Resources (Q3T7): Q3T7 responses—"A few links for further resources went to journals where the full article wasn't freely available. Maybe find alternative free material?"

"Would like a separate "reference" section with all the relevant downloads and links in, as well as scattered among the weeks."

Learners mentioned that easy access to learning material for the course, as well as for further reading, was important to them and suggested that it should be made available with the course. Some learners mentioned that they found it difficult and confusing when they had to search for further reading material themselves (for example, searching on the internet for a topic) or when the references provided in the course were paid scientific articles and book chapters.

Learners suggested that they would like to have more supplementary reading material, a list of further reading materials and videos to be provided in one place, and specific links to be provided rather than finding the reading material themselves. They also suggested uploading the journal articles on the course website as many of them were not enrolled in any university and would not have access to journal articles that are typically available to full-time students. Some learners also mentioned technical issues such as the reference material link opening in the same web browser window (as opposed to a separate browser window or tab) that caused them to lose their work or accidentally close the browser window.

5) Time Related (Q3T5 and Q3T9): Q3T5 response—"Perhaps smaller chunks per week over a couple more weeks would make it easier to keep up with other time commitments."

In responses related to Q3T5 (increase length of course, reduce per-week load, and more even distribution of content over weeks), learners mentioned that the amount of content covered per week in the course was not appropriate. The pace of course was too fast in some weeks and too slow in other weeks. Many learners suggested different measures to handle it, such as increasing the course length to bring down the weekly load, distributing coursework more evenly among different weeks, and instructors spending more time on difficult topics.

Q3T9 response: "Less stuff in one week or adjusted time estimation. If I would have known that the course will demand significantly more than hours per week I would not have joined."

In responses associated with topic Q3T9 (better estimate of the time commitment and length of course), learners felt that the estimate of time commitment provided in the course syllabus was considerably lower than the actual time spent, and it is important to provide a better and more realistic estimate of time commitment needed for the course.

6) Video Related (Q3T6): Q3T6 responses: "Would enjoy more audio. Easier than video to download on slow internet access."

"More accurate subtitles lots of spelling mistakes and actual mistakes in transcription."

"Maybe, subtitles in French and other languages would provide some help and extend the range of this course to other people."

"The teacher could speak more loudly and slowly sometimes. It's ok for native English speakers, but not for the ones that aren't."

Learners recommended fixing various technical issues related to lecture videos, such as poor streaming quality, frequent switching between the instructor and worksheet, audio quality, not having the ability to download videos, and transcripts not being available or out of sync. Learners with low Internet speed suggested that the ability to download the videos or just the audio will enable them to go over the lecture without interruptions once downloaded.

Many learners also faced difficulties with courses due to language-related issues. For example, nonnative English speakers had difficulty in understanding some of the lectures and recommended that subtitles in different languages be made available with the videos for better understanding. Some of the English speakers had difficulty understanding courses in other languages and recommended the use of subtitles in English.

Learners also pointed out that there were grammatical errors and spelling mistakes in the video subtitles and suggested the subtitles be proofread before publishing. Some learners mentioned that they had difficulty in understanding the lecture because of issues with instructor's speech, such as the instructor's accent, the instructor spoke very fast in their nonnative language, or the instructor's speech not being very clear.

7) Better Information on Prerequisites (Q3T13): Q3T13 responses—"Perhaps more indication of prior knowledge of the subject matter required for the course. Although I 'kept up' I was quite intimidated by the level of knowledge and experience obvious from the other learners on the forum."

"It could be a bit more clearly defined as to the level of previous knowledge that you are expecting from participants."

Learners mentioned that the perquisites and background knowledge required for the course were not adequately listed in the course website, and there was a mismatch in their level of prior knowledge about the subject and that required for the course. They suggested providing a better description of the prerequisites needed for the course and a detailed course curriculum to know the topics and the level of depth in which the topics will be covered. Some learners also suggested that it would be helpful to provide some basic self-study material at the beginning of the course to learn or recap the content required for the course.

8) Assessment Related (Q3T8): Q3T8 responses—"If there were more activities to practice newly gained knowledge and reinforce memorization probably it would be more helpful."

"For all the assignments feedback is via peer reviews. If the last assignment could be reviewed by the lecturer or mentors that would be good."

Learners felt that interactive activities, assignments and quizzes in the course helped them in consolidating and

TABLE V
TOPICS RELATED TO MOOC CHARACTERISTICS IDENTIFIED IN PREVIOUS STUDIES

Factors contributing to low engagement in MOOCs	Previous Studies	Related topics identified
Difficult course content	[3, 6, 10]	Q1T11, Q2T6, Q3T10, Q3T3
High workload and lack of time	[3, 6, 10]	Q1T5, Q2T4, Q3T5, Q3T9
Mismatch between learner's perception and actual course content and design	[10]	Q1T5, Q2T2, Q3T4, Q3T13
Absence or poor quality of social interaction	[6, 10, 12]	Q1T1, Q2T1, Q3T2
Issues related to language proficiency and differences in cultural background	[3, 10, 12]	Q1T15, Q2T7, Q3T6
Hard to follow or non-engaging instructor	[6, 10]	Q1T3, Q1T9, Q2T6, Q3T3, Q3T10
Issues related to lecture videos	[6, 10]	Q1T8, Q2T14, Q3T6
Usability of the platform	[4, 11]	Q1T8, Q2T14
Quality of assessment and feedback	[6]	Q1T6, Q1T14, Q2T9, Q2T10 Q3T8
Perceived utility of the course	[11]	

retaining the course-content, checking progress, verifying their understanding of the subject matter, and gaining more clarity about the course content by getting a chance to apply the theory learned in the course to solve problems. They suggested having more and better-designed activities and quizzes for better retention and longer tests for evaluating their understanding of the subject. Many learners also mentioned that they would prefer their assignments to be graded by educators as opposed to optional peer review. In summary, the learners valued getting feedback on their understanding of the course but felt the current mechanism of getting feedback needs improvement.

9) Cost of Certificate (Q3T15): Q3T15 responses—"By providing free online certificate link to add to add to LinkedIn."

"I think the cost of the Certificates should be reduced so that more participants will be able to purchase them."

Learners felt that the certificate of participation or course completion should be free or have a lower cost. In responses associated with Q3T15, they mentioned that the cost of certificate should be reduced and suggested some ways of how the certificates can be used professionally such as linking them to LinkedIn profiles.

V. DISCUSSION

Several prominent themes emerged from learner responses to Q1, Q2, and Q3, including the following:

1) social interaction with peers and educators;
2) instructors who are engaging, explain clearly with the help of real-life examples and animations, and help students with questions;
3) course content that is not too long or difficult to understand;
4) detailed information about course prerequisites;
5) good-quality assessments that test their conceptual understanding;
6) detailed feedback on submitted work;
7) access to learning material;
8) lecture video subtitles;
9) time-related flexibility associated with courses;
10) usability of the platform; and
11) cost of the certificate.

These common themes that emerged from the responses to the different questions are indicative of the MOOC characteristics that mattered the most to learners and majorly impacted their MOOC learning experience. Many of these characteristics overlap with the findings of previous studies, as discussed in the next subsection.

A. Results in Context of Previous Studies

As mentioned in Section II, many of the previous studies were focused on identifying factors that lead to low engagement and completion rates in MOOCs. In Table V, we summarize the list of such factors identified by previous studies and topics corresponding to each factor that emerged from Q1, Q2, and Q3 responses.

As shown in Table V, many of the MOOC characteristics identified as Q1, Q2, and Q3 topics, overlapped with the MOOC factors identified in previous studies that were important for learners' engagement and completion. Some of the topics covered detailed aspects of MOOC factors identified by previous studies, probably because these topics emerged from a large collection of open-ended responses from MOOC learners from several courses.

There were also some topics identified in this study, which we were not able to directly correlate to one of the MOOC factors identified in previous studies. These include Q3T7 and Q1T4 that were related to providing access to further learning resources, Q1T20 related to instructor involvement in the discussion board and weekly feedback sessions, and Q3T15 and Q2T12 that were related to the cost of the certificate. These topics were indirectly related to some of the important MOOC factors identified in previous studies. For example, Q1T20 is another dimension of an effective instructor who is also actively involved in learners' discussion and provides regular feedback on their understanding of the material. Similarly, topics Q3T15 and Q2T12 about the cost of the certificate are related to the perceived utility of the course because learners would want to invest in the certificate if it is of professional utility, as also discussed in [25].

B. Implications

The findings of this study will be helpful for MOOC researchers, instructors, MOOC platforms, and educational institutions that offer MOOCs. For MOOC researchers, this study provides a broader understanding of MOOC learners by deriving insights from a very large collection of open-ended feedback responses of learners from different MOOCs and also confirms some of the findings from previous studies. For

educational institutions and MOOC quality evaluators, this study provided key indicators for judging learner satisfaction that will help them evaluate different MOOC platforms and determine the most suitable platform for offering their courses.

MOOC instructors can benefit from the identified significant pedagogical aspects while developing and teaching the course. They can incorporate some of the findings from the study to improve the learning experience, such as providing an accurate description of required background and detailed syllabus of the course in the beginning, providing more real-life examples while teaching, and weekly feedback videos. Many MOOCs are often taught by university professors who are used to teaching in a classroom environment with a more homogeneous group of students. Our findings indicate that their teaching methods need to be tailored according to the MOOC format, keeping the aforementioned learner preferences in mind.

The prominent themes from learners' responses also indicate that educational institutions and instructors offering MOOCs need to rethink the assessment and feedback mechanisms. While there was unity in learners' feedback that assessments need to be of good quality and should test their understanding of the course material, the learners were divided on the peer-review process; many learners felt that without expertise in subject matter, the feedback and grading of quizzes and assignments will not be of good quality.

For MOOC platforms, the results from this study will help in prioritizing their improvement efforts to increase learner engagement and retention on the platform. As more platforms are moving from free to freemium models, it is important for a platform's sustainability to keep the learners engaged and provide them with a valuable learning experience for which they would contribute monetarily and spread positive reviews. The findings also highlight the importance of platform-level support for worldwide learners, such as different languages, variable Internet connection, and pricing of certificates for learners from different countries.

Some aspects of the MOOC learning experience involve improvement efforts from different stakeholders such as social interaction, which emerged as one of the most significant aspects of the MOOC learning experience. It can be viewed from both pedagogical and technical dimensions. Pedagogically, interaction is an important aspect of learning and discussion can increase clarity of concepts. As suggested by learners, with the involvement of the instructor and teaching assistants, the quality of social interaction in a MOOC can be enhanced. From a technical viewpoint, it is important to have a user-friendly interface to navigate the discussion forum through multiple parallel discussion streams with many participants. This will enable learners to find topics of interest and stay connected. In their responses, learners suggested discussion forum posts to be monitored for content and organized based on content, so that they can read through them easily and participate in the ongoing discussion.

In summary, we suggest following practical recommendations that would be helpful for designing new MOOCs as well as improving existing MOOCs.

1) Carefully drafting the syllabus for the MOOC by ensuring that it contains detailed and accurate information about the prerequisites, average time commitment needed for the MOOC, topics to be covered in the MOOC, and a weekly schedule. It may be difficult to get all of it right in the first offering of the MOOC; therefore, the syllabus should be updated for subsequent offerings based on the feedback from learners. Through this, many issues raised by MOOC learners in their feedback can be addressed, such as realistic expectation regarding breadth and depth of course topics, prerequisites, difficulty level, and time commitment for MOOC.
2) Implementing artificial-intelligence-based approaches to conduct assessment at scale in MOOCs such as autograding numerical problems and descriptive text answers. Learners mentioned in their feedback that they see MOOCs more than textbooks, which can be interactive and provide them feedback beyond multiple choice questions.
3) The MOOC instructional team should include more real-world examples in content and during teaching and actively participate in discussion forums by posting conversation starter posts, responding regularly to ongoing threads.
4) MOOC platforms should provide enough support for the different needs of learners from diverse backgrounds and geographical locations, including multilanguage support in content and subtitles, providing small duration downloadable videos, lecture notes, and transcripts for learners with weaker Internet connection, pricing the certificate appropriately based on the country, and providing nonpaywall learning resources in an organized manner.

VI. Conclusion

MOOCs are a powerful medium for disseminating knowledge to a large number of interested learners anywhere in the world. However, they are still evolving to provide a better learning experience to different types of learners with diverse backgrounds and learning objectives. To improve the MOOC learning experience, it is important to identify the significant characteristics of MOOCs that lead to learner satisfaction or dissatisfaction.

In this study, we identified the most significant aspects of the MOOC learning experience from learners' perspective by mining their postcourse open-ended survey responses using LDA topic models and qualitative analysis. We can group these aspects in two dimensions: pedagogical and technical. The significant pedagogical aspects were instructor, content, social interaction, course-load, assessments, and feedback, and the significant technical aspects included detailed information about the course, language-related support, usability of the platform, accessibility of learning material, support related to low Internet speed in developing countries, and pricing of the certificate.

The methodology used in this study is replicable for exploratory analysis on large textual data and would be useful in educational research for similar tasks such as analyzing open-ended feedback or discussion forums. It is also important to note that while the LDA topic model provides a good starting point for

exploratory data analysis, its results need to be interpreted using qualitative analysis to obtain meaningful conclusions.

A. Limitations and Future Work

We acknowledge the fact that the postcourse survey used in this study would have been submitted mostly by learners who completed the MOOC and is, therefore, not representative of the opinions of all MOOC enrollees. These learners may have been more self-motivated as compared to learners who dropped out due to various reasons that were not captured in this dataset. Future work may consider collecting learners' open-ended feedback at various stages of the course in order to learn from those that disengage early or are only interested in casually using the MOOC materials.

The postcourse survey data were collected anonymously through an external survey platform and we did not have access to the course participation or precourse survey data. Therefore, we were not able to analyze the learners' feedback in context of their background, preparedness, motivation, participation, and performance in the MOOC. Such analyses would lead to deeper insights to understand how certain MOOC characteristics may have different impact on different types of learners. Future studies can conduct this analysis by collecting and analyzing data that connects learners' feedback with their biographic information and course participation.

We analyzed the surveys across the platform, rather than focusing on specific study areas such as humanities, engineering, etc. While this approach provided us with higher level preferences of MOOC learners across different study areas, there may be some logical variation in learner preferences depending on the study area of the course. Future work should examine these data at a deeper level to understand the similarities and differences among learner preferences across different subject areas such as Arts, STEM, Health, and Business.

The LDA topic model also has some limitations. While we discovered some prominent themes from learner responses, there may be other relevant underlying themes in learner responses that did not emerge as topics in our analysis. Future research can also use qualitative methods such as grounded theory to discover prominent themes present in open-ended feedback from MOOC learners and compare the results obtained by using LDA and qualitative analysis.

ACKNOWLEDGMENT

The authors would like to thank FutureLearn for providing the postcourse survey data. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the NSF.

REFERENCES

[1] D. Gamage, S. Fernando, and I. Perera, "Factors leading to an effective MOOC from participants perspective," in *Proc. 8th Int. Conf. Ubi-Media Comput.*, 2015, pp. 230–235.

[2] C. Sandeen, "Integrating MOOCs into traditional higher education: The emerging "MOOC 3.0" era," *Change, Mag. Higher Learn.*, vol. 45, no. 6, pp. 34–39, Nov. 2013.

[3] S. Zheng, M. B. Rosson, P. C. Shih, and J. M. Carroll, "Understanding student motivation, behaviors and perceptions in MOOCs," in *Proc. 18th ACM Conf. Comput. Supported Cooperative Work Social Comput.*, 2015, pp. 1882–1895.

[4] A. M. F. Yousef, M. A. Chatti, U. Schroeder, and M. Wosnitza, "What drives a successful MOOC? An empirical examination of criteria to assure design quality of MOOCs," in *Proc. IEEE 14th Int. Conf. Adv. Learn. Technol.*, 2014, pp. 44–48.

[5] H. C. Davis, K. Dickens, M. Leon Urrutia, M. del Mar Sanchéz Vera, and S. White, "MOOCs for Universities and Learners: An analysis of motivating factors," in *Proc. 6th Int. Conf. Comput. Supported Educ.*, 2014, pp. 105–116, doi: 10.5220/0004844901050116.

[6] P. Adamopoulos, "What makes a great MOOC? An interdisciplinary analysis of student retention in online courses," in *Proc. 34th Int. Conf. Inf. Syst.*, 2013, pp. 4720–4740.

[7] M. Kloft, F. Stiehler, Z. Zheng, and N. Pinkwart, "Predicting MOOC dropout over weeks using machine learning methods," in *Proc. EMNLP Workshop Anal. Large Scale Social Interact. MOOCs*, 2014, pp. 60–65.

[8] R. Rivard, "Measuring the MOOC dropout rate," *Inside Higher Educ.*, vol. 8, 2013.

[9] T.-I. Yang, A. Torget, and R. Mihalcea, "Topic modeling on historical newspapers," in *Proc. 5th ACL-HLT Workshop Lang. Technol. Cultural Heritage, Soc. Sci. Humanities*, 2011, pp. 96–104.

[10] T. Eriksson, T. Adawi, and C. Stöhr, ""Time is the bottleneck": A qualitative study exploring why learners drop out of MOOCs," *J. Comput. High. Educ.*, vol. 29, no. 1, pp. 133–146, Apr. 2017.

[11] M. Yang, Z. Shao, Q. Liu, and C. Liu, "Understanding the quality factors that influence the continuance intention of students toward participation in MOOCs," *Educ. Technol. Res. Develop.*, vol. 65, no. 5, pp. 1195–1214, Oct. 2017.

[12] A. M. F. Yousef, M. A. Chatti, U. Schroeder, M. Wosnitza, and H. Jakobs, "The state of MOOCs from 2008 to 2014: A critical analysis and future visions," in *Computer Supported Education*. Cham, Switzerland: Springer, 2015, pp. 305–327.

[13] M. E. Roberts *et al.*, "Structural topic models for open-ended survey responses," *Amer. J. Political Sci*, vol. 58, no. 4, pp. 1064–1082, Oct. 2014.

[14] A. Pea-Ayala, *Educational Data Mining: Applications and Trends*. Berlin, Germany: Springer, 2013.

[15] R. S. Baker, "Educational data mining: An advance for intelligent systems in education," *IEEE Intell. Syst.*, vol. 29, no. 3, pp. 78–82, May–Jun. 2014.

[16] S. Jiang, S. Jiang, M. Warschauer, A. E. Williams, and K. Schenke, "Predicting MOOC performance with week 1 behavior," in *Proc. 7th Int. Conf. Educ. Data Mining*, 2014, pp. 273–275, doi: 10.1.1.659.2890.

[17] D. Gašević, V. Kovanović, S. Joksimović, and G. Siemens, "Where is research on massive open online courses headed? A data analysis of the MOOC research initiative," *Int. Rev. Res. Open Distance Learn.*, vol. 15, no. 5, pp. 134–176, 2014.

[18] A. Pena-Ayala, "Educational data mining: A survey and a data mining-based analysis of recent works," *Expert Syst. Appl.*, vol. 41, no. 4, pp. 1432–1462, Mar. 2014.

[19] S. K. Mohamad and Z. Tasir, "Educational data mining: A review," *Procedia—Soc. Behav. Sci.*, vol. 97, pp. 320–324, Nov. 2013.

[20] C. Wang and D. M. Blei, "Collaborative topic modeling for recommending scientific articles," in *Proc. 17th ACM SIGKDD Int. Conf. Knowl. Discov. Data Mining*, 2011, pp. 448–456.

[21] D. Buenaño-Fernandez, M. González, D. Gil, and S. Luján-Mora, "Text mining of open-ended questions in self-assessment of university teachers: An LDA topic modeling approach," *IEEE Access*, vol. 8, pp. 35318–35330, 2020.

[22] W. H. Finch, M. E. Hernández Finch, C. E. McIntosh, and C. Braun, "The use of topic modeling with latent Dirichlet analysis with open-ended survey items," *Transl. Issues Psychol. Sci.*, vol. 4, no. 4, pp. 403–424, 2018.

[23] X. Kuang, H. S. Chae, B. Hughes, and G. Natriello, "An LDA topic model and social network analysis of a school blogging platform," in *Proc. 10th Int. Conf. Educ. Data Mining*, 2017, pp. 362–363.

[24] H. Bisgin, Z. Liu, H. Fang, X. Xu, and W. Tong, "Mining FDA drug labels using an unsupervised learning technique—Topic modeling," *BMC Bioinf.*, vol. 12, 2011, Art. no. S11.

[25] G. Nanda, N. M. Hicks, D. R. Waller, D. Goldwasser, and K. A. Douglas, "Understanding learners' opinion about participation certificates in online courses using topic modeling," in *Proc. 11th Int. Conf. Educ. Data Mining*, 2018, pp. 376–382.

[26] A. Ramesh, D. Goldwasser, B. Huang, H. Daume, and L. Getoor, "Understanding MOOC discussion forums using seeded LDA," in *Proc. 9th Workshop Innov. Use NLP Building Educ. Appl.*, 2014, pp. 28–33.
[27] A. Ezen-Can, K. E. Boyer, S. Kellogg, and S. Booth, "Unsupervised modeling for understanding MOOC discussion forums," in *Proc. 5th Int. Conf. Learn. Analytics Knowl.*, 2015, pp. 146–150.
[28] E. Hoque and G. Carenini, "ConVisIT: Interactive topic modeling for exploring asynchronous online conversations," in *Proc. 20th Int. Conf. Intell. User Interfaces*, 2015, pp. 169–180.
[29] C. A. Coleman, D. T. Seaton, and I. Chuang, "Probabilistic use cases: Discovering behavioral patterns for predicting certification," in *Proc. 22nd ACM Conf. Learn., Scale*, 2015, pp. 141–148.
[30] V. Kovanović, S. Joksimović, D. Gašević, G. Siemens, and M. Hatala, "What public media reveals about MOOCs: A systematic analysis of news reports," *Brit. J. Educ. Technol.*, vol. 46, no. 3, pp. 510–527, May 2015.
[31] A. K. McCallum, "MALLET: A machine learning for language toolkit." Accessed: Sep. 29, 2017. [Online]. Available: http://mallet.cs.umass.edu/
[32] D. M. Blei, A. Y. Ng, and M. I. Jordan, "Latent Dirichlet allocation," *J. Mach. Learn. Res.*, vol. 3, pp. 993–1022, 2003.
[33] H. M. Wallach, I. Murray, R. Salakhutdinov, and D. Mimno, "Evaluation methods for topic models," in *Proc. 26th Annu. Int. Conf. Mach. Learn.*, 2009, pp. 1–8.
[34] J. Chang, S. Gerrish, C. Wang, J. L. Boyd-Graber, and D. M. Blei, "Reading tea leaves: How humans interpret topic models," in *Proc. Int. Conf. Neural Inf. Process. Syst.*, 2009, vol. 22, pp. 288–296.
[35] D. O'Callaghan, D. Greene, J. Carthy, and P. Cunningham, "An analysis of the coherence of descriptors in topic modeling," *Expert Syst. Appl.*, vol. 42, no. 13, pp. 5645–5657, 2015.
[36] M. Röder, A. Both, and A. Hinneburg, "Exploring the space of topic coherence measures," in *Proc. 8th ACM Int. Conf. Web Search Data Mining*, 2015, pp. 399–408.
[37] D. Newman, J. H. Lau, K. Grieser, and T. Baldwin, "Automatic evaluation of topic coherence," in *Proc. Human Lang. Technol., Annu. Conf. North Amer. Chapter Assoc. Comput. Linguistics*, 2010, pp. 100–108.
[38] D. Mimno, H. M. Wallach, E. Talley, M. Leenders, and A. McCallum, "Optimizing semantic coherence in topic models," in *Proc. Conf. Empirical Methods Natural Lang. Process.*, 2011, pp. 262–272.
[39] "America's next topic model." Accessed: Dec. 13, 2017. [Online]. Available: https://www.kdnuggets.com/2016/07/americas-next-topic-model.html
[40] "Gensim: models.coherencemodel—Topic coherence pipeline." Accessed: Nov. 8, 2017. [Online]. Available: https://radimrehurek.com/gensim/models/coherencemodel.html
[41] "Welcome to pyLDAvis's Documentation!—pyLDAvis 2.1.1 documentation," 2015. [Online]. Available: http://pyldavis.readthedocs.io/en/latest/
[42] E. P. S. Baumer, D. Mimno, S. Guha, E. Quan, and G. K. Gay, "Comparing grounded theory and topic modeling: Extreme divergence or unlikely convergence?" *J. Assoc. Inf. Sci. Technol.*, vol. 68, no. 6, pp. 1397–1410, Jun. 2017.

Gaurav Nanda received the bachelor's degree in agricultural and food engineering (major) and electrical engineering (minor) and master's degree in water resources development and management from the Indian Institute of Technology Kharagpur, Kharagpur, India, in 2005 and 2005, respectively, and the Ph.D. degree in industrial engineering from Purdue University, West Lafayette, IN, USA, in 2017.

He is currently an Assistant Professor of Practice with the School of Engineering Technology, Purdue University. Previously, he was a Postdoctoral Researcher with Purdue University for two years and in the software industry for five years. His research interests include text mining, collaborative information systems, and intelligent decision support systems combining artificial intelligence and human expertise.

Kerrie A. Douglas received the B.A. degree in psychology, the M.S. degree in education, and the Ph.D. degree in educational psychology from Purdue University, West Lafayette, IN, USA, in 2000, 2009, and 2012, respectively.

She is currently an Assistant Professor with the School of Engineering Education, Purdue University. She studies how to improve assessment and evaluation methods in engineering courses.

David R. Waller received the Bachelor of Engineering degree in aerospace engineering and the Master of Applied Science degree in mechanical engineering from Purdue University, West Lafayette, IN, USA, in 2014 and 2016, respectively, where he is currently working toward the Ph.D. degree with the School of Engineering Education. His research interests include assessment of collaborative problem solving in engineering.

Hillary E. Merzdorf received the master's degree in industrial engineering from Purdue University, West Lafayette, IN, USA, in 2020. She is currently working toward the Ph.D. degree in engineering education with Purdue University, West Lafayette, IN, USA.

Her research interests include user-centered evaluation of digital learning technologies, online assessment in engineering education, and the effective use of student data.

Dan Goldwasser received the Ph.D. degree in computer science from the Department of Computer Science, University of Illinois at Urbana–Champaign, Champaign, IL, USA, in 2012.

He is currently an Assistant Professor with the Department of Computer Science, Purdue University, West Lafayette, IN, USA. Prior to joining Purdue University, he was a Postdoctoral Researcher with the University of Maryland, College Park, MD, USA. His research interests include connecting natural language with real-world scenarios, and using them to guide natural language understanding.