Discussion Analytics: Identifying Conversations and Social Learners in FutureLearn MOOCs

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ABSTRACT. Discussion among learners in MOOCs has been hailed as beneficial for social constructive learning. To understand the pedagogical value of MOOC discussion forums, several researchers have utilized content analysis techniques to associate individual postings with differing levels of cognitive activity. However, this analysis typically ignores the turn taking among discussion postings, such as learners responding to others' replies to their posts, learners receiving no reply for their posts, or learners just posting without conversing with others. This information is particularly important in understanding patterns of conversations that occur in MOOCs, and learners' commenting behaviors. Therefore, in this paper, we categorize comments in a FutureLearn MOOC based on their nature (*post vs. reply to others' post*), classify learners based on their contributions for each type of posting, and identify conversations based on the types of comments composing them. This categorization quantifies the dynamics of conversations in the discussion activities, allowing monitoring of on-going discussion activities in FutureLearn and further analysis on identified conversations, social learners, and types of comments with an unusual number in a course step.

Keywords: MOOCs; Computer-mediated Collaborative Learning; Learning Analytics; FutureLearn

1 Introduction

Discussion forums in Massive Open Online Courses (MOOCs) have attracted research interest since the beginning of MOOCs, particularly in the LAK community [1, 2]. This could be due to two reasons. Firstly, enormous text data are easily available for analysis, either by manual coding, text mining or natural language processing (e.g., [1–4]). The general findings from these content analyses are that postings in MOOC discussion forums indicate different levels of cognitive thinking. For example, Kellogg and colleagues [4] found that, in the two MOOCs for school teachers on digital learning and mathematics learning they analyzed, 2 to 3% of the discussion postings achieve the

highest phase of knowledge construction. Secondly, discussion among learners and educators in MOOCs is an important element of social constructive learning because it allows learners with varied experience and expertise from around the world to interact with each other [5]. Yet, this apparent advantage of discussion in MOOCs has been undermined by concerns about educators and learners being overwhelmed by the sheer number of postings, lack of focus on what is being discussed, lack of "appropriate" comments or responses (likes or replies) from educators and peers [1, 6, 7], and lack of in-depth discussion or recurrent interaction [8–10]. These drawbacks warrant further research to improve the discussion experiences of MOOC learners. To provide a basis for future learning analytics and qualitative research on discussion activities in Future-Learn, a relatively new MOOC platform that has not received as much research coverage as EdX or Coursera in LAK community, we propose an approach to categorize learners' discussion postings and their posting behaviours based on the discussion structure afforded by the FutureLearn platform. As will be discussed next, discussion activities in FutureLearn is different from the discussion forums used in other MOOC platforms, so a categorization approach tailored to its unique discussion function is needed for analytics and other research purposes [11]. After introducing FutureLearn, previous research on MOOC discussion will be reviewed before the proposed categorization is presented. We then explore how this categorization could be used in both quantitative and qualitative analysis to study the conversational interaction and discourse in a FutureLearn MOOC, and how educators and course designers could use the analytics for discussion monitoring and course revision.

2 FutureLearn

In FutureLearn, a discussion area is present in each course step, except in steps for quizzes and exercises. Learners are encouraged to share their experience, contribute their reflection, discuss issues raised in the course step, and interact with others in the discussion area right below or beside the course content [5, 9]. The focus of the discussion is dictated by the discussion prompt or the course content in that step, thus creating a shared attention for social learning among learners. This discussion function is different from the centralized discussion forum used in other MOOC platforms such as EdX and Coursera [1, 12], which is independent of the course step. The "discussion in context" approach taken by FutureLearn may be able to overcome the problem of lack of focus in MOOC discussion, one of the problems mentioned in the introduction.

This "discussion in context" approach also allows educators to design each step of the learning journey to support learners' conversations with themselves and others by building on their previous experience and existing knowledge while going through the course, in accordance with Laurillard's Conversational Framework [13, 14].The conversational framework operationalizes learning as an iterative process between reflecting within oneself and conversing with educators and others, while also interacting with the outside world. The process starts with learners' initial description of concepts. Through interaction with content, activities, or peers, learners adapt their initial understanding and expand their knowledge. Based on this framework, learning happens

through the whole process, not only relying on discussion with others and feedback, but also involving reflective conversation within learners themselves during the process. Similarly, clarification of concepts and sharing experience are as important as evaluating and debating with each other.

According to Laurillard [14], for the learning process of conversation with oneself and others to be successful, good learning design is needed. Different questions, prompts, course media may be designed to lead learners through a journey of initial reflection with concepts, interaction with content, others or practice environments, and finally synthesis or critical thinking of what has been learned. Under this framework, a discussion function that is attached to each stage of learning is needed, instead of a centralized discussion forum that relies on learners' initiative to raise topics or questions. Therefore, the FutureLearn "discussion in context" approach may be warranted to achieve the cycle of Laurillard's conversational framework, and can be a suitable testbed to examine how course step design may invoke different kinds of discussion postings during a learning journey, which is one of the research question considered in this paper.

3 Previous Research

3.1 Content Analysis

Several frameworks have been used in previous content analysis research (e.g., [3, 4, 15]) to categorize discussion postings in MOOCs and other small scale online discussions (see [16] for a review) into lower and higher order thinking within a fixed number of levels. This method is based on the assumption that discussion postings are indicative of learning processes [17], learners' interaction [17, 18], critical thinking [18] or learning goals [19]. For example, Henri's framework [17] comprised of five levels: participation, interaction, social, cognitive and metacognitive processes. In their analysis of MOOC discussions, Kellogg and colleagues [4] found that around 40% of the discussion comments in their MOOCs were sharing opinions and around 3% are metacognitive. Categorization of discussion postings based on these frameworks typically privileges the highest levels and is used to evaluate the quality of discussion. However, this emphasis is in contrast to Laurillard's framework, which values all the different kinds of conversations that comprise the cycle of the learning process.

3.2 Social Network Analysis

Social Network Analysis has been widely used to examine the social structures and the interactions among individuals in computer-mediated collaborative learning [20, 21] and MOOC discussions [8, 9, 22]. In the social network analysis, a tie or an edge is formed between two learners if one of them comments on the other's post, and the number of times they interact is taken as the weight of the tie. The density and dispersion of the ties among learners in turn indicate the social structure of the discussion forums or activities. Thus, social network analysis is useful for examining individuals'

interactions with others as well as the overall social structure of a network. For the overall social structure, the density of small-scale online discussions [21] was found to be high with only one or two learners at the periphery, whereas the MOOC discussion tended to be dispersive and fragmented [8]. At the individual level, Sunar and colleagues [9] found only 1.75% of learners had recurrent interactions with each other across the MOOC course period, and 20% of learners were identified to be at the core of the MOOC discussions analyzed by Kellogg and colleagues [4]. These studies seemed to show that the social structure and interaction among learners is not close-knit in MOOCs, perhaps due to the massive numbers of learners who are free to join or leave the discussion [8].

3.3 Summary

Undeniably, the content analysis and social network analysis are beneficial for educators to understand the discussion and social dynamics that has happened in their MOOCs overall. However, as indicated by [2, 14, 23], an analysis at the course level may not be helpful in the search for a theoretical or design explanation about the distribution of the comments of differing cognitive levels or the social dynamics in the discussion. One way of tackling this issue is to associate the content and social network analysis with the course step design. More importantly, categorizing discussion postings by using the content analysis frameworks mentioned above may mask the dynamics in a conversation because this method normally codes individual postings without recognizing turn-taking, replying, initiating conversation, or posting without receiving reply. Similarly, although social network analysis could reveal social interactions among learners across the course period, it did not reveal their interaction within a conversation or a discussion thread.

   As discussed earlier, conversations with oneself and others is fundamental to social learning in FutureLearn. Yet, content analysis and social network analysis may not necessarily reveal interaction among learners within conversations, such as turn-taking, replying to others' posts, replying to others' reply to one's own posts, or lone posting as conversations with oneself. Therefore, in the present study, we aimed to examine this aspect of interaction in the FutureLearn by classifying comments and learners in terms of conversational dynamics based on its unique discussion function that is not a forum. This classification may provide visualization that help educators or mentors to facilitate discussions during the course periods, and may set up the next step for in-depth content analysis, discourse analysis, conversational analysis or linguistic analysis [11, 24] that will inform the nature of social constructive learning in MOOC discussions.

4 Categorizing Learners' Comments in FutureLearn

As mentioned earlier, in FutureLearn learners are encouraged to comment under or beside the content of each course step, except in steps for quizzes and exercises. The commenting area takes a simple structure, differentiating between posts and replies

only. There is no hierarchical or threaded structure amongst replies under a post, and the replies are ordered by the time of posting. Learners receive notification by email when somebody replies under their posts, or when somebody replies after their reply under the same post.

Given that not every post receive replies, posts that receive no replies are categorized as lone posts, whereas those receives replies are initiating posts. An initiating post is the start of a conversation, if we assume a conversation consists of at least two turns, i.e., the post and one reply. Learners creating the initiating posts could be considered as initiators, to differentiate them from replying learners who reply to them.

Underneath an initiating post, a long list of replies probably does not reveal any conversational interaction at first glance, given that the commenting structure in FutureLearn is not threaded. However, a close examination of the replies underneath an initiating post could at least reveal the interaction among replying learners and the initiator within that conversation. A learner replying more than once underneath an initiating post indicates that they come back to the conversation again after making the first reply, possibly in order to respond to others' reply in relation to their first reply. Similarly, an initiator replying underneath his/her own initiating post suggest that he/she might be responding to other learners' reply to their initiating post. These two situations suggest that there are turn-takings between two learners or initiator within a conversation initiated by an initiating post [25]. Nonetheless, there are also cases where learners only reply once underneath an initiating post, or initiators never reply underneath his/her own initiating post. In short, the replies underneath an initiating post could be differentiated based on the order and number of times an individual learner reply under that initiating post, rather than the order in the long list of replies per se.

Based on the observation just mentioned, each comment on FutureLearn could thus be categorized into one of the five categories (See Figure 1 for a mock illustration):

1. **Initiating posts**: Posts that receive replies
2. **Lone posts**: Posts that receive no replies, also include the replies posted by the same learners in response to his/her own post, where no other learners reply to that post
3. **Replies**: Replies to others' initiating post, i.e., the first time or the only time a learner replies to an initiating post created by others
4. **Further replies**: Further replies under an initiating post that one has already replied to, i.e., the learner replies more than one time under an initiating post
5. **Initiator's replies**: Replies to others' replies to one's own initiating post, i.e., initiator replies under his/her own initiating post.
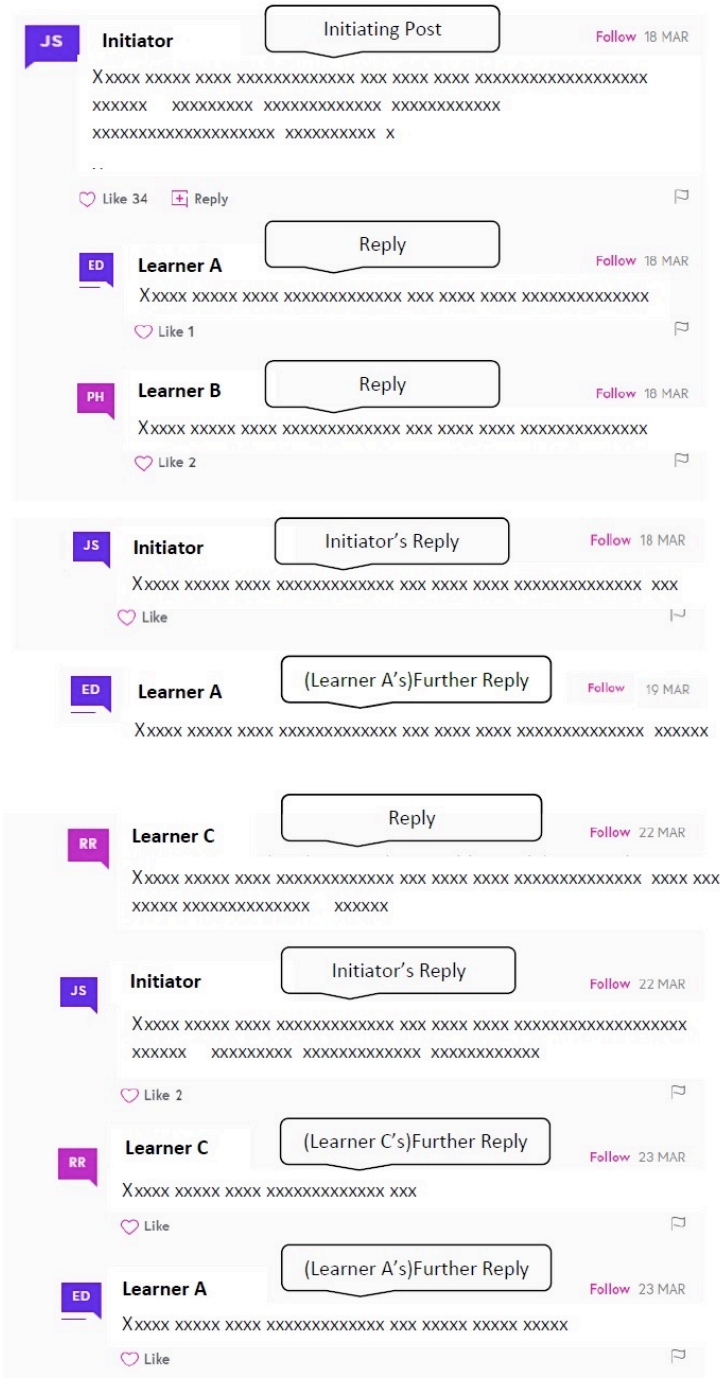
Fig. 1. Mock Illustration of Different Types of Comments within a Conversation

These five categories capture turn-takings in conversations, that is somewhat shaped by the FutureLearn platform [24, 25], despite it being not as neat as it could have been if content had been taken into account [17]. Nonetheless, we argue that these five categories could be used as a proxy for discussion dynamics among learners. Essentially, the differentiation between lone posts and initiating posts allows us to capture posts that initiate conversations, in contrast to lone posts that imply no explicit interaction among learners. Of note, lone posts could be read and 'liked' by many learners, suggesting an implicit interaction among learners. A reply is an explicit interaction between at least two learners. A further reply or initiator's reply shows that learners do get back to each other on the issue raised in their posts or replies, in other words a turn-taking.

5   *Research Questions*

To illustrate how this categorization approach could help educators and researchers in understanding the conversational dynamics in the discussion activities in Future-Learn, we are going to apply this categorization to one FutureLearn MOOC and conduct both quantitative analysis and qualitative analysis to explore the following questions:

1. What are the characteristics of conversations occurring in the FutureLearn discussions?
2. Are there different groups of social learners with distinctive commenting behaviours?
3. Is there a relationship between course step design and distribution of comment types?

By addressing these questions, a learning analytic approach is realized by quantifying the discussion dynamics in terms of the distribution of different types of comments, conversations and social learners. Educators could then make use of this information for their revision of course step design in the future run of their course, or for their intervention of on-going discussion activities. Prototype dashboards showing the analytics are presented after we address each research question.

6   Methods

6.1   Data Set

The comments data to be analyzed are from the first run of the FutureLearn Course "Inequalities in Personal Finance: the Baby Boom Legacy" offered by The Open University. The course explores the controversial issue of inequality with particular attention to pensions, housing, social benefits in developed countries, and presents alternative solutions to inequality that could be adopted by individuals and governments. The course content is mainly about the UK, but with some mentions of other developed countries, such as the US, Germany and Singapore. A recurrent contentious theme in the comments is whether governments should use taxpayers' money to help those at the poor end of the inequality continuum. The course lasted for four weeks, yet the data

captured is available from the start of the course until two weeks after the course period ends. There were 1951 learners, 636 (33%) of whom were social learners that contributed 10033 comments. Four educators also contributed 363 comments. Wherever space allows, the analysis of educators' comments are presented along with learners' comments, but interpretation and discussion will be on learners.

Based on the definition offered by FutureLearn, learners are those who visit at least one step of the course, whereas social learners comment at least once in the course. It should be noted that we are analyzing the comments data, so only social learners, rather than all learners, were included in the present study. Social learners did not necessarily comment in each course week, as shown in Table 1, and the number of social learners decreased across the weeks. The number of comments also dropped from Week 1 to Week 3, and plateaued between Week 3 and week 4. The reference to the week here is based on the four weeks of the course. For example, if a comment was posted in a week 2 step after the course ended, it was considered a week 2 post.

Table 1. Number of Social Learners and Comments in Each Course Week

	Social Learners	Learners' Comments	Educators' Comments
Week 1	516	2723	91
Week 2	366	2872	100
Week 3	290	2213	65
Week 4	266	2225	107

6.2 Data Analysis

All comments posted in the courses were categorized into the five proposed types and are shown in Table 2. There were more lone posts than initiating posts, yet replies were the most frequent comment types in this course. Additionally, some learners did engage in turn-takings, i.e., responding to others' replies to their own initiating posts or replying again under an initiating post, although the number of initiator's replies and further replies were lower than the other categories. This could be because they could only happen when an initiator receives a reply for their posts so that they could respond, or when there are other learners replying after a learner has replied to an initiating post.

As argued earlier, an overview of the distribution of the comments at the course level may not be informative for unpacking the conversational interaction among learners in the discussion activities in FutureLearn. We thus investigate the distribution of each type of comments at three levels: conversations, learners and course step design, corresponding to the three research questions raised.

Table 2. Distribution of Each Type of Comments

Types	Number of Learners' Comments	%	Number of Educators' Comments	%
Initiating Posts	1845	18%	23	6.3%
Lone Posts	2612	26%	39	11%
Replies	3871	39%	242	67%
Initiator's Replies	708	7%	10	2.7%
Further Replies	997	10%	49	13.4%
Total	10033	100%	363	100%

7 Conversations

Research Question 1: What are the characteristics of conversations occurring in the FutureLearn discussions?

7.1 Analysis and Results

A conversation is started by an initiating post and composed of all the replies, initiator's replies and further replies underneath it. Thus the number of conversations is equal to the initiating posts, which is 1845[1] in this course. These initiating posts were contributed by 404 social learners, whilst all the conversations involved 506 social learners (including both initiators and replying learners). Thirteen percent of the initiating posts in a conversation elicited more than five turns, i.e., replies, initiator's replies or further replies together[2], which was more than the 2.5% shown in [10] findings on their FutureLearn courses. There were 72 conversations with at least ten turns, the longest of which consisted of 51 turns. Table 3 shows the number and percentage of conversations identified based on the number of turns, number of initiator's replies, replies and further replies contributed by replying learners, and number of unique learners/educators involved.

The longest conversation in this course happened in a step that was not specifically designated as a discussion step. The initiating post was the initiator's[3] interpretation of a cartoon on that step that portrayed "*the 'rich' family had one child and the 'poor' had*

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[1] There were an additional 23 conversations initiated by educators as shown in Table 2, but are not included in the current analysis.

[2] The number of turns also included replies and further replies made by educators to ensure the completeness of a conversation.

[3] The comment data retrieved did not contain learners' name and the registration for this run of the course had ended before we started the analysis, so there is no way for us to obtain consent from learners to cite their comments, or to acknowledge them under the terms of Creative Commons License. Therefore, we anonymized them instead to protect their privacy.

two ... some people have children they cannot afford but expect someone to pick up the tab by having more benefits ...". This initiating post garnered 38 replies from 12 learners and 1 educator, and the initiator responded to them 13 times, such that there were a total of 51 turns. This, along with another 14 conversations with more than 20 turns, might make a case study for conversational analysis about learners addressing a controversial issue among themselves and how learners address a specific learner among all the learners involved in the conversation. At the same time, this finding also suggests that not only discussion prompts designed by educators, but also contents of initiating posts contributed by learners could generate discussion. A comparison between lone posts, initiating posts with only one reply and initiating posts eliciting more than 20 turns might help us to understand more about learners' roles in initiating conversation in MOOCs. The first reply in each conversation may also need to be taken into account, to understand if the reply stifles further conversation or if it is simply a supportive statement to a reflective post that hardly invites replies, given that there were 705 conversations (38%) with only one reply.

Table 3. Overview of Conversations

Nature of the conversations	Frequency	%
Conversations with only 1 reply	705	38%
Conversations with more than 5 turns	247	13%
Conversations with at least 10 turns	72	4%
Conversations with at least 20 turns	15	1%
Conversations with initiator's replies, i.e., repeated occurrence of the initiator	466	25%
Conversations with further replies, i.e., repeated occurrence of replying learners	413	22%
Conversations with both initiator's replies and further replies from others	207	11%
Conversations involving at least 5 unique learners/educators	170	9%
Conversations involving at least 10 unique learners/educators	12	1%

Secondly, in 466 conversations, learners who contributed the initiating post responded to replies from others at least once, and there were eleven conversations in which the initiators replied more than five times. A conversation with large number of initiator's replies may imply a conscientious initiator who responds to each reply he/she receives. Furthermore, in 413 conversations, learners who replied to the initiating post further replied at least once after other learners reply after their first reply. In short, in almost a quarter of the conversations generated in this course, learners engaged in turn-takings by getting back to each other on issues raised in their comments. It also pointed to the fact that, despite its simple commenting structure, there are turn-takings and discourse structure in the discussion in FutureLearn, and this information has not been captured

in previous content analysis research in MOOC discussion where postings were analyzed individually, or social network analysis where analysis is based on individuals rather than on a conversation. Detailed analysis of the initiator's replies and further replies in these conversations will shade light on how learners react to each other, especially when there is a disagreement.

Lastly, there were 12 long conversations involving more than ten unique learners/educators, containing replies, and initiators' replies or further replies from some of the replying learners/educators. In one such conversation, six out of the ten learners involved addressed the initiator's name at the start of their replies. At the same time there were replies addressing four other learners by name in the same conversation. Such conversations seem to be containing multiple sub conversations directed to the initiator, and overlapping turn-taking between different pairs of learners, similar to other computer-mediated communication such as Facebook [26] and Internet Relay Chat (IRC) [25].

7.2 Interim Discussion

The analysis above showed that the conversations in FutureLearn could be characterized by the number of turns, presence of initiator's replies or further replies and number of unique learners involved, despite the complexity revealed. A thorough conversational analysis on the different types of conversations identified above will surely unravel this complexity further and answer some of the questions arising from the findings, including how initiating posts, instead of lone posts, elicit conversations, how learners react to each other when they engage in turn-takings, and how multiple learners engaged in a single conversation.

On the other hand, this analysis could be a learning analytic tool for educators and mentors as they look into conversations with an unusual number of turns, initiator's replies, further replies, unique learners while monitoring the discussion activities when the course was still running. Conversations attracting huge number of learners or comprising repeated exchanges between few learners may contain some heated discussion in need of intervention by educators or mentors. For example, in a conversation with ten replies and seven learners, the last reply started with "*Thanks for the insult XX. A problem with the public schools is that ...*" Although the 'like' function may have helped educators filter for popular posts, it was found that in this course, there were 43 initiating posts receiving more than ten turns, but fewer than five 'likes'. Therefore, besides 'like', the replies and conversational dynamic measures of each initiating post will also help to focus attention of educators or mentors among the overwhelming comments contributed by learners.

8 Social Learners

Research Question 2: Are there different groups of social learners with distinctive commenting behaviours?

8.1 Analysis and Results

Preliminary k-mean clustering and hierarchical clustering were conducted with the aim of identifying no more than 10 groups of social learners. The clustering was based on the number of each type of comments contributed by a learner and the number of replies and likes received. Both clustering resulted in one group consisting of 85% of the social learners and other groups each with fewer than five learners. These results were not interpretable and led us to a simpler way of categorization - permutation and combination, and base our categorization on whether a learner contributed a certain type of comments rather than the number of each type of comments contributed.

32 (2^5) permutation and combination of social learner groups are possible based on whether a social learner contributes each of the five categories of comments. However, the learners enrolled for this MOOC did not show such a diverse pattern, and only 17 combinations were found (Table 4).

Table 4. Permutation and Combination of Social Learner Groups

Initiating post	Lone post	Reply	Further reply	Initiator's reply	Received Replies?	Number of Learners	7 Groups of Social Learners
0[4]	1	0	0	0	0	131	Loner
0	1	1	0	0	0	14	
0	0	1	0	0	0	19	
0	0	1	0	0	1	40	Replier
1	0	0	0	0	1	41	Initiator without replying
1	1	0	0	0	1	73	
1	0	0	0	1	1	11	Initiator who respond
1	1	0	0	1	1	26	
1	1	1	1	1	1	91	Active Social Learner
1	0	1	1	1	1	1	
1	1	1	1	0	1	27	
1	1	1	0	1	1	51	
1	0	1	1	0	1	7	
1	0	1	0	1	1	1	
1	1	1	0	0	1	75	Active social learners without turn-taking
1	0	1	0	0	1	23	
0	1	1	1	0	1	5	Reluctant active social learners

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[4] 0 indicates no contribution of the particular type of comment, 1 indicates at least one contribution of the particular type of comment.

We further reduced the number of groups into seven by imposing three more criteria. Firstly, learners who received no reply at all for their posts and/or after they replied underneath others' initiating posts were categorized into one group (Loners). Second, learners who contributed either further replies or intiator's replies were deemed as engaging in the same type of commenting behaviour, given that both types of comments indicate turn-takings (see Active Social Learners and Active Social Learners without Turn-takings below). Third, as long as learners contributed initiating post, whether or not they contributed lone post is not taken into account (see Initiators, Initiators who respond, Active Social Learners, Active Social Learners without Turn-taking below). The comments contributed by these seven identified social learner groups could be subjected to further analysis and/or intervention during the period of the course.

Group 1: Loners. 164 (26%) out of the 636 social learners never received a reply from others either for their own posts or their replies under others' initiating posts, although 110 of them received at least one like for their posts or replies. Among them, 131 contributed only lone posts, 19 contributed only replies, and 14 contributed both lone posts and replies. All except three of them commented fewer than 10 times, which might decrease the probability of their postings being seen and replied to. Some of them might have dropped out of the course, yet 71 of them completed at least half of the total steps in the course. 82 of them only commented in week 1, whereas the remaining 83 commented in other weeks. The inconsistency and infrequency of their commenting at the start of the course made it hard to tell whether or not receiving no reply dissuaded them from contributing any further to the discussion.

We examined all the comments by one loner. This learner created posts and replies 14 times across the four-week course period but never received a reply and received only one like. Four of his/her lone posts and one reply stated only *"I agreed"*, which did not provide substance to invite replies. In his/her longest lone post, *"i am single and not thinking to buy a house as far as i am single but for my family kinds and wife i prefer to buy a own[sic] house ……we can profit in the end mortgage a house in term of mone*y," there seems to be no sign of inviting others to comment. But he/she actually answered the discussion prompt *"Do you rent or buy"* that encourages self-reflection. He/she raised a question in one of his/her lone posts, but without a question mark, "*i paid, tax, unemployment insurance and pension from my salaries, how it would effect [sic] me if i will no longer live before i would able to use them*." It seems that this learner needs to improve his/her commenting skills and English writing, especially in elaborating his/her ideas and making his/her questions explicit so that other learners would have something concrete to comment on. Nonetheless, this learner completed the course despite not receiving replies from others.

There was one loner who only contributed one post which received 12 likes despite not receiving any reply. It was a reflection on his/her pension choice in response to a discussion prompt in week 2, *"I am retired so have some experience of the different schemes and what they might buy in retirement. I was very lucky to have a final salary scheme …. The problem with personal pensions is that you are at the mercy of the insurance companies… Saving throughout your working life for retirement does not necessarily mean you will receive the sort of income you envisaged."* This comment

resembles life advice from a senior that you will listen to rather than replying back. Another loner also commented once only by sharing information during week 3 about housing issues in his/her country by saying "*Here in Hungary, 80 % of the population have own property (flat or house). I live with my parents, we have a house,*" without receiving any likes or replies. These two lone posts provided information and personal story only without reference to others' viewpoints or invitation for others' input. They could be considered monologic, and this might be the reason for not receiving any reply [27]. This preliminary analysis of the three loners' comments showed that lone posts could be of varied nature.

Group 2: Repliers. 60 people only replied to others without creating their own initiating posts. 20 of them have all their replies as the last reply under an initiating post, i.e., nobody replies after them, and were already categorized as loners above. The remaining 40 people sometimes attracted replies after their replies under an initiating post, although we could not determine if the replies were targeted to their replies without considering the content of the replies. Only three of them contributed more than 10 replies throughout the course, and nine of them engaged in further replies after other learners replied after them.

Group 3: Initiators without Replying. 114 learners contributed only posts (both initiating posts and lone posts) but never replied to others' initiating posts despite receiving replies from others. Among them, 41 always had people replying to their posts, whereas 73 of them sometimes had lone posts that received no reply. Both groups never responded to others' replies under their initiating posts. Nonetheless, 91% of them did not contribute more than 10 posts. Yet, there were two initiators each created 90 posts, with only 31 and 8 posts receiving replies respectively.

Interestingly, there were three initiators received more than 10 replies to one of their initiating posts yet they never responded. One of them had been asked by other learners in their replies to him/her throughout the course for copying others' comments. The other one made only two initiating posts, both about state benefits. In both conversations initiated, there were replies for and against the initiator's negative attitudes towards those who claim benefits. The shorter initiating post was "*where i live work is a four letter word and they would love to receive[sic] a share without contributing, even when they can.*" which elicited ten replies from six learners. The first reply asked "*So you or your parenst[sic] has never received child benefit, used the NHS or attended state school?*" and one spoke for the initiator by saying "*...we don't know what is happening there, and therefore can't really criticise her comments*". The third initiator made only one post," *All animals are equal, but some animals are more equal than others. George Orwell, Animal Farm*", with the first reply asking "*Ah, XXX, but what chances of change? Are all politicians hypocrites wh[sic] won't effect change?*"

From these excerpts, it seems that initiators provoked some discussion about politics, and they might be unwilling to respond to others' 'hostile' replies with views which

50

were different from them. This awaits a full analysis of the initiating posts and the replies to them. Yet, it indicates a need to monitor long conversations, especially when the initiator is not responding at all.

Group 4: Initiators who Responded. 37 learners responded to others' replies to their initiating posts, yet they never replied to others' initiating posts. They were similar to the initiator group except they responded under their initiating posts. In one instance, the learner responded to a reply full of strong language. Their initiating post was *"The course comments have become a happy hunting ground for left wing/right wing prejudices. I welcome the presentation in the course of arguments derived from a broad base of statistical data,"* which attracted one hostile reply *"Can you explain to me what is wrong with people putting their various analysis of the circumstances they see in the world… I presume, despite your lip service to balance- that views…".* The learner of the initiating post in turn responded with *"I believe in open discussion and strive not to be judgmental. However I confess to a prejudice towards discussion that is illuminated by hard evidence."* Presumably, not every learner had the courage to respond to such a hostile reply, and might choose to keep quiet, as the example in the initiator group suggests.

Group 5: Active Social Learners. 91 out of the 636 social learners contributed all five types of comments. Sometimes their posts initiated a conversation, sometimes they were lone posts. They replied to others under an initiating post, responded to those who replied under their initiating posts, and further replied after their replies in others' initiating posts. Another 87 social learners were also similar to this group, except that one of them always received replies from others and never had a lone post, 27 of them never responded to others under their initiating posts but further replied to others under others' initiating posts, 51 of them never further replied under others' initiating posts but responded to others under their own initiating posts, and eight of them always received replies from others and either never responded or further replies. Although they did not contribute all five types of comments, these learners initiated posts that received replies, replied to others' posts and engaged in turn-taking as indicated by initiator' replies or further replies. Therefore, they were considered as active as the 91 learners who contributed all five types of comments. Putting these learners together, there were 178 active social learners in this course, comprising 28% of all social learners. 158 of them completed at least half of the course, and 85% of them commented more than ten times.

Group 6: Active Social Learners without Turn-taking. 75 learners contributed initiating posts and lone posts, and also replied to others' initiating posts, but never responded under their own initiating posts or further replied. Although they received replies for their initiating posts, they never responded to those replies. Similarly, they never replied further after other learners replies after them under the same initiating post. Although they never got back to others on the issues they commented before, they were still considered active given that they created posts as well as replied to others' initiating post. Additionally, there were 23 learners behaved similarly except that they

were not so fortunate to receive any reply for their posts such that they did not have any initiating posts. In sum, there were 98 learners in this group.

Group 7: Reluctant Active Social Learners. Lastly, five learners could be considered reluctant social learners as they created posts, replied to others' initiating posts, and engaged in turn-taking by replying further when other learners replied after they replied under an initiating post. They could be similar to the active social learners, just that they were not so fortunate to receive any replies to their lone posts. All of them contributed more replies than lone posts.

8.2   Interim Discussion

Table 5 summarizes the classification of the social learners discussed above and their distinctive features.

Table 5. Seven Groups of Social Learners

Groups	Distinctive Features	Number of Learners	Learners with more than ten comments
Loners	Never received replies	164	3
Repliers	Only replied to others	40	3
Initiators without replying	Never replied to others' posts or underneath own initiating posts	114	8
Initiators who responds	Never replied to others' posts but responded to others' replies underneath own initiating post	37	9
Active social learners	Initiated posts, replied to others, and engaging in turn-taking by replying under own initiating post or further replying	178	148
Active social learners without turn-taking	Initiated posts, replied to others but never replied under own initiating post or further replied	98	30
Reluctant active social learners	Created lone posts, replied to others, further replied	5	3

This classification shows that the learners' commenting behaviour in FutureLearn is not homogenous and could be distinguished by the types of comments they contributed and replies received. Also shown are the number of learners commenting more than ten times in each group. 204 social learners contributed comments more than ten times across the course periods, and more than half of them were active social learners. The

content of the comments and learning experience of the different groups of social learners warrant further research to understand the discussion activities in MOOCs. Analyzing comments contributed by individual learners from each group by using well-established content analysis frameworks, discourse analysis or conversational analysis will further shed light on social learners and inform course educators about their audiences, although social learners comprised only about one third of all the learners. Conducting in-depth interviews with learners from different groups about why and how they comment in the discussion might triangulate findings from the analysis of their comments, especially the initiators who only create posts, repliers who reply only and loners who contribute very few posts.

This classification also allows educators or mentors to target specific groups of learners for discussion monitoring. We suggest automatizing classification of learners in the middle term of the course, and looking into some of their latest comments for interventions. For loners, educators could reply to them by asking them to elaborate more on their arguments, or direct other learners to read their posts that are worthy of commenting. For initiators, educators may want to encourage them to either reply to others' posts or responded to others' replies to their initiating posts. However, as mentioned earlier, some initiators did not respond probably because of the hostility expressed by others' replies to their controversial initiating posts, so educators might want to look into the replies they received at the same time.

9   Course Step Design

Research Question 3: Is there a relationship between course step design and distribution of comment types?

9.1   Analysis and Results

Within the 91 steps that allow commenting in this course, 76 steps were dominated by replies, 15 steps by lone posts, whereas lone posts were the least in seven steps, initiator's replies in 48 steps and further replies in 36 steps. Closer inspection shows a difference among steps. For example, lone posts (53%) dominated step 1.2, which was the introduction to the course, and most posts were self-introduction. In contrast, in step 1.3, there were overwhelmingly more replies (43%), compared to initiating posts (17%) or lone posts (15%), suggesting learners were explicitly interacting with each other. In fact, step 1.3 was a series of explanations of terminology without any explicit discussion prompts, except the title "Inequalities of what?" Perhaps this is a big question and learners are at the initial stage of concept formulation, so they tended to discuss with each other without the need of being prompted. In contrast, in the dedicated discussion step 1.18, lone posts (60%) dominated. This might be due to the fact that the discussion prompt *"Think about the factors influencing your own income and consumption profile so far and what you expect in the future"* asked for self-reflection and sharing rather than discussion , and it is highly likely that learners were not critical or judgmental of others' personal choices and circumstances.

To systematically examine the relationship between course step designs and distribution of comment types, we conducted a preliminary analysis on the design of each course step based on the content in each step. The first author went through every step of the course as a learner, by watching all the videos and reading all the contents. However, no comment was read, in order to avoid any bias that might arise when we examined the relationship between course step design and comments posted by learners. After four iterations of categorizing the course step, five major categories were drawn, although there are 27 steps in the course that remain unclassified due to their multiple components. Therefore, in this exploratory study, we are only investigating 64 course steps that could be classified into the five categories we have come up with for this particular course:

1. Concept (18 Steps): explanation of concepts by using definitions
2. Countries comparison (11 Steps): concepts are explained and relevant issues are compared across countries, accompanied by graphs or charts.
3. Discussion (14 Steps): all dedicated discussion steps are included in this category because in this course, explicit questions are only raised in these steps. However, there are nuanced differences among the questions.
4. Expert opinion (12 Steps): expert opinions were featured either by their speech shown in a video or by summary of their published works.
5. UK issues (9 Steps): explanation of concepts with a focus on the UK, although it should be noted that UK affairs were constantly mentioned throughout the course.

Table 6. Comment types and course step design

Course Step Design	Initiating Posts	Lone Posts	Replies	Initiator's Replies	Further Replies
Concept	261	193	630	109	137
Countries comparison	151	152	408	52	98
Discussion	596	1341	1023	194	208
Expert Opinion	268	246	655	112	206
UK issues	115	96	276	53	82

A chi-square statistical test showed that the distribution of comments types is significantly associated with course step design, $\chi^2(16) = 623.68$, $p<.001$ (Table 6). Particularly, replies seem to be the most frequent types of comments in all course step designs except in the discussion steps, where lone posts dominated. This is rather counter-intuitive given that discussion steps are intended for learners to discuss with each other. However, in this course, quite a few discussion prompts ask for reflection about one's own financial status, the pension scheme of one's own country or personal choice on housing, so learners might not reply to each other but created a post in response to the discussion prompt instead. Nonetheless, discussion steps attracted most number of comments in each category compared to other course step design. Further analysis is needed for all the discussion steps and the comments posted. Another surprising result

is that the course steps dedicated for explaining concepts attracted fewer lone posts than assumed by the null hypothesis distribution in the chi-square goodness of fit test. One possible explanation is that most concepts introduced in the course are universal to all countries and people, so learners had a shared topic such that they could relate and reply to others' post more easily. Similarly, steps featuring country comparisons and UK, also garnered more replies, and fewer lone posts. Lastly, expert opinions not only elicited more replies but also more further replies than expected by the null hypothesis distribution. Learners seemed to be engaging in more turn-takings when discussing about opinions by eminent experts.

9.2   Interim Discussion

Overall, this results suggest that learners tended to interact with each other even without a prompt as long as there is a shared topic or a prominent opinion to converse about. It could also be possible that learners not only engaged in conversation with oneself when first encountering a concept, but also attempted to modulate or expand it by communicating with peers [13]. Although this result seems to suggest that the discussion steps do not produce learners' interaction as desired despite generating most number of comments, it awaits future research on the nature of discussion prompts in each step, to determine whether the prompt is designed for reflection or is not well-designed to get learners to talk to each other. An ad hoc analysis revealed that only one discussion step has a very high volume of replies (more than double of lone posts), and the step was presented with arguments against austerity measures in the UK, which inevitably provoked more discussion among learners, the majority of whom were presumably based in the UK.

Despite being inconclusive, this preliminary analysis demonstrates the potential of quantifying discussion activities in relation to course steps, such that educators could be informed of the unusual number of comment types in a particular course step, and intervene while the course is still running or make revision of the next run of their course accordingly.

10   Discussion Analytics

As argued in the interim discussions, the analytics of the five comment types at the level of conversations, social learners and course steps could be leveraged for research on FutureLearn discussion activities, course monitoring or course revision. The analytics are visualized below.

10.1   Conversations

In a weekly dashboard on conversations (Figure 2), educators and researchers could sort the conversations according to the types of comments and the total number of turns composing them, or the unique learners involved (equal to the number of replies), and be directed to the initiating post that elicits the particular conversation by clicking on

the conversation ID, such that they could read or analyze all the replies underneath the initiating post. A column indicating the number of replies made by educators could also be included to monitor educators or facilitators' activities.

Conversations	Step	Replies	Initiator's Replies	Further Replies	Turns
4365989	2.2	5	10	15	30
4374103	2.5	5	12	9	26
4352189	2.1	7	1	15	23
4357380	2.6	12	0	10	22
4357488	2.12	8	4	9	21

Sort by
Replies
Initiator's Replies
Further Replies
Turns

Fig. 2. Prototype Dashboard on Conversations in Week 2

10.2 Social Learners

As suggested earlier, different groups of social learners could be visualized when the course is half-way through so that educators could support identified individuals for the remaining of the course. In the dashboard (Figure 3), educators could filter for a particular group of social learners, and sort according to the number of comment types contributed, replies or likes received, and then be directed to the comments contributed by individual learner by clicking on their ID. It is also possible to include a column to indicate whether a learner receive a reply from the educators, if it helps educators to pay attention to learners that they never interacted with before.

Learner	Initiating Posts	Lone Posts	Replies	Initiator's Replies	Further Replies	Total	Replies Received	Likes Received	Visited Steps	Completed Steps
026c0706-	0	1	0	0	0	1	0	1	25	24
08349af0-	5	8	0	0	0	13	9	25	104	104
0149a5bb-	0	0	1	0	0	1	4	0	23	19
00ce83ce-	10	4	8	5	3	30	39	66	72	70
02c259f6-	0	1	1	0	0	2	2	6	104	104

Select Group:
Loners
Active social learners
Initiators without replying
Initiators who responded
Repliers
Active social learners without turn-
Reluctant active social learners

Sort By:
Initiating Posts
Lone Posts
Replies
Initiator's Replies
Further Replies
Total Comments
Replies Received
Likes Received

Fig. 3. Prototype Dashboard on Social Learners

10.3 Course Step

Lastly, a dashboard highlighting the most and the least frequent types of comments in each step could be created (Figure 4). Educators then could identify a step that has

unexpectedly generated too many comments of a certain type that is not in line with their teaching objective. For example, if there are disproportionate number of lone posts in a step, the educators may want to intervene while the course is still running by posting comments directing learners to some lone posts that are worth reading and commenting, or by posting more comments to guide learners how to create initiating posts.

Step	Initiating Posts	Lone Posts	Replies	Initiator's Replies	Further Replies	Total	Longest conversations	Learners involved
1.1	54	87	98	30	22	291	16	168
1.2	11	44	22	4	2	83	9	114
1.3	28	25	70	19	22	162	30	74
1.4	21	25	54	13	20	132	22	75
1.5	7	16	22	2	3	50	9	66

Fig. 4. Prototype Dashboard on Each Course Step

This visualization awaits to be developed and tested with educators to evaluate its implication in course monitoring, especially its function in sifting through the sheer number of comments posted in the discussions activities [7]. The discussion analytics visualized here could be automated from the comment data provided by FutureLearn to partner institutions who offer courses through its platform. It does not require intensive manual coding or accuracy check for machine learning because the categorization is purely based on the commenting structures of FutureLearn. Most importantly, it provides a systematic way for both educators and researchers to leverage the data currently available for the investigation of the patterns of conversations and dynamics in the discussion activities in FutureLearn.

11   General Discussion

To unveil the patterns of conversations among learners in FutureLearn, we categorized the comments in a FutureLearn course into five types: *initiating posts* that receive replies, *lone posts* that receive no replies, *replies* to others' initiating post, *initiator's replies* to others' replies to his/her initiating posts, and *further replies* when one replies again to an initiating post. This categorization could be further applied at the level of conversations and social learners. Beside the number of replies each conversation involves, conversations under each initiating post also vary by the presence of initiator's replies, replying learners' further replies, number of unique learners involved. Lastly, based on the types of comments contributed and the replies received by each social learner, seven groups of learners were identified. The preliminary quantitative and qualitative analysis based on this categorization revealed the heterogeneity of social learners as well as the complex conversations that happened in a FutureLearn course. At the same time, these categorizations provided an analytics method for educators and mentors to negotiate through the seemingly overwhelming discussion postings. Educators

could identify conversations, course steps and learners with an unusual number of certain types of comments and intervene accordingly during discussion monitoring or use this information to revise their course step design for the next run. Lastly, these categorizations also set the scenes for future research on FutureLearn discussion activities such that researchers could base their analysis on certain categories of interest to them. Below we highlight the theoretical basis of our categorization of comments and several findings from our preliminary analysis that warrant further investigation.

The proposed categorization extended previous research [4, 15] on MOOC discussion that analyzed postings individually by taking into account dynamics and discourse structures of conversations. It also allows examination of interaction patterns among learners within the context of conversations and their posting behaviours, instead of the number of people they have ties with or the position they occupy in a social network. The differentiation between new (both initiating posts and lone posts) and replies (replies, initiator's replies and further replies) reflects the computer-mediated discourse that learners engaged in [24]. Similar to other computer-mediated communication, creating a post normally is to address all learners in general, whereas replying to a specific post is to target the initiator of that post or other learners who have replied to that post. This difference between a conversation in the global context of a course step and a conversation contextualized to an initiating post is well illustrated by the fact that most discussion steps in this course generated more lone posts, whereas the longest conversation with 51 turns was elicited by a provoking post in a step without any discussion prompt. This finding also pointed to the fact that not only discussion prompts and course steps designed by educators could generate discussion, but learners also play a role in eliciting discussion. The differentiation between an initiating post and lone post thus provides us a way to examine how learners' post could elicit discussion. Furthermore, a differentiation between initiating posts attracting one reply and many replies, and analysis of the first reply under each initiating post might provide additional insight on learners' role in discussion generation.

Secondly, we recognized turn-takings in a conversation by identifying initiator's replies and replying learner's further replies, which are contributed by learners who came back to a conversation that they initiated or replied before. Analyzing conversations with such turn-takings might reveal how learners react to each other, especially when there is a disagreement. On the contrary, conversations without such turn-takings beg the question about why there is a lack of initiator's replies or further replies, and how a conversation could be sustained by multiple interlocutors who only contributed once. As shown in the example cited in this paper, hostile replies might put learners off from replying again to engage in turn-taking. On the other hand, within both conversations with and without turn-taking, multiple sub-conversations exist such that individual learner may only address a specific reply among the many replies underneath the initiating post. This phenomenon might be similar to other computer-mediated communications where users only addressed the initiating post or one of the many replies underneath it [25, 26], by using linguistic strategies such as name addressing or back-channeling to indicate their intended target user [11]. An investigation of these strategies among the FutureLearn learners, especially in a conversation longer than ten turns, will

provide an insight on how learners negotiate through the sheer number of comments in MOOC discussion.

Although our preliminary analysis on the different types of comments and conversations have been mainly qualitative in nature, it is possible to conduct quantitative analysis to understand the social dynamics and discourse in MOOC discussion. Chen and Chiu [28] used content analysis and dynamic multi-level modelling to take both the content and sequential nature of discussion postings into account in their research on a university course class forum. They found that earlier messages that expressed disagreement or new ideas were more likely to elicit replies from others. It is possible that the conversations we analyzed in this paper were elicited by initiating posts or replies with such contents, and this warrant future research. Under our categorization framework, their method could be applied to the level of initiating posts and lone posts to understand how the discussion evolves in a particular course step. It could also be applied to the conversational level under each initiating post with an additional variable that differentiates replies, initiator's replies and further replies. However, their content analysis framework was tailored to the sequential nature of discussion, and was different from the well-established content analysis framework [17, 18] that considered messages individually.

Besides considering the conversational dynamics of discussion postings, we also conducted a preliminary quantitative analysis to investigate the relationship between the distribution of comment types and course step design, given that teaching design could facilitate learners' conversation with themselves and others [14]. FutureLearn "discussion in context" approach allows such an analysis on the course step levels, compared to the centralized discussion forum in other MOOC platforms that is detached from course step design. However, the results in this paper showed that discussion steps seem to elicit more lone posts than other steps in this particular course that we analyzed. Further analysis on the prompts in each discussion steps may shed more insights on design and conversation generated, as Golanics and Nussbaum [29] found in an experimental study that goal instruction and question elaboration in discussion prompts promoted more argumentation in a university course online discussion forum.

Lastly, this paper also recognized the individuality of various types of social learners when previous MOOC research has only focused on a minority of super-posters [13]. Further analysis of learners' comments and personal backgrounds such as education levels and language abilities, as well as in-depth interview on their experiences and commenting strategies related to participation in discussion will provide valuable insights to educators and MOOC designers to better understand the different groups of social learners. Furthermore, social network analysis could also be used to understand the network position of each group of social learners identified in the present study, and a more detailed classification of social learners may be achieved by combining social network analysis with our proposed categorization.

12   Caveats

Admittedly, the categorization of comment types in this paper is based solely on the structure in the discussion activities such that the categorization label for some comments may not be valid in light of their content. Specifically, a lone post in our categorization may not be 'lone' in content, but could be addressing comments that have been posted earlier [17], and/or could be similarly responded to by subsequent comments. For example, "*I see comments about Australian pensions… does anyone have a link to information as to the level of pensions and how they are funded across the developed world.*". There was a lone post that even explicitly mentioned the name of the other learner, *"I agree with XX. State pension system is as good as it gets. ...."* These learners might choose not to reply directly to the other learners perhaps because there were too many learners with similar ideas to reply to. As discussed earlier, these lone posts may be components of a conversation at the global level in a course step that address all learners in general.

Nonetheless, these posts were considered lone posts as they were standalone, and in the FutureLearn system, such posts will not trigger notification emails to any learners, and will not receive notification from anybody, except when being 'liked'. This contrasts with initiating posts whose poster will receive notification for every reply received, or a reply that will trigger notifications to the initiator and other learners who replied before the reply. Therefore, lone posts also differ from the other four comments types on the ground of this interactional feature.

The second issue with this categorization concerns with vicarious learning and learners who do not post. It is possible that some of the learners who do not take part in the discussion activities (67% in the course analyzed in this study) read and 'like' some of the comments. However, we do not know who likes what from the data provided, therefore we could not incorporate it into our categorization of learners. It is possible that the initiators who never replied will have read and liked others' posts or replies, rather than fixating on their own initiating posts only. Another way of determining if initiators read others' replies to them might be the data of them clicking the notification sent to them when they receive replies. On the other hand, the 'like' count has allowed us to establish that lone posts received 'likes' despite not receiving replies whereas initiating posts could receive many replies but without any 'likes'. Still, in this exploratory study, we did not add this dimension into our categorization of comment types and conversations, mainly due to the fact that no solid basis has been established to operationalize the 'like' count, for example, the cut-off point to differentiate between well-liked and less-liked comments.

Third, the classification of social learners is based on the types of comments contributed across the whole course periods. It did not take into account the number and proportion of different types of comments contributed, 'like' received by each social learners, as well as the weekly participation in the discussion activities. Not every social learners commented every week in this course, and learners in FutureLearn do not necessarily engage with course materials every week [3]. Therefore, the active social learners identified in the present study does not necessarily mean that they participated in

the discussion every week or every step, but simply refers to the fact that they contributed initiating post, replied to others' posts, and engaged in turn-taking by further replying or replying to others' reply to their initiating posts. An earlier attempt in our cluster analysis in trying to include weekly participation and proportion of different types of comments resulted in too many groups that elude any meaningful interpretation. Nonetheless, our classification successfully identifies every social learners, instead of only the super-posters who received attention so far in MOOC research [12].

Fourth, the comments quoted in the present paper are not representative of all the comments in the identified categories, conversations or group of social learners. They happened to be the first instance to show up when we filtered for the examples. A systematic analysis of the contents of each comment by using well-established content analysis techniques reviewed in the introduction, conversational analysis or discourse analysis [11] is warranted to further shed light on the characteristics of each type of comments, conversations and social learners identified by the categorization approach we proposed.

Fifth, the analysis is based solely on the first run of one course and this course is full of contentious issues due to its topic on inequality. The distribution of the comments types, conversations and group of learners may differ in other courses of different nature or course step design. Nonetheless, because the categorization is based solely on structural relationships, it could readily be applied to other FutureLearn courses. Additionally, an analysis of the other runs of the same course will be particularly useful in understanding the relationship between the distribution of comment types and course step design presented in this paper. Consistent patterns may point to the influence of the course design whereas inconsistent patterns may reveal a cohort effect.

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