

Title	オンライン学習経験を向上させるためのMOOCの非同期型 ディスカッションフォーラムデザイン:SWAYAM の事例研究
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Doctoral Dissertation

Designing the asynchronous discussion forum of MOOC to enhance learning
experiences through bridging the gap between learners and educational
designers: A case study of SWAYAM

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Abstract

Background

Though online learning has shown rapid growth in the past two years, it still lacks relevant learning discussions among learners and instructors specifically in the case of asynchronous courses. The effectiveness of asynchronous online learning can be determined by analyzing the discussion forums. Also, numerous studies in the past few years have increasingly focused on design issues of massive open online courses (MOOCs), but only a few researchers have focused on designing the discussion forum of MOOCs by bridging the gap between the learners and the educational designer in learning experiences to improve the interaction among learners and instructors. In addition, the literature on this discipline from the student's perspective is sparse and is based only on the classification of discussion forum posts.

Originality

This doctoral research conducted a unique navigation experiment to address the discussion forum's organization and the forum usability issues from the learner's perspective. The research combined both quantitative and qualitative approaches to understanding discussion forum posts and learners' experiences. These findings add substantially to our understanding of an interactive user interface in terms of design, usability, and time efficiency that can increase the interest of learners and instructors.

Research objectives

The main research objective of the thesis is to propose a design method for discussion forum of MOOCs focusing on interaction to enhance learning experiences. Accordingly, this research has two sub-objectives: The first sub-objective is to recommend principles for relevant interaction through developing a classification method of posts in an asynchronous discussion forum. The second sub-objective is to bridge the gap between learners and educational designers of MOOCs through designing asynchronous discussion forums.

Research methods

The first study to fulfill sub-objective 1, namely Study1, presents a framework for analyzing content-related and non-content-related posts and their interaction in an asynchronous discussion forum. The second study to achieve the second sub-objective 2 conducted an unique navigation experiment to observe learners' behaviour and usability of asynchronous discussion forum. The experiment was designed based on three factors: 1.) classification of posts and type of participants, 2.) design of three different patterns of discussion forum 3.) evaluation of learner's experience.

Findings

The findings of study 1 suggest significant recommendations that help in increasing relevant interactions among learners and instructors along with eight principles. The most striking observation to emerge from the analysis was the redundancy of non-content related posts was high in number which hinders the relevant discussion related to course content. Interestingly, it is found that overall course design is directly proportional to the learning process. Therefore, eight principles based on social, cognitive, and teaching presence were recommended in asynchronous learning and discussion forum to enhance the learning process and maintain interaction among learners and instructors.

Study 2 contributes to the re-designing of the effective asynchronous discussion forum to improve the quality of the learning process. Despite interest in issues faced by learners, most of the studies have focused on the instructor's experience and the learner's performance in MOOCs. The present study is expected to contribute to our understanding of learners' perspectives in asynchronous discussion forums. There is a significant difference between the user interface of the original and the other two redesigned discussion forums that were designed based on the results of the first sub-objective study. Our research has highlighted the importance of discussion forum design that MOOC designers can implement for effective and efficient interaction in the asynchronous discussion forum. This study contributes to improving the quality of the learning process in online learning.

Implications

Implementing the discussed designed themes based on human-centered, elements of the educational model and machine learning model leads to a better understanding of discussion form posts and aid in re-designing the asynchronous discussion forum. A framework for the classification of posts and investigating responsible factors for relevant interaction among learners and instructors from study 1 can be adopted by researchers, developers, and facilitators of MOOCs. It is recommended that the design theme discussed in the research study should be adopted by the MOOC designer along with the understanding of the roles of the instructors and the learners for an effective and efficient online education system. A well-designed asynchronous discussion forum leads to better construction of structured knowledge and ultimately in the learning process and improves the overall growth of MOOCs. Research study 2 provides a framework with design demerits, design merits, and design ideas to bridge the gap between learners and the educational designer for learning experiences in the asynchronous discussion forum of MOOCs and create equal attention and opportunities for learners. Our study provides the foundation for a new way of constructing knowledge and producing better online education systems in developing countries also.

Keywords Higher education, E-learning, Massive open online course, Asynchronous discussion forum, educational design, learner interaction

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List of Abbreviations

MOOC	Massive Open Online Course
AR	Assignment Related
QR	Quiz Related
ATLAS	Archive for Technology, Lifeworld and Everyday Language.
AW	Academic Writing
COI	Community of Inquiry
CP	Computer Programming
CPP	C plus plus
CQA	Community Question Answering
CR	Content Related
LDA	Latent Dirichlet Allocation
NCR	Non-Content Related
RQ1	Research question 1
RQ2	Research question 2
RQ3	Research question 3
SME	Subject Matter Expert
SNE	Distributed Stochastic Neighbor Embedding
SP	Social Presence
TP	Teaching Presence
CQ	Cognitive Presence
SWAYAM	Study Webs of Active learning for Young Aspiring Minds
TR	Time Related
UCD	User Centered Design
LCD	Learner Centered Design
TAM	Technology Acceptance Model
EDR	Education Design Research
tf-idf	term frequency-inverse document frequency
DULCA	Design User Learner Centered Approach

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Chapter 1 Introduction

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1.1 Research background

With the rapid development of information technology, E-learning became an essential approach to enhance our way of learning new knowledge and developing skills. Moreover, In the past two years, online education has become an essential part of our education system due to the COVID-19 global pandemic (Baber, 2021; Muthuprasad et al., 2021; Rahiem, 2021). Additionally, recent trends in online education, including obtaining knowledge and developing practical and communication skills, have led to an increase in the number of learners engaged in distance learning (Ma et al., 2021). Interest in online education has also been boosted due to the needs of learners for flexible learning hours, an adaptive study environment, and access to distance education (Castro & Tumibay, 2021). On the other side, increasing demands for learning centers such as universities and colleges cannot be fulfilled by the conventional way of teaching. In this regard, MOOCs (Massive Open Online Courses) are one of the leading platforms in online education that has been developed to provide knowledge or information in the form of course content for various types of learners. There are numerous MOOCs platforms such as Coursera (coursera.org), edX (edx.org), FutureLearn (futurelearn.com), Udemy (udemy.com), Udacity (udacity.com), and SWAYAM (swayam.gov.in), etc. In recent times, MOOCs have also gained attention because of flexibility in participation, motivation, language, and open access to lifelong-learning opportunities because they provide substantial content to a large number of learners in a cost and time-efficient way (Ezen-Can et al., 2015; Reich & Ruipérez-Valiente, 2019). In terms of time efficiency, MOOCs provide pre-recorded video lectures convenient for both learners and instructors (Chauhan & Goel, 2015).

Though online learning has demonstrated rapid growth in the past two years, it still lacks relevant learning discussions among learners and instructors, specifically in the case of asynchronous courses. Also, if we compare with traditional classroom learning and many intelligent tutoring systems, MOOC learners face difficulty in interacting with instructors and peer learners. This lack of interaction and collaboration has been identified as one of the primary reasons for learner dropout from MOOCs (Gamage et al., 2020). MOOCs which combine course content with a discussion forum, constitute one platform for E-learning. However, interaction in conventional classrooms and online learning is different. The current pandemic has implemented conventional classroom methods difficult in educational institutions because of lockdowns. Online learning has consequently displaced traditional classroom approaches in these contexts. In virtual learning platforms, the

interaction system can be real-time and cannot be. In both cases, interaction is difficult to control when the number of participants is large. Even it is more challenging to interact and access the discussion forum if it is provided with pre-recorded learning videos. It is not only difficult for learners to access the information from the discussion forum but also for the instructors to respond. Past research conducted a survey of postgraduate students showing learners' positive and negative attitudes regarding MOOCs as shown in Table 1 (Ambadkar, 2020). Although most of the students agreed with MOOCs' merits. However, lack of interaction with the instructor was found as the most difficult problem in learning.

Table 1 The attitude of respondents toward MOOCs (Ambadkar, 2020)

Item	Dimension	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
The lack of one-to-one classroom teaching in MOOCs is a problem.	Negative	5.00%	37.50%	42.50%	15.00%	0.00%
Find self-motivation and setting goals for completion of MOOCs to be difficult.	Negative	3.75%	31.25%	38.75%	23.75%	2.50%
Find it difficult to learn without direct one-to-one interaction and support of a teacher.	Negative	7.50%	48.75%	11.25%	27.50%	5.00%
I would be comfortable using a computer several times a week to participate in a course.	Positive	7.50%	61.25%	21.25%	5.00%	5.00%
MOOCs are good because they expose students to professors from across the country.	Positive	8.75%	61.25%	23.75%	6.25%	0.00%
MOOCs provide students with scheduling flexibility (to be able to study in free time).	Positive	15.00%	67.50%	15.00%	2.50%	0.00%
MOOCs are good for overall improvement and lifelong learning of skills.	Positive	13.75%	57.50%	23.75%	5.00%	0.00%
MOOCs are good for lowering the cost of education for students and families.	Positive	31.25%	50.00%	16.25%	2.50%	0.00%

I like SWAYAM (Study Webs of Active learning for Young Aspiring Minds) MOOCs because it is free and affordable.	Positive	20.00%	48.75%	25.00%	6.25%	0.00%
I like MOOCs platform for its ease of access to course content.	Positive	12.50%	51.25%	30.00%	6.25%	0.00%

The platform of online studies creates confusion in the discussion forum, hindering teacher-student interaction (D. Yang et al., 2015). However, interaction and collaboration between learners are a necessary part of the discussion forum of the online learning world (McKenzie & Murphy, 2000). Figure 1 describes the general way of interaction in MOOCs as online discussion forums are one of the primary platforms for interaction among learners and instructors (Neha & Kim, 2021b). Therefore, the discussion forum is also considered a primary platform for knowledge construction through social interaction, sharing information, egocentric elaboration, allocentric elaboration, application and transfer, coordination, and reflection (Vasodavan et al., 2020). A well-designed interactive discussion forum is one of the methods of enabling effective interaction between learners and instructors in the online learning process. However, there are a variety of difficulties in accessing forums, such as following the discussion, and the structure, and motivating learners to participate in debate (De Lima et al., n.d.). Additionally navigating the discussion forum and finding the information on the topic being discussed become a more difficult and time-consuming task when the number of posts increases (Peng et al., 2020). Numerous studies in the past few years have increasingly focused on design issues of MOOCs, but only a few researchers have focused on designing the discussion forum of MOOCs by identifying and bridging the gap between the learners and the educational designer in learning experiences to improve the interaction among learners and instructors. A well-structured discussion forum is considered an essential requirement for smooth interaction and collaboration (Audeh et al., 2017; Kim, 2021). Currently, a systematic understanding of how discussion forum posts contribute to interaction and collaboration is still lacking. The effectiveness of asynchronous online learning can be determined through the scrutiny of discussion forums. In such a case, research suggests that adopting relevant interaction methods can improve the dialogical learning process exponentially (Goh, 2020). The term “relevant interaction,” in the context of asynchronous online learning in MOOCs refers to the response provided to a relevant post by the facilitator or peer learners within a

stipulated time duration that further motivates both the instructors and learners. Therefore, this study investigated relevant interaction techniques in an asynchronous online learning course using a mixed approach of classification of discussion forum posts with identification of content-related (CR) and non-content-related (NCR) queries using query subjects and query detail alongside the implementation of learning models.

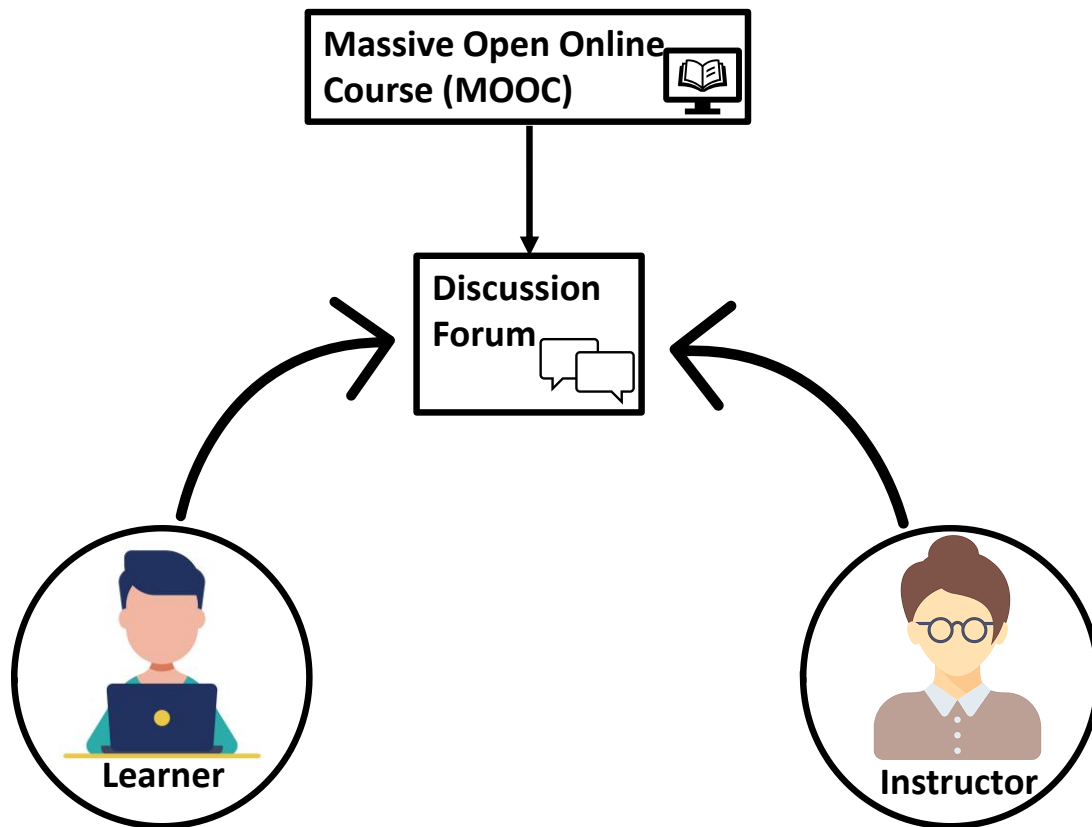


Figure 1 Way of Interaction in MOOCs (Neha & Kim, 2021b)

1.2 Scope of the research

The goal of this study is to provide a recommendation system to enhance the interaction among learners and instructors in asynchronous MOOCs through the classification of discussion forum posts and redesigning the discussion forum based on interaction factors. The study focused on the classification of discussion forum posts based on different indicators and educational frameworks with implementation. In addition, the literature on this discipline from the student's perspective is sparse and is based mainly on the classification of discussion forum posts. Investigating the factors that can increase participation and interaction will contribute to the field of educational research (Baek &

Shore, 2019). It is demanding to understand the discussion forum posts to provide adaptive support to learners and instructors (Ezen-Can et al., 2015).

In addition, recommending principles that are responsible for effective interaction between learners and instructors can also assist the frontliners (designers and developers) of MOOCs. According to the Learning pyramid developed by the National Training Laboratory Institute, 50 percent of the learning process depends upon discussion and this discussion phase relies on the learner's interaction with studying materials and instructors (Cheng et al., 2021). If we compare this with traditional classroom learning, it is not surprising that many MOOC learners face difficulty when it comes to interacting with instructors. A well-structured discussion forum benefits learners, instructors, and developers of MOOCs.

This study examined the effect of the design of discussion forums on user experience. The research conducted a unique navigation experiment to address the discussion forum's organization and the forum usability issues from the learner's perspective and combined both quantitative and qualitative approaches to understand discussion forum posts and learners' behaviour. These findings add substantially to our understanding of an interactive user interface in terms of design, usability, and time efficiency that can increase the interest of learners and instructors.

1.3 Significance of the study

Lacking the interactive design of a discussion forum leads to less interest and motivation by learners. Therefore, this study provides important insights into the factors responsible for interaction among learners and instructors and the designing of the asynchronous discussion forum in MOOCs to enhance the interactions. This work makes a significant contribution to the field of interaction in online education.

To fill the current literature gaps, this doctoral research study combines both quantitative and qualitative approaches in recommending principles for interactions and redesigning the existing asynchronous discussion forum to enhance the learning process. The study provides a conceptual framework and recommendation model that will benefit learners, instructors, educational designers, and facilitators of MOOCs to improve the efficiency and quality of online learning platforms.

1.4 Research objectives

The main research objective of the thesis is to propose a design method for discussion forum of MOOCs to enhance learning experiences. Accordingly, this research has two sub-objectives: The first sub-objective is to recommend principle for relevant interaction among learners and instructors through developing a classification method of the posts. The second sub-objective is to bridge the gap between learners and educational designers of MOOCs through designing asynchronous discussion forums. The first sub-objective study suggested significant principles that help in increasing relevant interactions among learners and instructors. These principles were further implemented in designing an asynchronous discussion forum to achieve the second sub-objective. The second sub-objective contributes to the redesigning of the effective asynchronous discussion forum to improve the quality of the learning process. There were significant differences between the user interface of the original and the other two redesigned discussion forums that were designed based on the results of the first sub-objective study.

Figure 2 demonstrates the flow of sub-research objectives to accomplish the main research objective.

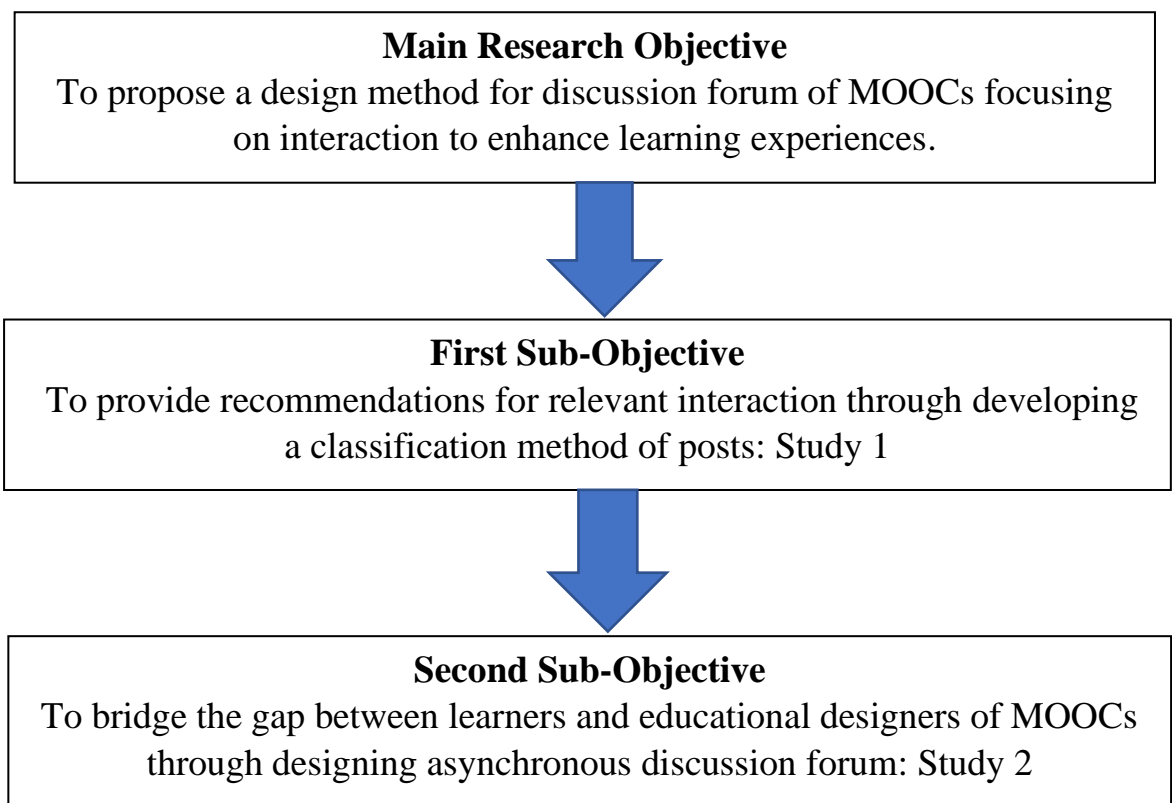


Figure 2 Research objectives of this thesis

1.5 Structure of the thesis

The structure of this dissertation is organized as follows:

Chapter 1 provides an overview of the research, the background of the research problem, the research objectives, and the significance of the study.

Chapter 2 (Literature Review) describes the existing design of the discussion forum for interaction and classification of posts in the asynchronous discussion forum. This chapter also describes the theoretical educational framework to analyze the discussion forum posts.

Chapter 3 (Research Methodology) outlines the mixed methods design used in this study. Details of the research design, process, data collection, and analysis procedures are provided in this chapter.

Chapter 4 (Principles for interaction) presents the data analysis in three cases to analyze discussion forum posts and existing interaction. Classification of posts was investigated based on several educational indicators.

Chapter 5 (Redesigning asynchronous discussion forum) presents the design idea of a discussion forum based on a navigation experiment conducted with an ethnographic study and learner and user centered approach.

Chapter 6 (Discussion and conclusion) summarizes the recommendation principles for relevant interactions among learners and instructors. The chapter also states the study's contributions, recommendations for learners, instructors, and educational designers, and future research directions.

Chapter 2 Literature Review

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2.1 Existing discussion forum design for interaction

Understanding the responsible factors for interaction and learner satisfaction can decrease the dropout rate of learners and aid in perceived learning form asynchronous online learning. The three general factors that leads to learner satisfaction and perceived learning are– clarity of design, interaction with instructor and active discussion among peer learners (Swan, 2001). These factors are further related to four kinds of interactivity which are dependent to each other and community of inquiry.

(1) Interaction with content (cognitive presence) where learner interacts with content to gain content knowledge through a media such as discussion forum. This type of interaction includes a concept of clear feedback and clear navigation to support effective design of online learning and future research is needed to explore these concepts.

(2) Interaction with instructors (teaching presence) where instructor delivers content knowledge and clarifies the concept in discussion forum and increase learner motivation so that learners can ask questions confidently in the future. This kind of interaction shows correlation between perceived interactions with instructors made and the average number of responses per learner that instructors made in discussion forum. However, instructors faced some challenges such as faceless classroom, adapting the learner centered teaching, managing time and techniques for establishing the learning community. The demand of current research in online teaching is for instructor activity and interaction as well as dealing with content interaction specifically attention towards structure and design and interaction among peer learners (learning community).

(3) Interaction with peer learners (social presence) where learners can learn from each other and enhance their knowledge which is an important factor in success of online courses. Researchers identified and discussed how individual differences in the learner profile present psychological challenges for MOOC-based learners: individual differences in skills, preferences and cognitive profile; engagement, motivation, learning and performance; and the ability to monitor and appropriately respond to the demands of both the external and internal contexts of learning. In order to address psychological challenges, we advocated the application of a learner perspective on MOOC-based learning and demonstrated how such an approach, by its very nature, supports the detailed consideration of an individual learner's psychological attributes,

skills and preferences and thereby highlights the importance of considering the psychological constructs that explain learner behaviour. The identification of the skills learners requires to maximize the educational benefits of MOOCs, together with conceptualization of the psychological underpinnings of skills as barriers and/or enablers to technology-enhanced learning, permit the characterization of factors that support effective MOOC based learning, thereby offering interesting insights into how the benefits of MOOC based learning can be maximized (Terras & Ramsay, 2015).

(4) Interaction with interface where learner deal with usability of medium to interact with content, instructor, and other peer learners related to the usability of discussion forum and this usability is defined by perceived usefulness and perceived ease of use. All together research studies shows that well-structured online course design and easy to use platform deal with increased access of instructors and feature more equitable and successful discussion. This led to higher level of satisfaction and work together to support online learning (Karen, 2001). According to Moore's framework also, learner must interact with technological medium to interact with the content, instructor, or other learners. The transaction distance theory stated by Moore explains how interaction affects learners' psychological perceptions of distance (Moore, 1989). Researchers reported that students who participated in online collaborative tasks expressed higher levels of satisfaction with their learning process compared to those who engaged in task-oriented interaction with their instructor (Jung et al., 2002). In addition to the level of satisfaction, researchers have investigated important factors affecting the perceptions of student satisfaction with collaborative learning. Moreover, learners do not learn well by listening to their instructors, memorizing or giving answers in certain patterns. Learners learn better by talking about things they learn, discussing and applying what they learn (Chickering & Gamson, 1991). In MOOCs, learner engagement is a significant factor in evaluating the learning process. The learning ability of MOOC learners provides a motivational basis for MOOC learners to participate in discussion forums. Moreover, MOOC learners with faster learning progress are more likely to participate in MOOC discussion forums, improve communication relevance, and advance the autonomy of MOOC online reviews (B. Wu, 2021). MOOC learners are very likely to engage in learning activities in a different way compared to those studying in online courses in formal, conventional programs. Previous study investigated the cognitive processing effect of viewing, voting, and commenting, on` students' peer

learning and performance in a MOOC. Due to the massive number of learners, instructors are less likely to give timely support or feedback to all the learners in a MOOC. Therefore, in a MOOC learning environment, some learners like to participate in the learning as viewers rather than as commenters (Chiu & Hew, 2018). In this study, we were especially interested in actual discussion forum design and relationship between design features and learner's perceptions to aid the viewers.

However, learning engagement has been determined by learners' posts on the discussion forum, their views, and course assessment (Ramesh et al., 2013). Figure 3 represents the common structure of a typical web forum consisting of threads and posts in MOOCs. However, a realistic web forum structure of an asynchronous discussion forum consists of various threads. Furthermore, the thread comprises several posts from learners and instructors as shown in

Figure 4.

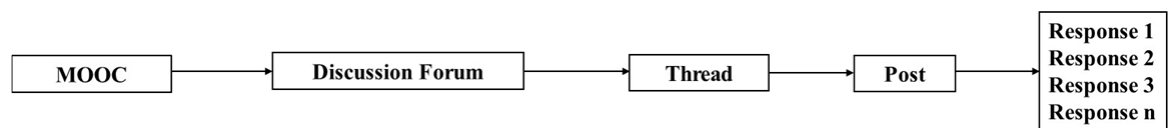


Figure 3 Typical web forum structure of an online learning website

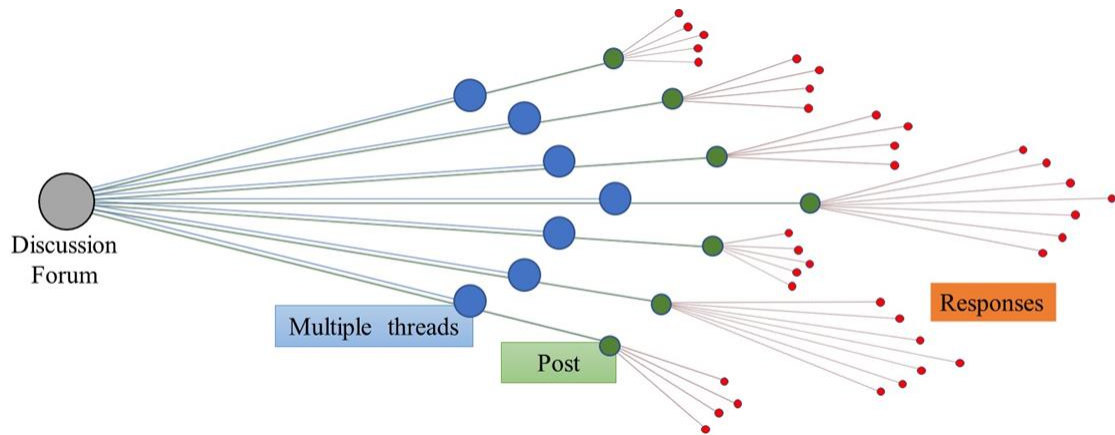
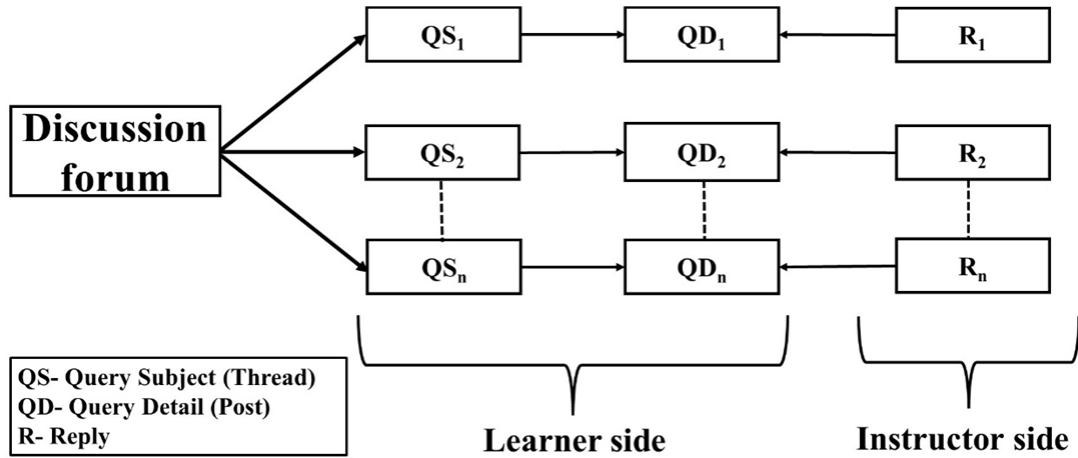


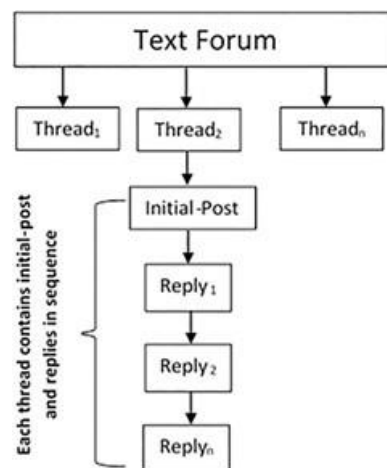
Figure 4 Realistic complex web forum structure of MOOCs discussion forum

Numerous discussion forums are maintained by online learning websites (Audeh et al., 2017). In Figure 5 (a), the existing system has a learner side and an instructor side (Neha & Kim, 2021b). In this type of discussion, learners input the query subject (thread) and query in detail (post). Then, each query requires to be examined by the instructor. The challenging part is that the learner side who put queries are individuals, but the instructor side is limited in the number to reply to each query. Past research reported that at least 30% of the courses generated a large number of new discussion threads that were hard for learners and instructors to understand (Brinton et al., 2014). It becomes a burden for instructors to reply to each query individually. In Figure 5 (b), the discussion forum starts with a thread and an initial post related to its thread, but it ends with various responses (Osman et al., 2019). However, some responses from learners may or may not be informative in the thread. It is also a difficult task for instructors to examine the unstructured discussion form and respond appropriately, considering the learners' behavior. The main challenge in a discussion forum is to maintain instructor and learner interaction. Therefore, there is a demand for a tool or method that can work automatically. Chaturvedi et al. proposed three predictive models for analyzing discussion forums. The first model was the logistic regression model which is based on thread level and clustered post features and the other two models were based on thread structure while making the prediction. The research study of the predictive model concluded that analyzing course information, discussion forum structure, and posts is

important to predict learner and instructor behavior. Furthermore, providing relevant posts to the instructor aid in a timely response. However, the study focused majorly on instructor intervention rather than learner centered and design issues in MOOCs discussion forums (Chaturvedi et al., 2014).



(a)



(b)

Figure 5 Existing system of the discussion forum (a) with learner and instructor side (Neha & Kim, 2021b) (b) with multiple threads and initial posts, and responses (Osman Id et al., 2019)

Consequently, MOOC discussion forums provide a wide opportunity for researchers for data mining due to the broad range of online courses and various types of learners (Reich, 2015). Discussion forum posts include questions, answers, and sentimental comments; however, this study focused on finding relevant posts with maximum and minimum interaction. The term “interactivity” holds a relationship with learning outcomes that directly depend on the nature of interactivity, including communication, engagement, reflection, questioning and answering technique, elaboration, discussion, problem-solving aptitude, construction, and analysis among others. Existing research has focused on active and passive learner engagement through discussion forum activities. Furthermore, it has highlighted that discussion forum posts can be used to express satisfaction levels along with motivation and interest to complete the course (Chaturvedi et al., 2014). Several research efforts have been devoted to supporting the discussion forum in MOOCs for its importance. The Discussion forum is regarded as the only way for students and instructors to communicate in MOOCs (FENG et al., 2018). The author expressed 18 features based on user interaction behavior and performed on a limited data set of discussion forums. The author reported that an online discussion forum actively encourages cognitive engagement and critical thinking. Despite this fact, virtual learning did not support coherent and interactive dialogue which is important for conversational learning (Thomas, 2002). Feedback is information about the content and understanding of the construction that students have derived from the learning experience (Hattie & Timperley, 2007). Based on the finding the author concluded that MOOC discussion forums can give rise to confusing states which are mainly caused by not getting a response from the instructor on time (D. Yang et al., 2015).

The existing literature on discussion forums focuses specifically on learning behavior patterns (Rantanen et al., 2019a; Sarsam et al., 2021; Vasodavan et al., 2020). However, most of these studies focused only on features used to find CR queries in the discussion forum (Cui & Wise, 2015; Marra et al., 2004; Romero et al., 2013). The quality of questions and chances of getting answers can be increased by understanding the factors that contribute to questions being answered as well as questions that remain ignored which can further help the discussion forum users (Fong et al., 2015). The manual effort can break the continuation of the evaluation and efficiency of instructors as it requires

a considerable amount of time. Data and text mining can be a solution to decline the problems faced by instructors, but it requires a highly specified domain (Dringus & Ellis, 2005). The implementation of machine learning and expert system achieves a precision that is comparable to top-ranked methods and there is no need to train with human experts (Villena-Román et al., 2011). However, our study initially adopted manual classification for smaller size discussion forums (less than 500 threads) to deeply analyze the structure of discussion forums with no “missed thread” (Chaturvedi et al., 2014) and later moved to machine learning technique for larger dataset (more than 500 threads).

The previous study compared student experiences and behavior’s across different learning system designs, courses, and discussion forums (Demmans Epp et al., 2020). Interesting research showed that personality traits, motivation, and interest in the specific content of a person can be analyzed by looking at their participation in an online platform (Jenny et al., 2016). Past research focused on the structure of discussion forum posts to understand the students’ behavior better and concluded that analysis of students’ behavior can benefit learning analytics communication. A research technique was proposed to improve the system’s performance in searching for questions and answers in the discussion forum and proved that non-content features play a significant role in improving searching performance (Hong & Davison, 2009). The author emphasizes that content-related queries are less frequently answered by the instructor (Cui & Wise, 2015). Feature selection is an important task in finding the intention post in the discussion forum (Liu et al., 2011). Linguistic features can aid in detecting content-related and non-content-related queries so that the instructor can focus more on the former (Chen et al., 2013). The community question answering system (CQA) can aid in finding relevant answers by the descriptive attributes of questions and classification of queries concerning the problem that is to be solved. This can be achieved with collaborative support from information technologies (Srba & Bielikova, 2016).

Existing research has also mainly focused on the analysis of social platform conversation. These studies focus more on the emotions and, sentiments of discussion posts (Adikari et al., 2021). For instance, the author worked on small private online courses but ended up identifying emotional behavior related to topics in discussion forums (Peng et al., 2020). Motivation among students, course expectations through the discussion rubric method, and the emphasis on content and task-oriented discussions

were among the elements that were adopted to improve an online discussion forum (Rovai, 2007). Furthermore, a restructured discussion forum can act as a pedagogical resource to provide knowledge for learners (Betouene & Mocozet, 2021).

Also, the number of posts in a discussion forum is directly proportional to the course duration. The research was conducted based on the size of the discussion forum (number of participants in a forum) and reported that most of the participants were social and motivated learners. Generally, MOOCs are characterized by many learners; subsequently, their discussion forums become difficult for instructors to manage, and the quality of the interaction between learners and instructors gradually declines. The author also found that the size of the discussion forum is linearly dependent on the content contribution of each participant (Baek & Shore, 2019). However, the contribution of online discussion forums is due primarily to the participation of active learners. It was worth noting that higher-performing learners engage more actively in the discussion forum than low-performing learners. However, high-performing learners were not interacting with other high-performing learners in the discussion forum (Gillani & Eynon, 2014). The literature on discussion forums also highlighted the patterns of learner interaction through various parameters such as cognitive engagement, critical thinking, coherent dialogue, and interactive dialogue in learner posts. However, the author draws attention to the lack of interactive and collaborative learning in the online discussion forums analyzed (Thomas, 2002). Previous research also established the relationship between confusion in the learning process due to the massive number of learner posts and the rate of dropout from MOOCs (D. Yang et al., 2015). The intermingling of queries with different categories was also observed in the discussion forum posts (Wise, Cui, Jin, et al., 2017a) and tracking of discussion forum posts to examine the relationship between the achievement emotions of learners and the weekly dropout rate (Xing et al., 2019).

Manual analysis of text or discussion forum posts is time-consuming and resource demanding. Therefore, several tools and techniques were developed to analyze discussion forum posts automatically (Anbalagan et al., 2015; Ezen-Can et al., 2015; Ntourmas et al., 2021). These techniques include supervised learning, unsupervised learning, and text mining. Text mining is one of the techniques most widely used in the analysis of discussion and feedback forums (Deng & Benckendorff, 2021; Dringus & Ellis, 2005). Text mining transfers unstructured text into a structured form using word

trends, patterns, and categorization with keywords to identify valuable information. Unsupervised text mining collected convincing keywords from four different models, including Latent Dirichlet Allocation (LDA), Key phrase extraction (topic rank), Text rank, and Frequency-based word cloud to form word clusters that identify the topic of discussions (Adikari et al., 2021). The previous study focused on the discussion posts, including the number of posts, words in the post, discussion topics, learner's emotions, learner's behavior, word index, time index, and topic time distribution using the text mining technique (Peng et al., 2020). Text mining can be accomplished using voyant tools to extract useful information from massive text datasets of any format (Hodhod & Fleenor, 2018). In an unstructured feedback forum, voyant tools worked well in the textual analysis function (Maramba et al., 2015).

The literature on facilitating online discussion forums suggests that the forum can be divided into social-emotional and group discussions (content and task-oriented) using a discussion rubric to make it more productive (Rovai, 2007). This study considered group discussions to be content-related posts and social discussions to be non-content-related posts.

2.2 Classification of posts in the asynchronous discussion forum

Classification of discussion threads in MOOC forums is essential and should be reasonable for the better utilization of MOOC forums (D. Yang et al., 2015). Several research efforts have been devoted to designing classification methods for queries in the discussion forum (Z. Chen et al., 2013; Fong et al., 2015; Hong & Davison, 2009; Srba & Bielikova, 2016). In 2017, the researcher introduced a linguistic model to find content-related posts based on the initial threads. In the linguistic model, the bag of words technique was used with unigrams and bigrams only. However, stop words were not removed from the model (Wise, Cui, Jin, et al., 2017a). Feng et al. adopted a classification method for Rossi's dataset of 60 courses (language independent). The classification method used 23 limited interactive features and transformed sparse features that were based on the structure and popularity of social discussion (Feng et al., 2018).

A large volume of published articles describes the role of data mining tools in assessing asynchronous discussion forums. Using data mining techniques and diverse visualization, successful modeling opportunities can be found for discussion forum

posts (Dringus & Ellis, 2005). A model was developed using the concept of design and facilitation to construct practical knowledge through social-emotional and task-related discussions (Rovai, 2007). Improving the quality of online discussion forums through the learners' activities leads to course-relevant discussions (Brinton et al., 2014). Another model was developed for community question answering that determines the quality of questions using good and bad questions to facilitate relevant queries in the discussion forum. Most forum users do not consider other learners' similar questions or repetitions of the same questions before starting a new discussion; eventually, it increases the load in online discussion forums (Yusof et al., 2015).

The model was developed to make reviewer comments more meaningful by categorizing them into content-related and non-content-related for revising the entire document, but the model was limited to research articles (Ocharo & Hasegawa, 2018). Other efforts have been made to identify content-related queries from MOOC discussion forums using queries' starting posts and linguistic features (Wise, Cui, Jin, et al., 2017a). However, the study failed to identify non-content-related queries found in large numbers in any discussion forum. Later a language and content-independent model was introduced to analyze discussion threads using twenty-three limited interactive features, including structure, popularity, and social work (Feng et al., 2018). Seven features were extracted, including language summary features, linguistic features, grammar, punctuation, function words, and social and LDA topics to identify the learner's expression in the online discussion forum (Xing et al., 2019). Subsequently, a topic-tracking model was created using thread posting, replying, quoting, and common posting labels instead of linguistic features (Peng et al., 2020). The use of common posting labels aids in creating clusters of content-related queries and non-content-related queries.

In the past, eight major dimensions were analyzed to classify discussion forum posts as shown in *Table 2*. These dimensions were social presence, cognitive presence, behaviour, relevance, learning sources, topic, summary, and pattern (Ahmad et al., 2022). Among the eight dimensions, we observed that social presence, cognitive, relevancy of posts, and topic classification were the top four criteria widely used for the analysis of discussion forum posts and suitable for our research study as well as shown in *Table 3*. Furthermore, several studies had adopted the cognitive method to analyze learner outcomes through discussion forums (G. Barbosa et al., 2020; Cheng et

al., 2021; Farrow et al., 2019; Hayati et al., 2020; Kovanovic et al., 2017; Neto et al., 2018; Y. Wu & Wu, 2018). Indicators of social presence further helped in sorting the positive and negative correlations with learner prestige (Zou et al., 2021a). In addition, similar posts or posts sharing the same interest are common in group discussions (Ahmad et al., 2022) and classification of the same-interest posts can aid in reducing repetitive posts. Several classification models based on the relevancy of posts have been designed to categorize CR (content-related) and NCR (non-content-related) (Cui & Wise, 2015; Wise et al., 2016; Wise, Cui, & Jin, 2017; Wise, Cui, Jin, et al., 2017a; Wise & Cui, 2018a, 2018b) posts, addressing the needs of both learners and instructors. Our pilot study focused on separating the posts based on five self-defined significant indicators and their interaction frequencies with facilitators and other learners (Neha & Kim, 2020). Apart from this, previous research has also investigated factors that can increase interaction among learners and instructors (Neha & Kim, 2021). Moreover, the study contributes to the field of asynchronous learning by highlighting the importance of relevant posts for interaction in discussion forums through the Community of Inquiry (CoI) framework.

Table 2 Eight dimensions to classify posts based on research trend (Ahmad et al., 2022)

Dimensions	Measurements	Indicators
Social	Social presence (A. Barbosa et al., 2021; G. Barbosa et al., 2020; Zou et al., 2021b)	•Affective
		•Interactive
		•Cohesive
	Sentiment (Fu et al., 2018; Kang et al., 2018; Liu et al., 2018)	•Positive
		•Negative
		•Neutral
Relevance or Importance	Relevance of thread (Wise, Cui, & Jin, 2017; Wise, Cui, Jin, et al., 2017b)	•Content-related thread

	<ul style="list-style-type: none"> •Non-content-related thread
Importance of post (Almatrafi et al., 2018; MacHado et al., 2019; Sun et al., 2019)	<ul style="list-style-type: none"> •Important post •Not important post
Importance of sentence (Le et al., 2018)	<ul style="list-style-type: none"> •Important sentence •Unimportant sentence
Type of thread (FENG et al., 2018)	<ul style="list-style-type: none"> •Meetups •General discussions •Lectures •Assignments •Platform •Issues; course feedback
Relevance of starting post (Ntourmas et al., 2019a, 2021)	<ul style="list-style-type: none"> •Content-related •Logistics-related •No-action-required

Cognitive	Cognitive presence (A. Barbosa et al., 2021; G. Barbosa et al., 2020; Farrow et al., 2019; Hayati et al., 2019; Kovanovic et al., 2017; Neto et al., 2018; Y. Wu & Wu, 2018)	<ul style="list-style-type: none"> •Triggering event •Exploration •Integration •Resolution •Other
	Cognitive engagement (Hayati et al., 2020; Y. Wu & Wu, 2018)	<ul style="list-style-type: none"> •Active •Constructive •Interactive •Passive
	Cognitive level (Cheng et al., 2021)	<ul style="list-style-type: none"> •Remembering •Understanding •Applying •Analyzing •Evaluating •Creating
Topic	Topic model (Atapattu et al., 2016; C. M. Chen et al., 2021; Fu et al., 2018; Gottipati et al., 2019; Lan et al., 2019; Liu et al., 2018; Peng et al., 2020, 2021; Rolim et al., 2019; Setiawan et al., 2020; Wong et al., 2017)	<ul style="list-style-type: none"> •Topic extraction •Topic ranking •Visualization

Learning Sources	Type of learning resource (An et al., 2019)	<ul style="list-style-type: none"> •Assessment •Exam •Video •Courseware (“Read,” “Slides,” “Transcript,” and “Additional resources”)
Summary	Summary (Gottipati et al., 2019)	•Topic-based summary
Pattern	Chance discovery (Wong et al., 2017)	•Keygraph

Table 3 Systematic research trend for classification of discussion forum posts

Dimensions	Focus	User	No. of academic studies
Social	Understanding learning presence in the discussion.	Instructor	15
Cognitive			12
Behaviour			9

Relevance	Helping learners in organizing & navigating discussion.	Instructor & Learner	13
Learning resources			1
Topic	Extracting main points from discussion transcripts.	Instructor & Learner	12
Summary			1
Pattern	Predicting learner's performances in the discussion.	Instructor	1

2.3 Learning experience in MOOCs based on theoretical framework

2.3.1 CoI framework

CoI is considered the most popular framework for analyzing educational transactions among learners and instructors (Hasani et al., 2022). The CoI framework with its three key elements- Cognitive presence, social presence, and Teaching presence is presented in Figure 6.

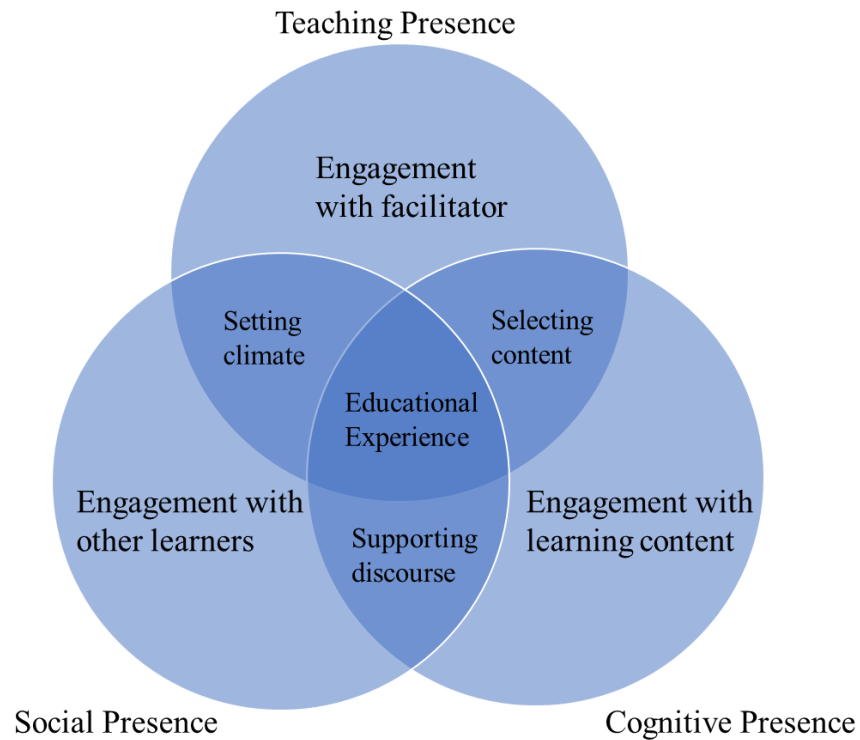


Figure 6 Elements of an educational experience (Hasani et al., 2022)

The CoI framework with its three core elements (cognitive, social, and teaching presence) create an interactive learning process. The first element Cognitive presence, in the context of the discussion forum, is defined as the construction of meaningful thoughts through reflection and engagement with learning content using critical thinking (A. Barbosa et al., 2021; Neto et al., 2021; A. C. M. Yang et al., 2021). Cognitive presence focuses on the learners' ability to engage in meaningful dialog exchange and participation in the discussion forum. Cognitive presence posts are indicated by triggering events, exploring problems, integrating new meaningful ideas, and providing solutions. The second element social presence connects all learners to the discussion forum through their social and emotional thoughts (A. Barbosa et al., 2021; Ferreira et al., 2020; Zou et al., 2021a). Social presence can be measured by learners' critical thinking skills that allow them to post freely. Classification of posts with social presence was based on learners' emotions, open communication, and group participation. In this study, most of the posts were related to learners' emotions regarding the course structure. The third element of teaching presence is the key

element that not only manages the discussion forum by guiding and directing learners but also the whole teaching content including the design of the course and development of the learning process. Teaching presence includes design, facilitation, and direction provided by the facilitator for optimal learning results. Teaching presence plays a significant role in improving social and cognitive presence which later provides better learning effects (Singh et al., 2022).

The CoI framework plays a significant role (Fiock, 2020) in creating an online learning community with seven principles of good practice (Chickering & Gamson, 1991). Table 4 describes the CoI framework with three major components: cognitive presence, social presence, and teaching presence, along with ten indicators to define these three components. The CoI coding template was further used for the classification of posts in the current study. Generally, cognitive presence and social presence are directly dependent on teaching presence (Garrison et al., 1999). In the research study, we adopted the CoI framework which is considered a “growing base” for educators and researchers to understand asynchronous educational transactions. Second, we adopted the Interactive, Constructive, Active, and Passive (ICAP) framework to classify types of learners (ElaineFarrow et al., 2021).

Table 4 CoI components with its indicators (Garrison et al., 1999)

Elements	Categories	Indicators (examples only)
Cognitive Presence	Triggering Event	Sense of puzzlement
	Exploration	Information exchange
	Integration	Connecting ideas
	Resolution	Apply new ideas
Social Presence	Emotional Expression	Emotions
	Open Communication	Risk-free expression
	Group Cohesion	Encouraging collaboration
Teaching Presence	Instructional Management	Defining and initiating discussion topics
	Building Understanding	Sharing personal meaning
	Direct Instruction	Focusing discussion

The three elements of the CoI framework perfectly describe the selected MOOC platform for this study:

a.) In case of Teaching presence:

- Engagement with facilitator/direction: Content was provided in the form of pre-recorded videos.
- Regulated learning: Quizzes, assignment, and the final exam was provided for assessment.
- Setting climate: Mainly text-based

b.) In case of social presence:

- Discussion Boards: “Ask a question” module was provided to engage with other learners.

c.) In the case of Cognitive presence:

- No specific module directly connected learners with course content-related discussions. The “Ask a question” module was provided for both social and cognitive presence.

2.3.2 ICAP framework and speech act theory

The ICAP framework (Chi & Wylie, 2014) and speech act theory (Arguello & Shaffer, 2015) were used as the primary and secondary bases for group learners, respectively. Six indicators were defined according to speech act theory that specifically targeted the learners based on their post type. The first type of learner directly asks questions and seeks information. The second type of learner is mainly interested in answering questions and providing information on discussions. The third type of learner is dissatisfied or faces difficulties in learning. The fourth type of learner provides solutions to the issues raised in the discussion forum. The fifth type expresses positive sentiments toward the course content. The sixth type acknowledges negative sentiments in the discussion forum (Hecking et al., 2016; Joksimovic et al., 2020). The ICAP framework works in four modes—interactive, constructive, active, and passive. In the framework, the interactive mode allows for interaction and collaboration with other

learners; the constructive mode is found to be productive in providing ideas and building knowledge; the active mode indicates participation, understanding, and focus on learning activities; the passive mode indicates receiving information only through discussions without participating in other activities related to the learning process (Hayati et al., 2020; Y. Wu & Wu, 2018). These two frameworks (CoI and ICAP) provide an approach for analyzing learner engagement which further aids in understanding the learning process.

Chapter 3 Research Methodology

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3.1 A summary of the research design

The main research objective of the thesis is to propose a design method of asynchronous discussion forum of MOOCs to enhance learning experiences.

To achieve the main research objective, this research has two sub-objectives: The first sub-objective is to recommend principles for relevant interaction among learners and instructors through developing a classification method of the posts in an asynchronous discussion forum. The second sub-objective is to bridge the gap between learners and educational designers of MOOCs through designing asynchronous discussion forums. The first sub-objective developed a classification method to classify posts and analyze the structure of the discussion forum. Consecutively, the first sub-objective study suggested significant principles that help in increasing relevant interactions among learners and instructors. These principles were further implemented in designing an asynchronous discussion forum. The second sub-objective contributes to the re-designing of the effective asynchronous discussion forum for bridging the gap between learners and educational designers of MOOCs. There were significant differences between the user interface of the original and the other two redesigned discussion forums.

According, there are two major studies conducted to fulfill two sub-objectives and the main research objective. The first study to achieve sub-objective 1, referred to in this thesis as Study 1, presents strategies for classification and evaluating discussion forum posts in MOOCs. It adopts various methods of classification of posts based on a theoretical and educational model. The proposed strategies or recommended model is later used in the second sub-objective for redesigning the discussion forum in improving relevant interaction among learners and instructors.

The second sub-objective and main research objective referred to as Study 2 in this thesis consists of designing, implementing, and evaluating discussion forums in MOOCs. The second study to achieve sub-objective 2 and the main research objective, implemented the design ideas to redesign the existing discussion forum based on the classification of posts and other recommended principles. The study 2 focused on designing the discussion forum of MOOCs by bridging the gap between the learners and the educational designer in learning experiences to improve the interaction among

learners and instructors. In addition, the literature on this discipline from the student's perspective is sparse and is based mainly on the classification of discussion forum posts.

This work examines the effect of the design of discussion forums on user experience. For the main research study, we conducted a unique navigation experiment to address the discussion forum's organization and the forum usability issues from the learner's perspective and combined both quantitative and qualitative approaches to understanding discussion forum posts and learners' experiences. These findings add substantially to our understanding of an interactive user interface in terms of design, usability, and time efficiency that can increase the interest of learners and instructors.

Table 5 below demonstrates the overall research design, procedure, and respective outcome of each research phase.

Table 5 Research design, process, and outcome

Phases 1: Identifying factors for interaction			
Procedure	Designing	Collecting	Analyzing
Details	Case I: Two computer courses Case II: Comparison of theoretical and practical discussion forum posts Case III: Academic writing course	Focused on both CR and NCR in detail. Using self-defined keywords and education model.	Qualitative and quantitative data of discussion forum posts for identifying posts and their interaction.
Outcomes	Case I: Frequency of interaction Case II: Similarities and differences in theoretical and practical courses discussion forum Case III: Relevant posts	Classified posts	Factors for interaction. Recommended interaction model.

Phase 2: Redesigning discussion forum			
Procedure	Designing	Collecting	Analyzing
Details	Redesigning the existing discussion forum	Recruiting 28 participants,	Comparing the performance of participants in
	Designing the question sheet for the navigation experiment.	Tracking of participant time taken, number of clicks, and scroll.	three discussion forums using One Sample t-test.
		Keywords used for navigation.	Comparison of three discussion forums using
		Participant feedback	chi-square test.
Outcome	Better user interface	Real-time user	$t1 > t2 > t3$
		experience	$c1 > c3 > c2$
			$s2 > s3 > s1$

3.2 Study 1: Principles for interaction

3.2.1 An overview of Study 1

Designing an interactive education tool is a challenging task, especially if there is a high number of participating students. Therefore, we extracted all the data for study 1 from an Indian MOOC platform - SWAYAM approved by the University Grant Commission with a large number of learners (https://swayam.gov.in/nc_details/). It is developed by the Ministry of Education, National Program on Technology Enhanced Learning, and Indian Institute of Technology Madras with the help of Google Inc. and Persistent Systems Ltd along with nine national coordinators. SWAYAM means “itself” in the Hindi language and basically, it means “self-learning.” However, facilitators are available to deal with discussion forum posts. This platform provides all the courses free of charge except for the examination which comes along with certification and the facility of valid university course credit transfer. It delivers all the courses that are taught from class ninth to postgraduate in India by well-known instructors from prestigious institutes (Ambadkar, 2020). Most of the courses are in the English

language. However, India is a diverse country with diverse cultures and languages. Therefore, currently, the platform also provides twenty-seven post-graduate courses in eight different Indian languages (Hindi, Gujarati, Marathi, Bangla, Telugu, Kannada, Malayalam, and Tamil). In our case study, we only selected courses that are available in the English language.

Currently, approximately 28 million learners are enrolled in the SWAYAM platform, and 2,226,700 learners registered for the examination. However, the successful certified learners were only fifty percent i.e 1,180,257 (https://swayam.gov.in/nc_details/ accessed on November 6, 2022). The ratio of enrolled learners to passed learners is quite challenging and significant to analyze. Therefore, it is significant to design an interactive education tool for the massive number of learners and courses.

In the Discussion forum of SWAYAM, there are unstructured comments. Comments may cover questions, phrases, sentences, paragraphs, replicated ones, etc. Usually, a course in SWAYAM is for 12 weeks and a learner can put comments in an online discussion forum of a particularly registered course. These comments may be related to the content, quiz, assignment, or inquiries.

Data were extracted in text form using python language from two computer courses, a practical course, and an academic course to compare the discussion forum posts in terms of their similarities and differences along with the focus on CR and NCR. Data consisted of real discussion forum posts with post id, post title, learner id, post content, post URL, and post duration. All the course materials included pre-recorded video lectures, transcripts, assignments, quizzes, and google groups discussion forums. In study 1, the analysis of the discussion forum was accompanied by three cases namely Case I for comparing two computer courses; Case II for comparing theoretical course and practical course; Case III Academic writing course to specifically focus on CR. Table 6 describes the four targeted data samples consisting of the course title, course type, course category, duration of the course, starting date of the course, ending date of the course, registered learners, number of posts, and link to discussion forums collected in this doctoral study.

Table 6 Details of four sample courses for the study

Course title	A Practical Refresher In Computer Engineering (Computer Architecture)	Computer Networks	C and CPP	Academic writing course
Course type	Computer course	Computer course (Theoretical)	Practical course	Content focused
Category	Annual Refresher Programming in Teaching	Computer Science and Engineering	Multidisciplinary	Multidisciplinary
Duration	16 weeks	12 weeks	Self Paced	15 weeks
Start Date	3 September 2019	16 January 2020	Self Paced	13 January
End Date	31 December 2019	18 April 2020	Self Paced	25April, 2020
Registered learners	7,318	11,939 (Case I) 11,973 (Case II)	15,645	7546
Posts	95 (till 4 March 2020)	16 (till 4 March 2020)	137 (till 30 Sept 2020)	819 (till 30 May 2022)
Link to the	https://groups.google.com/a/nptel.iit	https://groups.google.com/a/wayam2.ac.i	https://groups.google.com/a/sway	https://groups.google.com/a/sway

discussion	m.ac.in/g/noc20-	n/g/cec20-	am2.ac.in/g/aic2	am2.ac.in/g/cec2
forum	cs25-discuss	cs01-discuss	0-sp06-discuss	0-ma04-discuss

Case I: Data collection from two computer courses

This case was conducted in the early time of SWAYAM, and it was not that much popular as it is now because of the online education trend or COVID-19. The design of the online discussion forum was also different from the current design as shown in Figure 7 and Figure 8. The category of both courses was computer science and engineering. We selected the two computer courses entitled Computer Architecture and Computer Network to analyze CR posts with keywords. The duration of the Computer Architecture course was of 16 weeks (3 September to 31 December 2019) with 7318 enrolled learners and only one facilitator. The duration of the Computer Network course was of 12 weeks (16 January to 18 April 2020) with 11,939 enrolled learners and only one facilitator.

The screenshot shows the SWAYAM platform interface. At the top, there's a navigation bar with 'AICTE', 'A Practical Refresher in Computer Engineering', and links for 'Announcements', 'About the Course', 'Ask a Question', 'Progress', and 'Mentor'. Below this, the page title is 'Unit 2 - Introduction to Computer Architecture'. On the left, a 'Course outline' sidebar lists topics like 'Flipped Classroom Teaching Model', 'Introduction to Computer Architecture', 'The Abstract Parts of a Computer', 'IC Technology', 'The Hardware Software Interface', 'Computer Performance Quantification', 'Single Cycle implementation Of MIPS', 'Pipelining', and 'Cache memory'. The main content area displays a video player for 'Introduction to Computer Architecture' by Bhaskaran Raman, Room 406, KR Building, Department of CSE, IIT Bombay. The video title is 'CS305 Computer Architecture' and the content includes 'What is Computer Architecture?' and 'Why Study Computer Architecture?'. Below the video player, there's a section for 'Previously asked questions around the same time' with a red dashed border. It contains a 'Short Description:' field and a 'Detailed question:' field. At the bottom, there are buttons for 'Post question' and 'Keep watching', and a note stating 'To post questions, you must be a member of Course Discussion Group'.

Figure 7 Modules of the previous design of SWAYAM MOOC

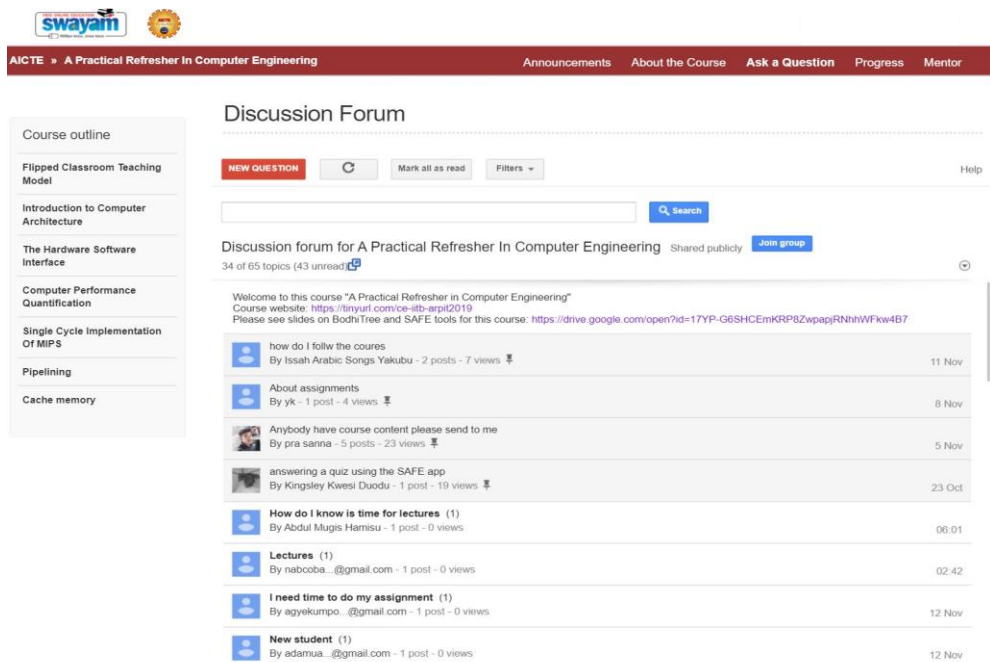


Figure 8 Previous discussion forum design of SWAYAM (accessed in April 2020)

Case II: Data collection from the theoretical course and practical course

In this study, we selected theoretical and practical courses to analyze the similarities and differences between discussion forum posts. Google group was chosen as a platform for discussion where the learner can put post thread and post detail (highlighted part was post thread or title and the underline part was post in detail) as shown in Figure 9. The duration of the theoretical course in 2020 was of 12 weeks (16 January to 18 April) with 11,973 enrolled learners and one facilitator. On the other side, the duration of the practical course in 2020 was of 12 weeks (16 January to 18 April) with 15,645 enrolled learners and six facilitators.












	SAVITA ..., cec20...@sway...	2	Regarding Exam – Sorry, There is no option I think, but you can take help from SWAYAM support rec	Nov 24	☆
	Pradnya ..., cec20...@sway...	2	Regarding certificate – Already announced Marks of SWAYAM September 2020 CBT based exam is	Nov 24	☆
	Devigayathri Natrajan		Regarding registration of examination – Respected team, I have failed to register for this examinati	Oct 25	☆
	hart...@gmail.com		Regrding result of exam conducted on 30-09-2020 compter network and its certificate – Anyone ca	Oct 5	☆
	n2i0...@... , ... cec20...@s...	5	Issue regarding providing the certificates. – Certificates are given by SWAYAM after the examinatio	Sep 17	☆
	robinm...@g..., ... PUSHPA ...	3	Regarding to change exam centre or to Promote for the course – Sir want we gets our certificate wi	Sep 14	☆
	robinm...@..., cec20...@sw...	2	Regarding to exam centre – Please contact to SWAYAM as given below in exam guide For any furth	Aug 12	★
	gauta...@... , cec20...@sw...	2	Regarding For Examination Centre Change – Please contact to SWAYAM as given below in exam gu	Aug 12	☆
	prat...@g..., cec20...@swa...	2	REGISTERED FOR THE EXAM BUT COLLEGE NAME HAS BEEN MISTYPED – Please contact to SWA'	Aug 12	★
	atishk...@..., cec20...@sw...	2	Related to eligibility for exam – Please calculate your progress from your best 5 assignments, it shc	Aug 12	★
	amit k..., cec20...@swaya...	2	about the certificate – see announcement On Sunday, July 19, 2020 at 11:39:56 AM UTC+5:30, amit	Aug 5	★

Figure 9 Example of a current discussion forum in SWAYAM

Case III: Data collection from an academic writing course

The duration of the AW course in 2020 was of 15 weeks (13 January to 25 April) with 7546 enrolled learners and 5 facilitators. Each facilitator has a specific role namely course coordinator & subject matter expert, co-course coordinator & subject matter expert, subject matter expert, instructional designer, and a production part. This course was found to be the most popular among all the SWAYAM MOOCs with the maximum number of exam registrations. It ranked in the top 30 MOOCs in the world. The most interesting fact about the course was that the internal assessment was assessed through an assignment, activity as well as discussion forum participation. Furthermore, participants in the discussion forum were graduate students, researchers, and professionals. Therefore, selecting the course for the current study was beneficial because it provided an opportunity to analyze a broad perspective in terms of interaction. Figure 10 presents the existing modules (Announcements, About the Course, Ask a Question, Progress, Mentor, and Review Assignment) in the AW course.

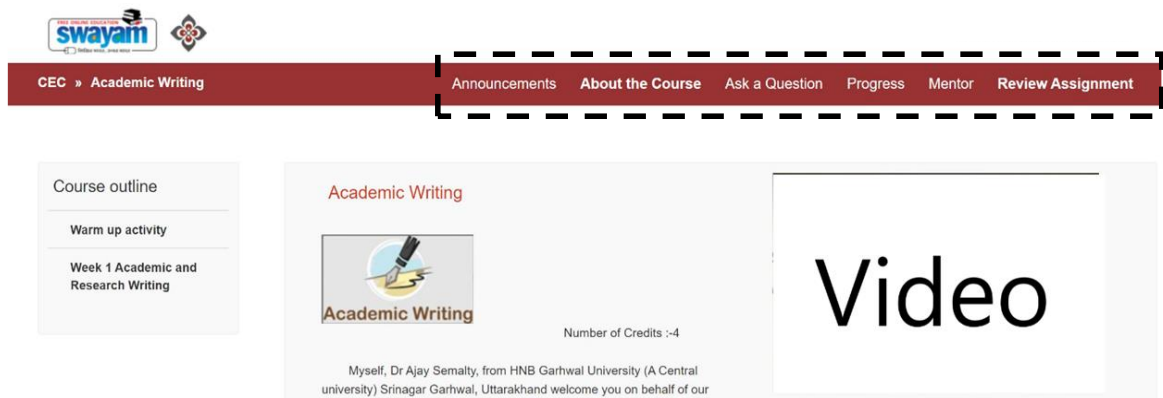


Figure 10 Existing modules in SWAYAM MOOC

3.2.2 Research questions

In study 1, three research questions were framed to recommend a pathway for relevant interaction based on the literature review:

RQ1: What is the existing interaction state in an asynchronous discussion forum according to the classification of queries?

RQ2: How does the frequency of discussion forum posts vary?

RQ3: What can be the recommended model for interaction based on CoI and ICAP framework in asynchronous learning?

3.2.3 Research methods

This study followed the eight steps suggested for content analysis of discussion forum (Rodriguez, 2014).

1. Data coding based on keywords using the software program Atlas. ti, which is very helpful in sorting, analyzing, and reporting data. We also used Voyant tools to automatically classify similar posts.
2. Data coding using an existing theoretical rationale or research design such as the COI (Garrison et al., 2001).

3. Examining and understanding the online discussion strategies to enhance the learning process. We accomplished this step by examining seven principles for good practice for learner-instructor interaction suggested for MOOC practitioners (Fiock, 2020).
4. Modify the criteria (indicators) of the coding instrument to align with the identification of the content of the online discussion messages concerning the learning objectives.
5. Select coders who are knowledgeable about the subject matter of the online discussions.
6. Plan thorough training for the coders.
7. Assess training of coders for inter-rater reliability measurements that are at least .8. We also performed Cohen's Kappa test to validate the coding.
8. In analyzing the online discussions, analyze for cognitive presence, teaching presence, and social presence

3.2.4 Data coding and analysis

This study focused on investigating the factors for interaction by analyzing the discussion forum posts. The study was carried out as mixed-method research to analyze the discussion forum posts in three cases.

Data coding and analysis in Case I:

The main task in study 1 was of analyzing the discussion forum in detail and the data was of a smaller size in case I. Therefore, we manually classified discussion forum posts from the two computer courses of SWAYAM, but their classification was challenging due to their unstructured nature (Rantanen et al., 2019b). As, in the earlier design of the discussion forum, there was a short description box and a detailed question box for learners to post the questions. Therefore, the system or research idea was to follow the statistical procedure as it will take the input data from the short description box which is already present while asking questions in SWAYAM. Then it will map these input data with five indicators to classify comments and these indicators were CR, AR, QR, TR, and Others depending on the query. In the initial stage, a data set of manual classification or human-coded data was required to secure the accuracy of

indicator-based segregation. After that, a classifier was trained to predict the query. The construction of the classifier can be done by checking the repository data or log file where we can find the previously asked queries. In case some comments/queries do not contain any of the categorized tags. Therefore, the system categorized it as "others" to aid in segregating relevant and irrelevant parts. Further, we need an expert system that will use simple rules based on the logic expression for fine-tuning. Some keywords from the short description box may overlap with others. For instance, it will categorize the query based on the number of terms that satisfy the logical expression. Each input is then tested for acceptance, rejection, or for the option to categorize as "others". One of the roles of feedback is to determine the quality and standard of teaching and learning. In classroom teaching, there is an advantage that a learner can ask questions at any point, but some learners feel shy while asking questions at the same time. In E-learning, it takes a lot of time for the supervisor to answer every post and it becomes more difficult when the comments are unstructured. Sometime there may be a repetition of comments also occurs. We can solve such problems by focusing on discussions in online learning.

Segregation of comments in the discussion forum can make the task easier for the subject matter expert (SME) in SWAYAM to answer the queries effectively. It can save the time of the learner and the SME simultaneously because, in this situation, SME does not need to answer every post and the learner can get the knowledge frequently from discussions. For instance, queries related to the content part can be answered separately. Analysis of coded data can be done by calculating the students taking part in the discussion forum of a course over students enrolled in that course. Analyzing the type and number of queries can help in determining the most occurring problem. After solving queries related to an indicator, we can evaluate by observing the learner participation experience. For instance, there is a quiz system in SWAYAM so maybe solving queries related to the quiz can enhance the number of quiz takers and the same can be done in the case of assignments, content, etc. However, in the case study I, it was difficult to categorize CR posts especially when it varies from one course to another course.

Data coding and analysis in Case II:

In case study II, the focus was to compare the theoretical and practical discussion forum posts in terms of CR posts and NCR posts. The study understands the structure of the discussion forum based on the analysis of different types of queries and learners' participation. We employed both qualitative and quantitative analysis for this research study. Generally, queries can be classified as CR and NCR. CR query subjects are those that contain subject-specific words and vary from course to course. NCR query subjects are those that have social and management queries. These queries are related to submitting assignments, tests, or quiz-related queries that forum administrators can answer. In case study II, we focused on similar queries by the learners, instructors' replies, and peer learning, as well as the number of participants with CR and NCR queries. Those queries included CR, AR queries, and TR queries. We found that mostly AR and TR were related to the inquiry. Therefore, we considered them as NCR queries and the remaining queries were CR based on the query subject. Features were extracted for NCR queries. These features from the query subject were used to train a classification model as shown in Figure 11 (Neha & Kim, 2021a). In addition, NCR words were further classified as AR and TR query types. These features can be used to train a classification model for various queries. Table 7 shows the various words that were used in NCR queries (Neha & Kim, 2021a).

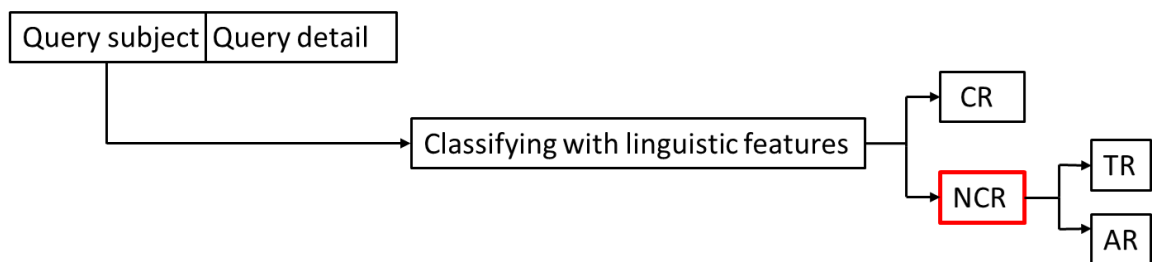


Figure 11 Classification of queries for data coding (Neha & Kim, 2021a)

Table 7 Words commonly used in NCR (Neha & Kim, 2021a)

Query type	List of words for classification
AR	Submit, assignment, regarding, start, exam, submission, correct, answers, week,
TR	Online, test, certificate, related, exam, regarding, examination, credit, points, issue, providing, change, centre, college, name, mistyped, eligibility, find, out, roll, number, procedure, not, yet, received, payment, fees, conduct, grading, showing, wrong, answer, email, question, where, due, date, course, type, closed

Further the classification of posts from the theoretical and practical course by only using their post subjects or query subjects with voyant tools (<https://voyant-tools.org/>) to check the reliability of the classification of posts. The entire set of 296 query subjects was analyzed. These query subjects were manually labeled as CR and NCR as shown in Table 8.

Table 8 Sample Dataset with query subject

Query number	Query subject	Type of query
1	C in windows	CR
2	Lecture slides	CR
3	for subject assignment	NCR
4	matrix multiplication	CR
5	Certificate Detail reg	NCR
6	thankyou	NCR
7	System operator	CR
8	About certification	NCR
9	related test	NCR
10	confusion	CR
11	assignment	NCR
12	Regarding assignment	NCR
13	Error in C++	CR

14	c	CR
15	online test	NCR

During the evaluation phase, the results from voyant tools were compared with the result obtained by manual coding. CR queries contain domain-specific keywords for the course and direct academic queries. They require appropriate discussions between learners and instructors. NCR (non-academic or management) queries are related to assignments, quizzes, and tests related queries. The primary task in carrying out this study was data pre-processing. In previous studies, several classification models were used to pre-process discussion forum data. Linguistic features were used in the classification models to categorize the queries (FENG et al., 2018; Osman Id et al., 2019). Previous research was also limited in conducting a study on the online discussion forum of two programming computer courses or theoretical courses instead of comparing the practical and theoretical course discussion forums in MOOCs (Waller et al., 2020).

Examples of query subject pre-processing:

Content-related example:

- Before pre-processing: compilation of the program in Windows OS.
- After pre-processing: compilation, program, Windows, OS.

Non-content-related example:

- Before pre-processing: how to submit an assignment.
- After pre-processing: submit, assignment.

In the examples, stop words like “he, of, in, I, how” were removed manually. Stop words occur frequently and have no meaning in the context of queries. Content-related query words such as compilation, program, Windows, and OS are retained. Likewise, words such as submit, and assignment were considered for the categorization of non-content-related queries.

In case II, voyant tools were used for the analysis of discussion forum posts as it is widely used for both qualitative and quantitative measurement. To our knowledge, no previous work has employed this tool to focus on non-content-related query subjects of

Google group discussion forums. Voyant tools work with text analysis and data exploration functions to visualize datasets that traditional means may not achieve (Miller, 2018). Text mining has also been widely used in analyzing various aspects of discussion forum posts. However, in this study, we focused instead on the usability of the Cirrus, Correlation, and Scatter plot features of voyant tools to analyze queries. Voyant tools also enable us to remove stop words automatically. Therefore, voyant Tools is a particularly suitable option for digital humanities study (Sampsel, 2018).

The content of a discussion forum can be analyzed at various levels (query subjects, queries itself, replies, number of views on the query). For the following three reasons, the query subject (query thread) was the most valuable unit of analysis for creating a model:

- 1) MOOC Google group discussions are represented to learners as a threaded conversation in the form of query subjects providing an idea of the query type. Learners decide what to read based on this query subject.
- 2) Query subjects may change direction when other learners join the conversation. To verify this, an analysis was conducted to check each query conversation.
- 3) Query subjects aid in identifying relevant features for categorization and creating a model for clustering queries. In particular, the Scatter plot feature in voyant Tools can aid in clustering queries with similar attributes. A previous study found that instructors responded more frequently to clusters of overlapping forum queries (Neha & Kim, 2020).

This study aimed to determine whether the query subject could accurately obtain the idea of a query and further aid in creating clusters of similar queries using voyant Tools.

The research supporting this study had three primary goals. It sought to determine if:

- 1) Query subjects of content-related threads have linguistic features that distinguish them from non-content-related posts.
- 2) Linguistic features can be used to create a model that reliably identifies query subjects of content-related posts in a MOOC Google group discussion forum.
- 3) Voyant Tools can determine the frequencies of content-related and non-content-related query subjects.

The toolkit used in voyant tools

The entire 296 query subjects were analyzed using the online voyant tools (a web-based application). Duplicate or repetitive query subjects were also considered to determine their frequency of occurrence. Three different tools out of twenty-four were used for experiments. These tools were the Cirrus tool, Correlation tool, and Scatter plot tool.

Cirrus tool

Cirrus is a word cloud generator that creates a visual image by ranking the words of a corpus or document according to the frequency of occurrence. It automatically filters stop words, saving time and effort during data pre-processing. This tool helped generate the topics of discussion according to the frequency. The cirrus tool and the correlations tool facilitated in identifying the features to classify query subjects. The cirrus tool aids in identifying the most frequent discussions. The tool helped in investigating high-frequency queries in both the practical and the theoretical courses. The high frequency of NCR posts, for instance, was assignment, exam, certificate, and test as seen in Figure 12.



Figure 12 Word Cloud using Cirrus tool

Correlation tool

This tool enables us to find the co-occurrence of two or more lexical items. The co-occurrence can be positive or negative. The tool provides correlating pairs of words in the text. This tool aids in finding the meaning of the query directly without focusing on stop words.

Scatter plot tool

This tool is designed for data visualization using dimensionality reduction methods. It includes analysis functions with the dimensional representation of the data. The Analysis function provides four techniques. These are Principal component analysis, Correspondence analysis, t-SNE (t-Distributed Stochastic Neighbour Embedding) analysis, and document similarity.

In this study, t-SNE analysis was carried out on qualitative textual data. The t-SNE technique aids in finding the most complex information [8]. Data were analyzed using the parameters perplexity (P) and iteration (I). The level of perplexity ranges from 5 to 100, and the number of iterations that can be performed is between 100 and 5000.

Feature extraction and modeling

Discussion forum queries include course content-specific queries, repetitive queries, queries categorized as frequently asked questions (FAQ), and management queries. Several words in the query subject were used to classify various categories of queries. Feature extraction aided in data mining of discussion forum queries. In the current dataset, there were 1,182 total words with 392 unique word forms. However, the study considered the most frequent words provided by voyant tools for feature extraction as shown in Table 9. The most frequent words in the discussion were associated with non-content-related queries, i.e., assignment, exam, certificate, regarding, and test. Finding content-related features from the online discussion forum corpus was difficult because the keywords varied from course to course. This study lacked various categories of classification because it was limited to two discussion forums.

Table 9 Summary of the dataset in feature extraction using Voyant tool

Words	Quantity
Total words	1,182
Unique word forums	392
Vocabulary density	0.33
Average words per sentence	62.2
Most frequent words	assignment (45); exam (39); certificate (30); test (22)

Data coding and analysis in Case III:

In the initial phase, two expert researchers performed manual coding of up to 100 posts which were based on conventional content analysis and summative content analysis

(Hsieh and Shannon, 2005). Inter-rater reliability was good (99%). Also, Cohen's Kappa was calculated with value 0.662. Then, Transcript analysis was conducted using ATLAS.ti. The coding strategy was performed in cycles including descriptive coding, sorting, synthesizing, and theorizing (Saldana, 2013) using two learning models—CoI and ICAP framework. The coding stages kept track of the frequencies of posts.

Stage 1: Descriptive coding was performed in two categories to get a general idea about the posts. The first category was of CR posts were intended for academic writers to get an actual idea about the content or the topic being discussed in the pre-recorded video of MOOC and the second category targeted learners in the course itself, including NCR posts related to distress, technical issues, assignment, course certificates, and examinations.

Stage 2: In this stage codes were categorized, and themes were generated based on the CoI model (cognitive, social, and teaching presence) to find the relationship between stage 1 coding and the CoI model.

Stage 3: In stage 3, pattern coding was performed to analyze the sequence of the posts. This allowed us to analyze the frequency of similar posts by various learners and teaching presence.

Overall, content analysis (Hsiu- Fang Hsieh and Sarah E. Shannon, 2005) was performed as shown in

Table 10. Categorizing posts further provided valuable information to the instructors about the interest of the learners, such as the most discussed topic and the frequency of participation of the learners. Relevant and irrelevant posts were filtered by analyzing the discussion forum posts to make the learning process efficient and effective.

Table 10 Three approaches to content analysis

Type of content analysis	Timing of defining Codes or Keywords	Source of codes or keywords	In this research
Conventional content analysis	Codes are defined during the data analysis (Observation)	Codes are derived from data	<ul style="list-style-type: none"> • CR • NCR • Distress
Directed content analysis	Codes are defined before and during the data analysis (Theory)	Codes are derived from theory or relevant research findings	<ul style="list-style-type: none"> CoI model • Cognitive • Social • Teaching
Summative content analysis	Keywords are identified before and during the data analysis (Keywords)	Keywords are derived based on the interest of researchers or a review of the literature	<ul style="list-style-type: none"> CR keywords such as plagiarism, journal, publication NCR keywords such as assignment, examination (dates, fees, pattern, registration)

3.3 Study 2: Design User and Learner-Centered Approach (DULCA)

3.3.1 An overview of Study 2

MOOCs are widely accepted as the key to obtaining higher education qualifications with the advantage of distance learning. In distance learning, discussion forums are used to facilitate interaction between learners and instructors. It is well known that structured discussion plays a crucial role in the learning process. However, navigation was found to be the major task while exploring existing discussion forums (Ntourmas et al., 2019b). Therefore, Study 2 aims to bridge the gap between the experience of learners and the educational designer of MOOCs. Toward this objective, a navigation experiment was conducted on participants (n=28) for two weeks in September 2022. Each participant was rewarded and spent one hour in total for the experiment including explanation, purpose, instructions for experimenting, testing of three designs as well as feedback. In this experiment, three types of discussion forum platforms with different designs were delivered to the participants. The experiment was designed based on three factors: 1.) classification of discussion forum posts and participants, 2.) design of three different patterns of discussion forum 3.) evaluation of learner's experience. The findings of the study contribute to the re-designing of the effective asynchronous discussion forum to improve the quality of the learning process. These findings add substantially to our understanding of an interactive user interface in terms of design, usability, and time efficiency that can increase the interest of learners and instructors. Despite the interest in issues faced by learners, few studies have focused on the instructor's experience and the learner's performance in MOOC. Previous studies have failed to address the organization of the discussion forum and the usability issues of the forum from the learner's side. The aim of Study 2 in the context of an asynchronous discussion forum was a.) supporting the learning process, b) motivating learners, and c.) achieving learning goals through solving usability and accessibility issues of discussion forum design. The present study is expected to contribute to our understanding of learners' perspectives in asynchronous discussion forums. Our research has highlighted the importance of discussion forum design that can be implemented by MOOC designers for effective and efficient interaction in the asynchronous discussion forum.

3.3.2 Research questions

RQ 1: How to redesign a learner-centered discussion forum to reduce the navigation process?

RQ 2: What is the gap between learners and educational designers in terms of issues, benefits, and design ideas in the discussion forum to enhance relevant interactions and the learning process?

3.3.3 Research methods

Study 2 adopted the UCD (User-centered design) and LCD (learner-centered design) methods (Dhar & Yammiyavar, 2012) to address the need of users in the context of the learning system with the involvement of both learners and users (Hasani et al., 2022). Table 11 describes the UCD and LCD approaches. Considering the UCD and LCD approach, the study followed five steps: Step 1: Specifying the context of use by classifying posts and literature study; Step 2: Identifying user and learner requirements; Step 3: Designing the interactive design; Step 4: Prototyping; Step 5: Design evaluation.

Table 11 UCD and LCD approach (Dhar & Yammiyavar, 2012)

UCD	LCD	Dimensions
User	Learner	Focus
Supporting user while completing a task.	Supporting the learning process while the learner completes a task.	Goal
Users are experts and have significant knowledge about their task.	Learners are novice and lacks knowledge about their task.	Domain knowledge

Users share common characteristics.	Learners have diverse individual characteristics.	Characteristics
Assisting users to spend time and cognitive resources to complete the task rather than focusing users to learn the tool to complete the task.	Motivating learners to employ strategies to stay engaged and achieve desired learning goal.	Approach
To make the user, understand the tool to complete a task.	To help the learners employ strategies to accomplish learning goals.	Target

3.3.4 Classification for framework

3.3.4.1 Classification of discussion forum posts

We exported data from the Academic writing course from Case III of Study 1. However, two major categories based on related keywords namely CR and NCR were chosen for the experiment. We adopted an LDA (Latent Dirichlet Allocation) technique to understand the discussion forum posts (Cummins and Nambudiri 2022). The LDA model is an unsupervised technique widely used for analyzing content with the categorization of similar posts in discussion forums (Huang et al., 2021; Peng et al., 2020), and each extracted topic is a compact semantic cluster and worked with the low similarity between different labels or topics (Huang and Wang 2021). Therefore, the topics were labeled manually based on the highest probability (prob) occurring word in the topic itself. We used tf-idf method to calculate the weight of each keyword. Among 819 posts, we classified several themes as CR and NCR. However, the eight highest frequency words from five relevant topics namely manuscript (52), journal (52), h-index (27), plagiarism (22), and publish (14) under the category of CR were considered as shown in

Table 12. Although all the keywords from the CR category can be interrelated. However, it depends upon the instructor how many categories are necessary according to the frequency of posts and can be maintained by MOOC design facilitators. Similarly, Table 13 describes the three NCR relevant topics having the ten highest frequency words that were considered represents the NCR topics namely assignment (152), examination (194), and distress (32). In NCR categorization, three relevant topics having the ten highest frequency words were considered. This study helped in tracking the interest of learners in a particular topic.

Table 12 Word probabilities within topics created by the LDA model for CR

Word	Prob	Word	Prob	Word	Prob	Word	Prob	Word	Prob
manuscript	0.025	plagiarism	0.059	journal	0.111	index	0.078	publish	0.008
peer	0.016	idea	0.057	plant	0.058	Scopus	0.056	scholar	0.007
write	0.013	write	0.051	impact	0.026	scholar	0.053	google	0.007
score	0.013	origin	0.033	finance	0.029	google	0.051	rank	0.007
attach	0.012	letter	0.025	Scopus	0.028	factor	0.033	best	0.006
obtain	0.011	person	0.025	factor	0.025	impact	0.025	research	0.006
submit	0.011	author	0.019	molecular	0.020	psycho	0.020	score	0.006
review	0.008	word	0.017	biology	0.020	journal	0.019	answer	0.006

Table 13 Word probabilities within topics created by the LDA model for NCR

Word	Prob	Word	Prob	Word	Prob
assignment	0.041	exam	0.010	distress	0.060
week	0.040	certificate	0.007	expect	0.020
course	0.032	score	0.005	complete	0.013
quiz	0.026	grade	0.005	easier	0.012
submit	0.021	assignment	0.005	upload	0.012

grade	0.018	result	0.004	material	0.012
mark	0.015	link	0.004	content	0.012
learn	0.014	dear	0.004	course	0.011
write	0.014	receive	0.004	end	0.010
assess	0.014	kindly	0.004	valid	0.010

3.3.4.2 Type of participants

We set three unique combinations to select the participants for our experiments as shown in

Table 14. The first combination of recruited participants was selected from our laboratory to focus on both perspectives of education and designing. As our laboratory has an excellent student with a background in educational research and design so we selected all those English-speaking students. The second combination was of Indian students in our university and the MOOC platform to observe their familiarity with the system. However, the ratio was fifty-fifty. Although some of the Indian participants were already familiar with the SWAYAM platform; they never used the SWAYAM discussion forum. Therefore, there was no major difference in the user experience. The third combination or majority of recruited participants were from diverse countries with diverse experiences and ideas from international participants.

Table 14 Combination of themes for participation

Combination			Target participants	Number of cases
Designing research	×	Educational	KIM LAB, JAIST	5
Indian	×	Indian MOOC platform	Indian students, JAIST	8
Diverse	×	Ideas	International participant, JAIST	15

Table 15 summarizes the participants' demographics and backgrounds. A total of twenty-eight participants from seven different countries including China, India, Japan, Myanmar, Vietnam, Bangladesh, and Thailand participated in the experiment. Among twenty-eight recruited participants, eighteen participants were male and ten were

female. Regarding age, most participants were 25-30 years old. Only four participants were between 35-40. The majority of participants were Ph.D. students, and seven students were from master's studies. There were only three post-docs employed. According to participants' experience with the discussion forum, three categories were set as experienced, not experienced and they were not sure, or they do not remember. Furthermore, three groups were categorized based on their experience of asynchronous discussion forums; thirteen were in the category of experienced (G1); seven participants with no experience (G2), and eight were unsure whether they used the asynchronous discussion forum in the past or not (G3). However, all the participants have a research background from the same university.

Table 15 Participant's demographics and background

Participants' demographics and background		Number of cases (n=28)
Gender	Male	18
	Female	10
Age	21-25	5
	25-30	13
	30-35	6
	35-40	4

Education	Master's student	7
	Ph.D.'s student	18
	Post Doc	3
User experience	Experienced (G1)	13
	Non-experienced (G2)	7
	May be (G3)	8
Theme	KIM LAB	5
	Indian	8
	International	15
Country	China	7
	India	8
	Japan	3
	Myanmar	1
	Vietnam	4
	Bangladesh	2
	Thailand	3

3.3.5 Designing the interactive discussion forum

3.3.5.1 Design of question sheet

The question sheet used in the navigation experiment was designed based on the BRUSO model. The BRUSO model is an effective model used in designing the survey questionnaire sheet (Peterson, 2000). However, in the navigation experiment, we also

need to select certain questions that should be easy to understand by recruited participants in terms of concision, relevancy, clarity, subject-specific, and intent toward the goal. Therefore, we implemented the BRUSO model while selecting questions from the original discussion forum asked by real learners.

- **Brief:** Ignoring the long questions that are seven to eight sentences.
- **Relevant:** Considering only those queries that had a response by the instructor or other learners.
- **Unambiguous:** Six questions were set depending upon the time availability for the experiment.
- **Specific:** Selected only those questions that we already classified namely examination, content-related, assignment, and certificate.
- **Objective:** Each question consisted of different words. As in the experiment, we also need to test the keyword selection by participants and usability using the searching technique. Therefore, we also implemented the Prisma method along with the BRUSO model to select the questions with the following specific conditions:

- **IDENTIFICATION:**

Total posts in the discussion forum (n= 819)

Initial six pages only (n=180)

- **SCREENING:**

Screening is based on classified keywords namely examination, content-related, assignment, and certificate.

Several posts relating to a particular keyword

- **INCLUDED:**

Repetitive queries (Similar kinds of questions asked by other learners in different formats).

Selected only popular posts (n=6) depending upon the views and BRUSO model as shown in Figure 13.

Question sheet

Question 1: How to download the Admit Card?

Question 2: If research is published in conference proceedings, can it still be published in journals?

Question 3: When marks of second subjective assignment will be posted on Website?

Question 4: What is the requirement of a PhD thesis either a research paper or a review paper?

Question 5: Link for certificate of webinar held on 20 and 24 th may

Question 6: Exam Mock test link

Figure 13 Design of question sheet

3.3.4.2 Design and prototype of three kinds of the discussion forum

The main objective of designing information architecture is to present information easy to navigate and easy to understand. To achieve this objective, the context (what we are presenting) and the user (who is processing) work parallelly (Santoso et al., 2018). Furthermore, four design components were formulated to achieve our discussion forum design goal: 1.) An organization of discussion forum posts 2.) labeling system of discussion forum posts 3.) navigation system to browse the posts 4) a search system to search the posts (Jacob, 2009). Therefore, the discussion forum design was based on nine features that were somehow related to information visualization and the Gestalt principle (C. Chen, 2010; Shaw, 2010). The selected nine features were namely, platforms used for creating a discussion forum, color theme, alignment of categories, arrangement of categories, repetition of posts, navigation tool, icons, classification of posts, and locking system. Table 16 describes the three kinds of discussion forum designs that were delivered to each recruited participant in the experiment.

Table 16 Describes the three patterns of the discussion forum

Features	D1 (Original)	D2 (Redesigned)	D3 (Redesigned)
Platform used	Google groups	Google forms	Wix
Color theme	B/G: white. Text: black; blue and red combination for pre-mentioned exam information (not noticeable)	B/G: white. Text: black	B/G: black. Text: white. Link: separate color
Alignment of categories	No	Vertical	Horizontal
Arrangement of categories	No	Alphabetically	Alphabetically
Repetition of posts	Yes	Yes	No
Navigation tool	Yes	No	Yes, and for each category

Icons	No	No	Yes
Classification of posts	No	Only 5 sections	Further subcategories of CR
Locking system (posts that do not require further discussion)	No	No	Yes

• Original designed discussion forum (D1)

The discussion forum was already available in the google group discussion forum as shown in Figure 14, there were 819 comments with repetition of queries. The combination of the color theme was only black and white mainly. The background color was white, and the learner's posts were black. Furthermore, there was a combination of red and blue for mentioning some of the exam-related information which was not eye-catching. None of the participants noticed the exam information on the d1. All the posts were vertically aligned according to the posting date. A navigation tool was provided but with limitations.

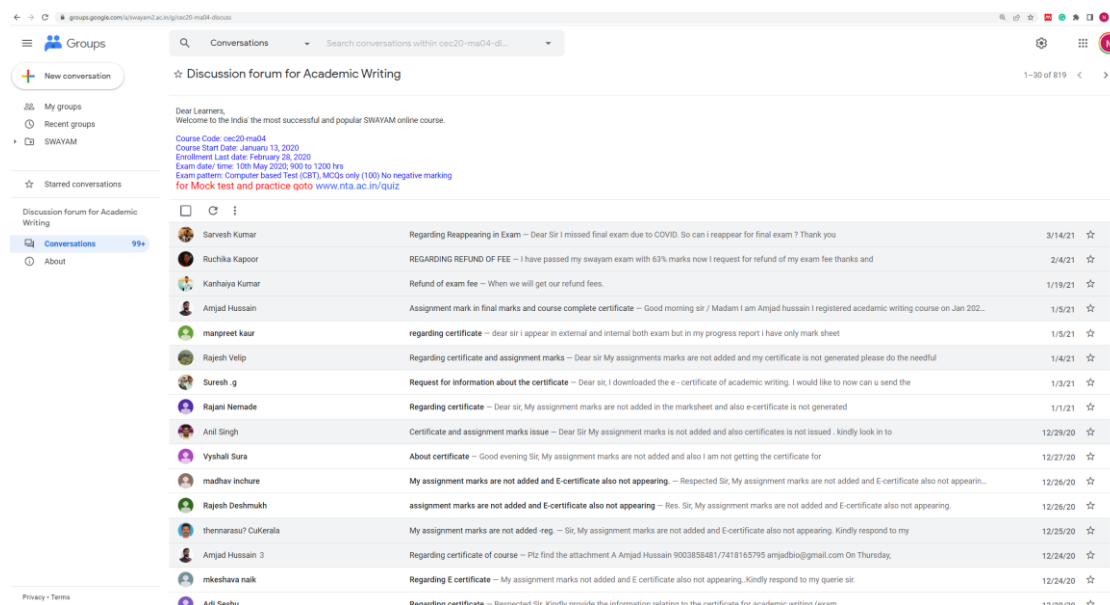


Figure 14 Original design of discussion forum in google groups (D1)

- **Redesigned discussion forum 1 based on scrolling (D2)**

The discussion forum was created in google forms to check the scrolling feature derived from D1 as shown in Figure 15. In D2, questions were chosen from the first initial 3 pages (until 90 questions) of the real discussion forum of the Academic writing course. The combination of color themes in the discussion forum was only black and white. All the posts were vertically aligned and distributed among their desired section. Each section was arranged according to alphabetical order and questions with answers were set in the topmost position of each specified section. Some posts were a combination of queries asking about two or more questions in the same post. For example, assignment and certificate-related posts. In this type of case, we considered the initial part of the question. A total of 66 questions were set in the discussion forum with five sections namely assignment (7), certificate (25), content-related (4), exam (27), and technical error (3).

Discussion forum

neha.balhara92@gmail.com
Switch account

Assignment

I registered acedamic writing course on Jan 2020 session and I attend exam in the month of September 2020. Still I didn't receive assignment marks in my final exam mark and course complete certificate. Kindly do the needful.

☐ Option 1

My assignment marks are not added and E-certificate also not appearing. Please give me replay for this issue.

Your answer

When marks of second subjective assignment will be posted on Website?

☐ As Manual Correction is in progress....very soon result may be released.

Is it either or option for the subjective assignments, which means only one will be considered for valuation? As i could not get any access to computer during these days of lockdown, i could not do few of my recent assignments. But, i have done both the first and second subjective assignments. So, what will happen? How will the marks be calculated. Please clarify.

☐ Only one subjective assignment (with the highest scoring) will be taken into consideration during the final result preparation.

My assignment marks is not added and also certificates is not issued .

☐ Option 1

My assignment marks not added and E certificate also not appearing..Kindly respond to my querie sir.

Figure 15 Redesign discussion forum in google forms (D2)

• Redesigned discussion forum 2 based on Categorization label (D3)

The discussion forum was customized in Wix software as shown in Figure 16. The color theme was a black background and white text, pastel pink for links. The alignment of posts was horizontal and alphabetical, and subcategories were also defined with no repetitive posts. However, we asked participants to first check the category if it did not

match then participants were allowed to use the search technique. Only one of the participants required that searching technique.

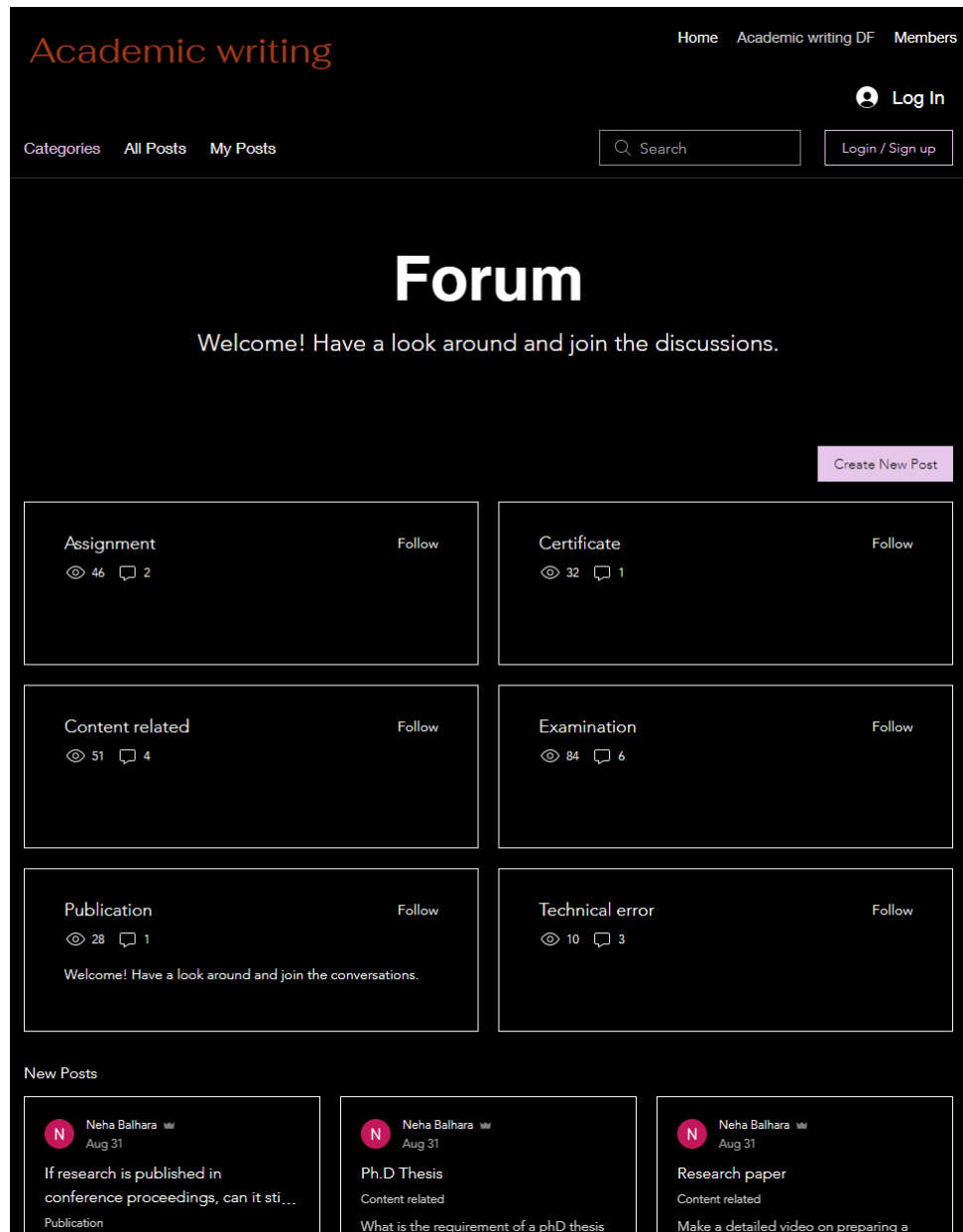


Figure 16 Redesign discussion forum in WIX (D3)

3.3.6 Design evaluation

Past research reported that navigation or finding a topic to discuss is the most difficult task in the usability issue of the forum platform. A study was conducted on OpenEdX

and claimed that navigation was the main problem under usability issues of the forum platform. Also, the task of searching for discussions of interest to post new questions was difficult to perform. Moreover, navigation within a discussion forum of large number of replies was much more time consuming. Another issue of search tool or function did not improve the navigation process because of typing issue, spell checker and many more. Therefore, this study focused on implementing a navigation experiment with design-based approach and development of classification method that distinguish CR and NCR posts. Therefore, the Anticipatory data reduction method was implemented to evaluate the study efficiently and effectively with reliable results (Ntourmas et al., 2019b).

3.3.6.1 Learner's experience and interaction with three patterns of a discussion forum:

Navigation was the task chosen for the experiment and three discussion forums were delivered to each participant for navigating the set of six questions. The sequence of distributing discussion forums to participant was based on their preference. During the experiment three variables were measured through python programming and later analyzed by SPSS software (Statistical Package for Social Sciences):

1. time taken in navigating questions from three different patterns of the discussion forum (t_1 , t_2 , t_3).
2. the number of clicks (c_1 , c_2 , c_3) clicked while searching questions.
3. the number of scrolls (s_1 , s_2 , s_3) performed by each participant in three different discussion forums (D_1 , D_2 , and D_3) respectively.

3.3.6.2 Organization and usability issues of patterns of a discussion forum:

The representation of the design or pattern of three discussion forums was evaluated by participants with three themes namely usability demerits, merits, and design ideas of each discussion forum.

Chapter 4 Results of Study1

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4.1 Existing interaction state in three cases

4.1.1 Case I: Two computer courses

4.1.1.1 Analysis of various posts in the discussion forum of two computer courses

Figure 17 shows a considerable difference between CR and NCR posts in both computer courses. Analysis of various posts of the SWAYAM discussion forum in computer networks (Course A) and computer architecture course (Course B) showed that the posts were CR, QR, AR, TR, and others (those post that was not related to the specified indicators). We observed that the highest number of posts asked by learners was of content related to both courses. In Course A, the content-related queries were 38% while in Course B were 49%.

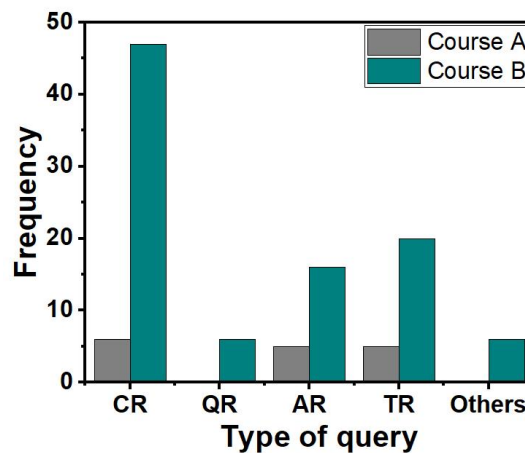


Figure 17 Analysis of various posts in two computer courses

4.1.1.2 Interactions among learners and the supervisor

It was rare to find a thread with a similar format of queries in the discussion forum of these two courses. For example, in the case of a computer architecture course, there were 95 posts in the discussion forum in which there were only 4 similar posts that were posted in a single thread, but all the posts had a reply from the instructor and a single

reply was from a learner as shown in Figure 18. Overall, only 9 posts out of 95 got a reply from the instructor.

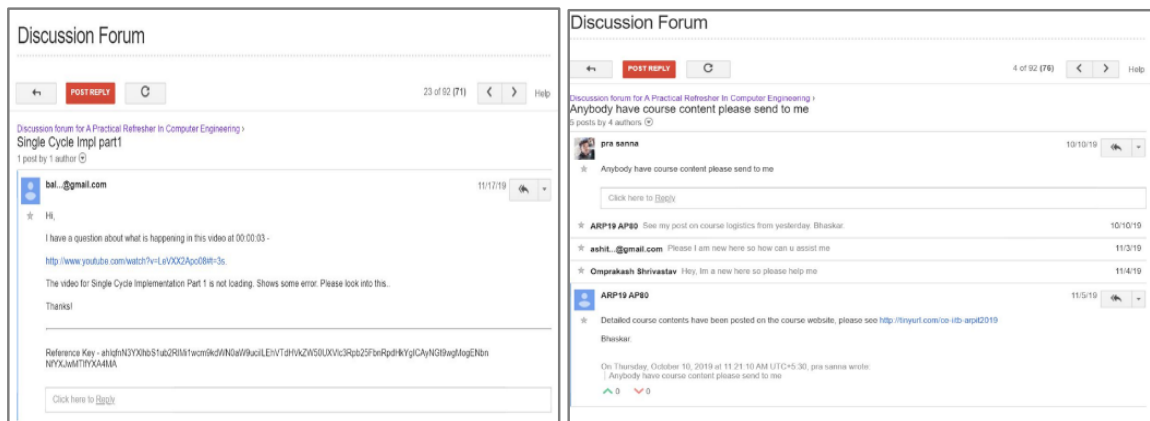


Figure 18 Screenshot of a Discussion forum with a single post (left side) and similar posts in a single thread (right side)

On the other hand, the computer networks course had only 16 posts so far, as of the 7th week of the total 12th week's course, and 10 posts from them were answered by the instructor and a single post by the learner. However, gradually when the number of posts increases, it results in a mingling of comments.

It becomes very difficult for an instructor to answer individually to all the posts. It was found that there is still no reply from the instructor regarding several posts related to the course content. However, CR posts are the most important part of an online discussion forum in an E-learning platform and should be higher. As Table 17 suggests, interactions regarding CR posts for Course A and Course B were 50% and 19% respectively, while interactions about AR (Course A 83 % and Course B 25 %) and TR (Course A 60 % and Course B 25 %) posts were comparatively high (Neha & Kim, 2020). Also, the total percentage of interaction between learners and instructors in course A was 69 % and, in course, B was 19 % as shown in Figure 19 which was very low compared to registered students.

Table 17 Interactions among learners and instructors in Case I (Neha & Kim, 2020)

In Course A			In Course B	
Query Type	No. of posts	Interactions	No. of posts	Interactions
CR	06	03 (50%)	47	09 (19%)
QR	00	00 (-)	06	00 (-)
AR	06	05 (83%)	16	04 (25%)
TR	05	03 (60%)	20	05 (25%)
Others	00	00 (-)	06	00 (-)
Total	16	11 (69%)	95	18 (19%)

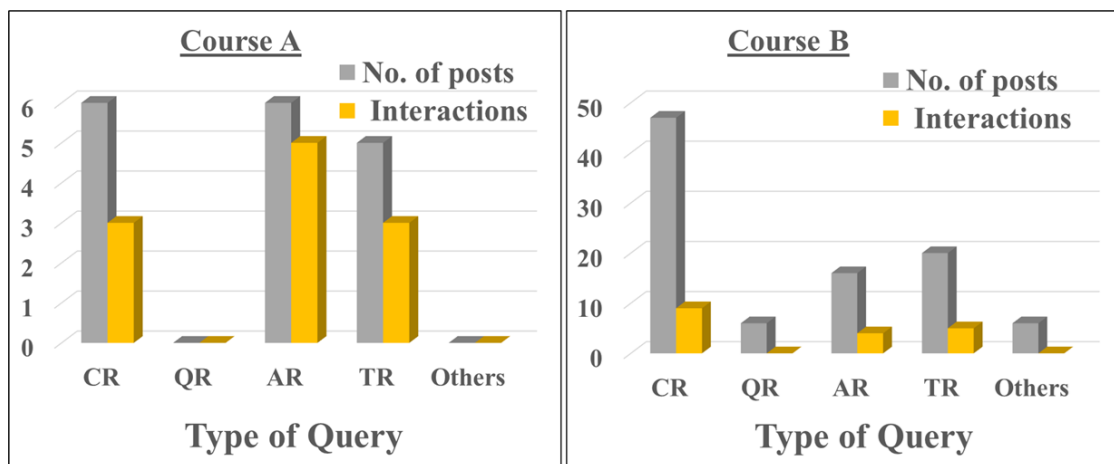


Figure 19 Frequency of posts and interaction in Case I

4.1.2 Case II: Theoretical course and practical course

4.1.2.1 Comparison of learners' queries and their interaction with instructors

Despite the large, registered learners with 11,973 in the theoretical course and 15,645 in the Practical course, there were few posts from the learner side for both courses, as shown in *Table 18* (Neha & Kim, 2021a). Moreover, the ratio of CR posts to NCR posts was significant for the theoretical course, which was 8% to 91%. However, for the practical course, this ratio was 55% to 44%. Also, the total interaction including peer learning and instructor reply was 85 posts (75%) of all the threads in the theoretical course and 108 posts (78%) of all the threads in the practical course.

Table 18 Interactions among learner and instructor in Case II (Neha & Kim, 2021a)

Type of Course	Theoretical course	Practical course
Total posts	113 (till 17 Sept.)	137 (till 30 Sept.)
Total Interactions	85 (75%)	108 (78%)
CR posts	10 (08%)	76 (55%)
NCR posts	103(91%)	61 (44%)

4.1.2.2 Peer learning

The result is somewhat surprising in the discussion forums of the theoretical course and practical course as we observed less exchange of information among learners. For the theoretical course, peer learning was 15%, while for the practical course it was only 2%. There was a lack of knowledge sharing and collaborative learning. However, these two are important factors when it comes to interpreting the question-answering process in the CQA system. Learners can communicate with each other on a specific identical question instead of asking the same question again. This can reduce instructor workload (Srba & Bielikova, 2016).

Role of linguistic features

The linguistic features extracted from the discussion forum posts for NCR are examination or exam, certificate, credit assignment, test, and question. These are the most commonly occurring words in the query subject. Query subject refers to the title of the query. We neglected the grammatical terms of queries.

For the theoretical course, we were able to extract 90 (87%) queries out of 103 NCR posts. In contrast, we extracted 55 (90%) queries out of exactly 61 queries of NCR by using these linguistic features in a practical course, as shown in Table 19 (Neha & Kim, 2021a). The classification technique used the linguistic feature assignment for AR posts and TR posts. The linguistic feature was examination, certificate, test, and credit. NCR posts were mostly related to inquiries.

Table 19 Role of linguistic features in classifying posts (Neha & Kim, 2021a)

Linguistic feature	Post type	Frequency in theoretical course	Frequency in the practical course
Assignment	AR	20	28
Examination	TR	38	8
Certificate	TR	14	14
Test	TR	17	3
Credit	TR	1	2

Table 20 shows several collocations such as "test date", "assessment date", "exam date", and "test week" from the dataset of posts subjects for a better understanding of posts. Each collocation shows a perfect positive relationship (value is greater than zero). The strongest correlations between the words of the post subject (Term 1 and Term 2) were determined using a correlation tool. The correlation of words describes the post type

without reading the complete post in detail. For example, “test date” describes the learner asking regarding the date of the test; “test week” describes asking about the week of the test. These features were later used to classify CR posts and NCR posts.

Table 20 Correlations of words in posts subjects

Term 1	Term 2	Correlation	Significance
Date	Test	0.97	0.0000022
Function	Submission	0.96	0.0000039
Date	Week	0.95	0.0000251
Correct	Submitted	0.93	0.0000636
File	Header	0.93	0.0000636
Start	Time	0.93	0.0000636
Completion	Related	0.93	0.0000950
Matrix	Related	0.93	0.0000950
Operating	Related	0.93	0.0000950
Enquiry	Examination	0.92	0.0001175
Examination	Wrong	0.92	0.0001175
Test	Week	0.92	0.0001277
Assessment	Date	0.92	0.0001341
Dates	Exam	0.92	0.0001525
Exams	Sir	0.91	0.0002267

Feasibility of voyant tools in clustering CR and NCR posts subjects

The priorities of posts can be set using the cirrus tool and the instructor can focus according to the significance of the posts in the online discussion forums. In the case of two discussion forums of practical and theoretical courses, the most frequent post asked by the learner was AR so it can be considered the prioritized post. It should be answered first by the instructors. However, the cirrus tool cannot generate clustering of CR and NCR posts subjects. Post subjects (thread title) are short headings to introduce the post type. However, several post subjects were found that were too long and time-consuming for the reader and writer to understand the post type. Using the Voyant Tools, these types of long post subjects were dealt with efficiently by removing unnecessary stop words.

The Scatter Plots were created using the t-SNE (Distributed Stochastic Neighbor Embedding) tool. The technique behind the analysis is tf-idf (term frequency-inverse document frequency). The tf-idf aids in determining the importance of a word in the document and clustering of terms. The range of perplexity (P) and the number of iterations (I) are the two crucial factors for an analyst. A high level of data resolution and more accurate data interpretation can be achieved by implementing perplexity and iteration (Hetenyi et al., 2019).

In this study, seven experiments were carried out in three phases. In the first phase of the experiment, clusters were generated by setting the value of perplexity as to the highest range (100) and the number of iterations as to the lowest range (100). However, the clusters were not sufficiently accurate to distinguish content-related and non-content-related queries as shown in Figure 20.

In the second phase, the level of perplexity remained constant, with varying iterations to test how the model changes at different iterations (Figure 21, Figure 22, and Figure 23). In the third phase, the level of perplexity was set to the highest value (Figure 24, and Figure 25). The results were able to demonstrate the clusters of CR posts and NCR posts independently. The finding suggested that, in general, there were more NCR posts than CR posts. The best result in a clustering of posts of CR and NCR posts was found with P=100 and I=1000, as shown in Figure 24. We observed that increased perplexity yields better visualization in our dataset. The Voyant Tools is effective in analyzing

discussion forum query subjects in terms of quality and quantity. The findings of this study indicate that the Voyant Tools offer several benefits to researchers and that their use as a tool for discussion forums should be further explored.

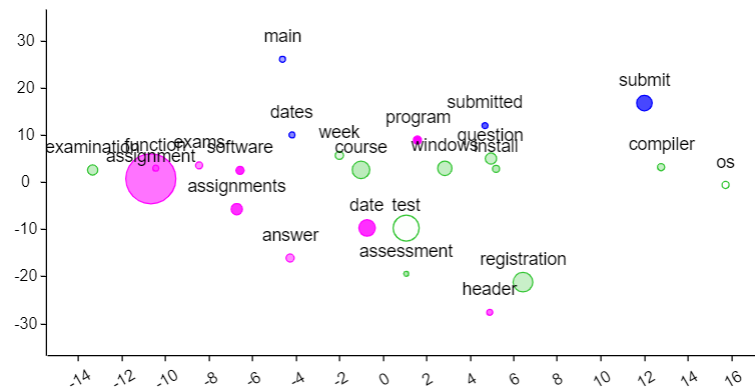


Figure 20 t-SNE generated clusters at P and I = 100 (same)

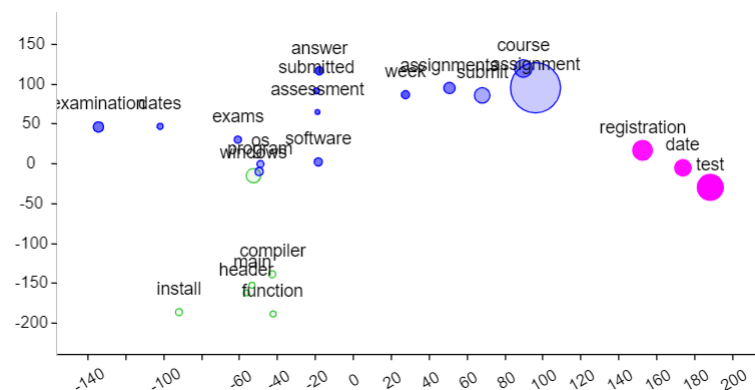


Figure 21 t-SNE generated clusters at P=5, I=2000

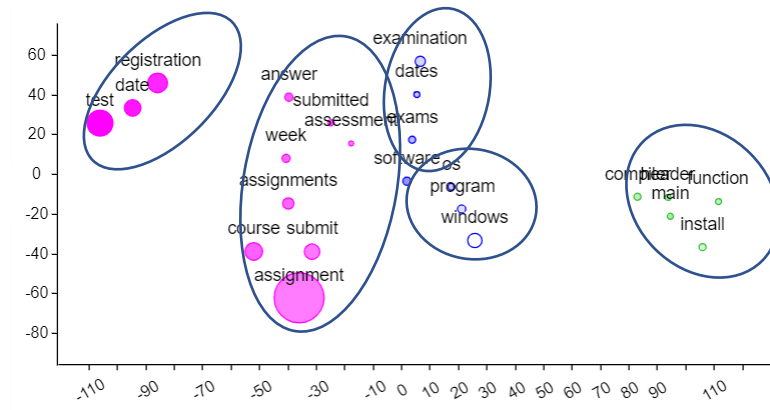


Figure 22 t-SNE generated clusters at P=5, I=3500

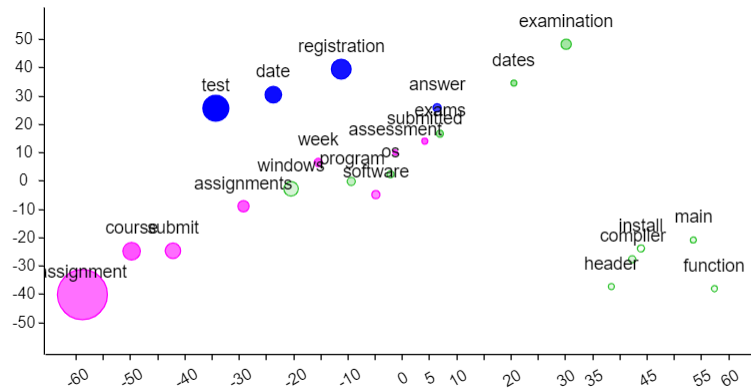


Figure 23 t-SNE generated clusters at P=5, I=5000

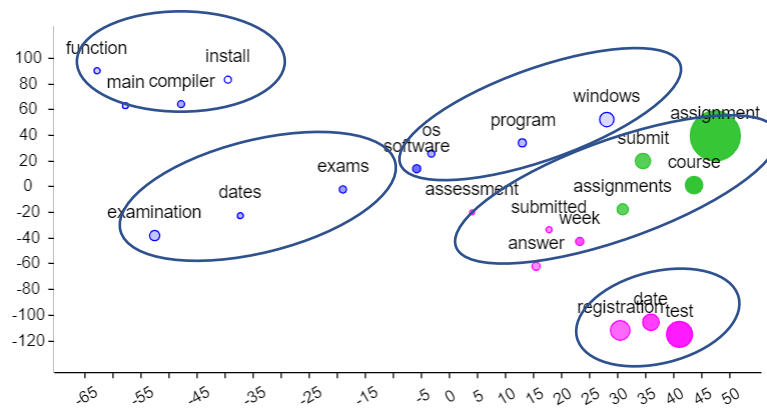


Figure 24 t-SNE generated clusters at P=100, I= 1000

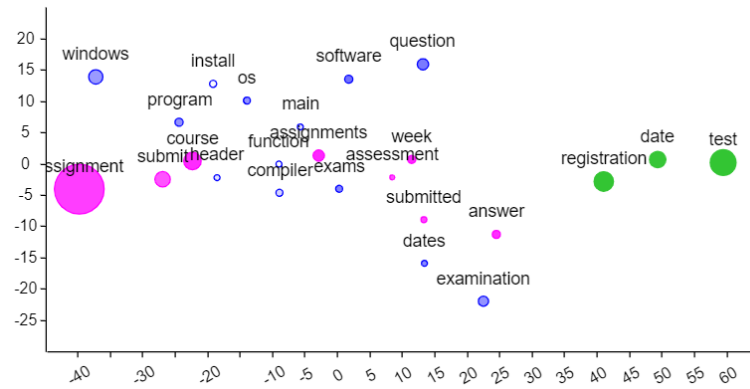


Figure 25 t-SNE generated clusters at P=100, I=1500

4.1.3 Case III: Academic writing course

4.1.3.1 Classification of posts based on related keywords

Content-related posts (CR)

The types of CR posts were analyzed to get the idea of course content based on extracted topics using a word cloud in ATLAS.ti as shown in Figure 26. A total of 301 posts were found to be CR. However, eight significant topics were extracted based on the course content and topic frequency—journal (93), h-index (41), research papers (38), plagiarism (30), impact factor (23), references (22), publication (20), and citation (15). Table 21 describes the investigated significant CR topics with examples and the frequency that shows the interest of learners. Furthermore, extracted significant topics can be used by the instructor to provide relevant knowledge and enhance the learner's performance in the assignment and final examination.

	<ul style="list-style-type: none"> • Is the journal university grant commission approved?
H-index (41)	<ul style="list-style-type: none"> • How can I find the H-index on Web of Science? • What is happening in this video at 00:03:56? • What is happening in this video at 00:00:02? • Sending one of the best teachers h-indexes from Scopus. • H-index of the expert in my research field is attached here.
Research papers (38)	<ul style="list-style-type: none"> • Is there any source for bibliometric analysis? • What is the minimum limit for inclusion in research papers? • Does Mendeley allow access to all free and subscription referencing? • Could you provide a standard research paper writing (introduction and methodology sections) for the humanities field? • Is it mandatory to write a review paper to do research?
Plagiarism (30)	<ul style="list-style-type: none"> • In Avoiding Plagiarism Part-2 more explanation is needed with examples. • Please advise what is the permissible plagiarism limit. • What does direct plagiarism mean? • What is the difference between plagiarism and similarity in academic writing? • Should we use the free plagiarism detecting software/website or not?
Impact factor (23)	<ul style="list-style-type: none"> • Best five journals in education with high impact factor. • Identified high impact factor to my field. • Attached lists of journals in my field with impact factor. • Unfortunately, they don't have any impact factor.

- High Impact Library & Information Science Journals are as follow.
- References (22)
- What is the reference format?
 - For a beginner, what is recommended to start textbook writing?
 - Can we include other's work giving reference to it as background in the abstract section?
 - Difference between the terms "clarity" and "unambiguous"?
 - Can you share a quality review paper in social sciences for reference?
- Publication (20)
- India's top 3 institutes based on World University Rankings.
 - How many publications are required during a research period?
 - Can I submit my thesis showing acceptance paper proofs?
 - According to QS World University Rankings
 - Can this course be considered sufficient for publication ethics and publication misconduct topics?
- Citation (15)
- How to differentiate our citations in this situation?
 - Using images or graphs published by other authors with proper citations in the text. Is it plagiarism?
 - URL of having maximum number of publications and citations.
 - Could not find my paper in Google Scholar?
 - How to ascertain citation of articles published by me?
-

Non-content related posts (NCR)

The maximum number of posts in the discussion forum were NCR. Most of the NCR posts were redundant and had high frequency. Therefore, we grouped NCR posts into five different categories with topic frequency namely assignment and quiz related posts (152), examination related posts (194), course certificate posts (86), technical issues (100), distress (32) based on the extracted keywords as shown in Table 22.

Table 22 Five different categories of non-content-related posts

Categories	Keywords	Criteria	Example posts
Assignment and quiz-related posts (152)	quiz, graded, assignment, assessment, week, marks	Assignment and quiz-related posts were merged during the classification of NCR posts because the posts were directly related to each other in terms of submission, assessment as well as problems related to their content. Furthermore, redundancy was checked to later categorize assignment and quiz-related posts as Frequently Asked Questions (FAQ).	<ul style="list-style-type: none"> • Are there any graded quizzes for week 15? • Is there any week 15 graded quiz? • How are the marks of internal assessment allotted as we have 14 graded quizzes? • When is week 14 graded quiz going to be released? • Folks, at long last, week 14 graded quiz is released. • Is there any graded quiz for week 14? I could only find a self-assessment. • There is no graded quiz for week 14.
Examination-related posts (194)	exam, fees, pattern, center, time, result from	important posts and information-seeking posts	<ul style="list-style-type: none"> • Resolve the issue for final examination. • Eligible for exam or not. • Any hint on schedule for the examination?

			<ul style="list-style-type: none"> • Would like to know the date of examination and when registration for the exam will happen? • My query is regarding the venue of examination.
Course certificate posts (86)	certificate	high frequency	<ul style="list-style-type: none"> • Still, I didn't receive course completion certificate. • No link for certificate. • Certificate has not been generated. • In my certificate, there is no gold logo even though I secured 80%. Request you kindly send hard copy to individuals with the logo. • When will we get the certificates?
Technical issues (100)	username, password, login, technical error, not working, problem, not found, not showing, not visible	high frequency of obstacles in the learning process	<ul style="list-style-type: none"> • Forgotten username; password • Problem in log in. • In the course outline, the blue dot cannot be seen. • Not able to see any pre-survey link. • Technical error in submitting. Submit button is not visible.
Distress (32)	personal, distress, uncertainty period, humble request, bad situation,	learner's personal experience	<ul style="list-style-type: none"> • Not able to submit because of personal reasons. Humble request. • Can someone please share the link? Unable to see were to login. • Extremely distressed, please provide update regarding registration. We have been waiting for months.

unable,
doubt,
difficult

- Also, I have the same doubt and am waiting for the answer eagerly.
 - How can I access the videos and PDFs of this course? How can I save them so?
-

4.1.3.2 Classification of posts based on the CoI framework

Generally, learners expressed their presence with long posts which were difficult to read in a short time and created confusion about what to read and what not for learners and facilitators. Using the CoI approach, the classification of posts was based on human judgment and snippets that fit the best under cognitive, social and teaching presence as shown in Table 23. Furthermore, all three presences of CoI are interrelated (Hasani et al., 2022). However, we categorized all the posts to make them meaningful educational experiences.

Table 23 Example posts for cognitive, social, and teaching presence

Cognitive presence	Social presence	Teaching presence
Like to add my opinion . So, I kindly request you to consider and clarify the same.	Could you please explain in interest of the learners?	The information you require is on the description of the course on the landing page
While delivering the lecture M38, Part 2, it has been told that...	But, in my opinion, the correct response should be evaluated and will be displayed by option... Please clarify in the interest of the learners.	Don't worry. It is getting the end of the course. You keep on learning.
Can anyone please clarify the right answer?	Many learners like me who have not realized this earlier.	Welcome to the course. On the left side of the course page...
Is the certificate of the course AW useful for UGC Career Advancement Scheme as per 7th pay commission for teachers in colleges and universities?	Let me use this platform to register a concern that may be mutually shared .	Dear Learner, Idea plagiarism...
Thank you so much for such wonderful topics. Really interesting and must-learn concepts. How to differentiate our citations in this situation?	Feeling highly unfortunate . Let me forego the fees as a punishment for making this wrong decision.	Dear Learner, Paraphrasing means...
Is it mandatory that all the quizzes should have been submitted? Latest notification , score of best 5 should be taken to check the internal score. Am I eligible?	Please think about the writing exam in the pandemic situation. Is it fair for all those who have enrolled to take the exam? Humble request . Kindly do the needful. I hope all the participants of this	The issue has been rectified. There should be no trouble in viewing...

4.1.3.3 Learner's behavior in the discussion forum

Table 24 presents the weekly course topics along with the frequency of discussion forum posts. The interest of learners varied according to the course topic. If the frequency of posts were below 20, the interest of learners was taken as “low”; if the post frequency was below 50, the learners’ interest was entered as “moderate” into the system, and when the frequency of posts was above 50, it was believed to be of “high interest”. Furthermore, Figure 27 presents the frequency of posts per month, including pre-course (before January 2020), during the course, and post-course (after April 2020) posting behaviors. Mostly the discussion forum was overloaded during the examination phase and this phase is important for learners to get a timely reply.

Table 24 Weekly course topics and the frequency of discussion posts

Week	Course topic of the week	Posts
Week 1	Academic and research writing: Introduction; Importance of academic writing; Basic rules of academic writing	Moderate
Week 2	English in academic writing I & II; Styles of research writing	Moderate
Week 3	Plagiarism: Introduction; Tools for the detection of plagiarism; Avoiding plagiarism	Moderate
Week 4	Journal metrics	Low
Week 5	Author metrics	Moderate
Week 6	Literature review: Introduction; Source of literature; Process of literature review	Moderate
Week 7	Online literature databases; Literature management tools	Low
Week 8	Review paper writing, I and II	Low
Week 9	Research paper writing I, II, and III	Moderate
Week 10	Referencing and citation; Submission and post submission	Moderate
Week 11	Thesis writing, I, II, and III	High
Week 12	Empirical study I, II, and III	High

Week 13	Challenges in Indian research and writing; Team management (mentor and collaborators); Time management	Moderate
Week 14	Research proposal writing; Abstract/conference paper/book/book chapter writing, OERs: Basic concept and licenses	High
Week 15	Open Educational Resources (OERs) for learning and research; OERs development I & II	High

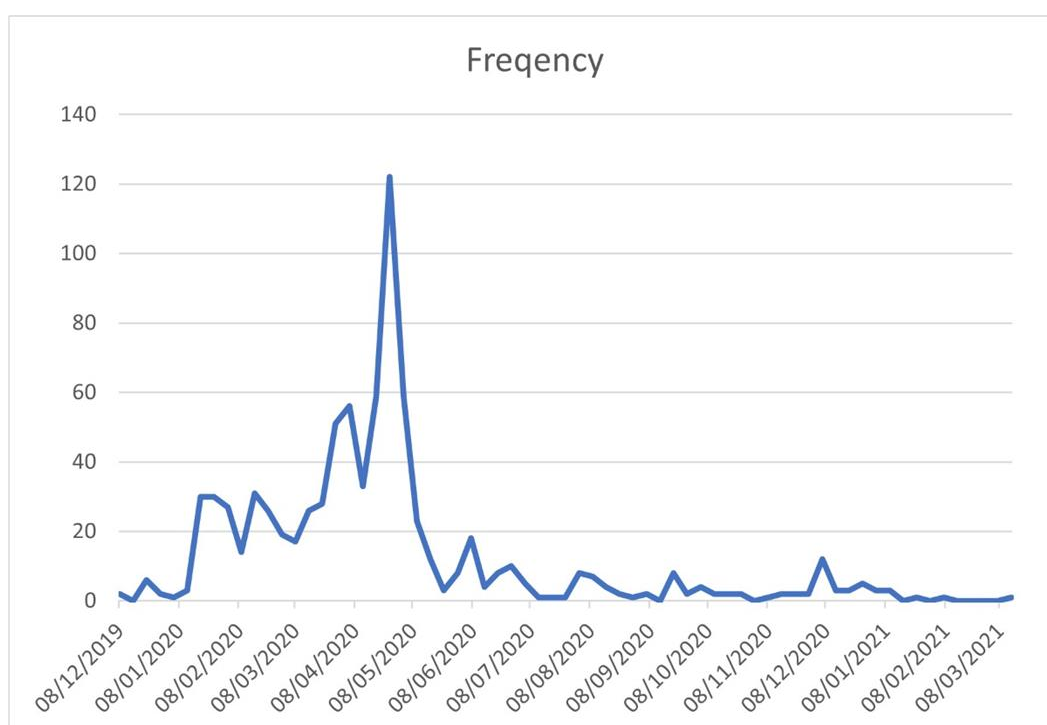


Figure 27 Frequency of posts per month

4.1.3.4 Classification of learners based on the ICAP framework:

Classification of learners based on their contribution in a discussion forum can help in analyzing learners' performance and their interests (Hecking et al., 2017). However, the dataset in the current study was limited to discussion forum posts only. A previous study by the authors analyzed the frequency of successful learners based on their participation in the discussion forum. Furthermore, the study observed that learners

who posted CR posts or both CR and NCR posts achieved better course grades as compared to only NCR contributors (Wise and Cui, 2018b). Therefore, in this study that focused on asynchronous discussion forums, we analyzed both CR and NCR contributors as shown in Table 25.

Table 25 Type of learners based on the ICAP framework

Type of learners	Previous study	Current study
Passive type	Learners who have no contributions to the discussion forum.	Learners who have only NCR posts but no CR posts.
Active type	Learners who have contributed at least one CR post.	Learners who have NCR or CR posts or social presence.
Constructive type	Learners who act as a knowledge constructor by initiating thread posts, typically CR posts.	Learners who post positive comments.
Interactive type	Constructive learners who exchange CR posts in a particular thread.	Learners with cognitive, social as well as teaching presence.

Chapter 5 Result of Study 2

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5.1 Learner's behaviour and interaction with three patterns of discussion forums

A significant difference was found between the three discussion forums. The result was significant at the $p < 0.05$ level. The One-Sample test revealed a significant difference between the time taken (t), the number of clicks (c), and the number of scrolls (s) performed by participants while navigating in D1, D2, and D3. Altogether, what particularly stands out is the time taken by participants in three different patterns of discussion forums. The time gap is worth highlighting, as $t1 > t2 > t3$ as shown in Table 26. The observed increase in $t1$ could be interpreted as the number of clicks and number of scrolls while navigating questions in the discussion forum. Therefore, we were also interested in tracking the number of clicking and scrolling which were also important in the navigation study. Further analysis showed that $c1 > c3 > c2$ (see Table 27) and $s2 > s3 > s1$ (see Table 28). Also, the analysis did not show any significant differences between G1, G2, and G3 at $p < 0.05$ as calculated by using the relative frequency contingency test on the mean difference of time taken in three discussion forums as shown in Table 29.

Table 26 One sample test for time taken in D1, D2 and D3

	t	df	One-sided p	Two-sided p	Mean difference	Lower	Upper
t1	15.381	27	<.001	<.001	442.393	383.38	501.41
t2	12.724	27	<.001	<.001	229.643	192.61	266.68
t3	16.809	27	<.001	<.001	214.714	188.51	240.92

Table 27 One sample test for number of clicks in D1, D2 and D3

	t	df	One-sided p	Two-sided p	Mean difference	Lower	Upper
c1	15.733	27	<.001	<.001	82.536	71.77	93.30
c2	15.760	27	<.001	<.001	45.964	39.98	51.95
c3	22.731	27	<.001	<.001	71.036	64.62	77.45

Table 28 One sample test for the number of scrolls in D1, D2 and D3

	t	df	One-sided p	Two-sided p	Mean difference	Lower	Upper
s1	3.273	27	.001	.003	46.214	17.24	75.19
s2	10.029	27	<.001	<.001	338.964	269.62	408.31
s3	8.316	27	<.001	<.001	109.036	82.13	135.94

Table 29 Time-frequency table for three groups

Discussion forum	D1		D2		D3	
Group	T>442.39	T<442.39	T>229.64	T<229.64	T>214.71	T<214.71
G1	7	6	5	8	6	7
G2	0	7	2	5	2	5
G3	2	6	4	4	5	3

5.2 Organization and usability issues in three patterns of the discussion forum

This section describes the three themes for usability issues in the three-discussion forum: (1) Design Demerits, (2) Design Merits, and (3) Design Ideas. A common view amongst participants was that the maximum design demerits were in D1 as shown in Table 30 with feedback frequency. In addition, participants encountered that D1 was the most difficult during the navigation of posts which argued it time taking platform with non-interactive features. However, scrolling from the D2 platform was a major challenge for participants.

Table 30 Design demerits in D1, D2, and D3

Design Demerits in D1	Design Demerits in D2	Design Demerits in D3
Difficult to search (7)	Inconvenient (5)	Limited categories (1)
Time taking (6)	Time taking (3)	-
Typing is Boring (3)	Scrolling is difficult (9)	Back button is difficult (1)
Not effective (2)	Less efficient (2)	-
Confusing (1)	-	Difficult to match category (4)
Not interactive (6)	Not interactive (2)	-

Table 31 and Table 32 describes the design merits and design ideas respectively. Most of the design merits (15) revealed by participants were from D3. The top three design merits indicated by participants from the three-discussion forum were categorization of posts (10), easy to navigate (9), searching option (8). All the creative and innovative design ideas by participants were relevant for designing asynchronous discussion forums as this research was conducted according to the learner's perspective. The design ideas recommended by participants were adding categorization of posts, adding short QnA for NCR, adding Icon button, adding pinned feature, adding the most frequent question according to time relevancy, adding a spelling check function while typing in the search option, auto removal of replicate questions, recommendation system, color pattern on themes, making font size big, folding questions with its subcategories, order of questions should be in an alphabetical way, post themes should be on top, adding upvote feature, setting the keywords with sections, require searching tool, more familiar keywords require, color for different categories, adding symbol or emoji, adding bold font, adding more keywords accession, require better categorization, and add graphics. Most of the design ideas recommended by participants in D1 and D2 were already implemented in D3 according to the literature. However, seven more innovative design ideas were suggested by participants which can be implemented by MOOCs designers.

Table 31 Design merits in D1, D2, and D3

Design Merits in D1	Design Merits in D2	Design Merits in D3
Search option is helpful (8)	Categories were in alphabetical order (1) Scrolling is easy (1) Section separation (2) Easy (2)	Categorization is beneficial (10) Easy (9) Friendly (1) Perfect (1) Convenient (4) Interactive (2) Well organized (1) Time saver (2) Better than d1 and d2 (1) Good (2) Good user interface (1) Search engine is helpful (1) System recommendation (1) Sorted (2) Enjoyed (2) Well prepared for beginners (1)

Table 32 Design Idea in D1, D2 and D3

Design Ideas in D1	Design Ideas in D2	Design Ideas in D3
Add categorization (2)	Color on themes (1)	Color for different categories (2)
Add short QnA for NCR (1)	Make font size big (1)	Add symbol or emoji (1)
Add Icon button (1)	Folding questions with its subcategories (1)	Add bold font (1)
Add pinned feature (1)	Order of questions should be in alphabetical way (1)	Add upvote (1)
Add most frequent question according to time relevancy (2)	Themes should be on top (1)	Add more keywords accession (1)
Add Spelling check function (2)	Add upvote feature (1)	Require better categorization (1)
Auto removal of replicate questions (1)	Setting the keywords with sections (1)	Add graphics (1)
Recommendation system (1)	Require searching tool (1)	
	More familiar keywords require (1)	

Chapter 6 Discussion and Conclusion

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6.1 From Study 1

6.1.1 Existing interaction state in asynchronous discussion forums

The results of this study showed that despite the large number of learners there were few posts. We observed that the instructor replied to 70 to 80% of the queries. Analyzing the different types of posts was the basic task in this research. Detecting keywords and classifying them as CR keywords and NCR keywords was a challenging task. CR posts contain keywords that were related to the content of the learning material. Since the material varies from course to course, it was difficult to find features for CR posts. Most of the posts were from NCR class and it became a redundant task for the instructor to respond to similar queries. NCR posts were related to inquiries regarding the course. After classification, we concluded that most of the NCR posts were similar and can be further categorized into classes. They can be marked as frequently asked questions to remove redundancy. Through this study, we could confirm that our classification method that filters NCR posts could organize discussion forums with enhanced efficiency for learners and instructors. The result of this study suggests principles that are responsible for effective interaction between learners and instructors in the discussion forum. These five recommendations can contribute to relevant interaction in the online discussion forum and support the educational research field -

- 1.) Similar posts clustered at the same place were more expected to answer by the instructor and reduced instructors' tasks.
- 2.) After the segregation of posts, learners can acquire frequent knowledge from discussion instead of navigating all the comments.
- 3.) Classification of posts helps the instructor to work on the specified area after finding the number of queries relating to specified indicators.
- 4.) Analyzing posts can assist in setting the priority of queries.
- 5.) Peer learning can be an aid to both the instructor and the learner.

Our analysis of discussion forum data from four different MOOCs offered on the same MOOC platforms suggests that learners had common issues while interacting with instructors. Interestingly, the results reveal discussion forums were more overloaded with NCR posts. Moreover, the frequency of posts and interactions was low as compared to registered learners. The frequency of posts was also significant in each case. Despite of low frequency of posts by learners, the ratio of the frequency of posts and their interaction was noteworthy. In Case II, the main aim of this study was to identify the frequency of CR and NCR posts subjects. The tools performed well in

prioritizing query subjects based on their occurrence and importance in the online discussion forum. The study used the scatter plot tool to identify the features for automatically clustering various queries as either CR or NCR. The finding suggests that repeated NCR queries can potentially be set as FAQs to reduce the burden on instructors. Removal of NCR posts can increase the discussion of relevant content-related queries. During the experiment with the scatter plot tool, it was observed that the frequency of CR and NCR posts also varies between practical and theoretical course discussion forums. For example, learners asked more content-related queries in the practical course discussion forum than in the theoretical course forum. In case III, the ratio of the frequency of posts was still low as compared to registered learners. However, learners were interested in the course with a variety of posts and eager to interact with an instructor for their regularity in the learning process. All four discussion forums of different MOOCs lack a relevant interaction for CR posts which ultimately depresses the learning process.

6.1.2 Learner's behavior in discussion forum during the course

There are several phases of the low and high frequency of posts by learners in the asynchronous discussion forum of MOOC. The frequency of posts increases as the course get started. However, discussion posts were set up and declined throughout the course due to the absence of assistance and evenly learners become demotivated because of no response or late reply from facilitators. The phase leads to a serious impact on MOOCs. Table 33 shows some examples of posts that shows learners were determined towards the course initially but later they express demotivation due to the absence of facilitation:

Table 33 Examples of posts showing demotivation among learners

Example posts	Phrases expressing demotivation
Extremely in distress, please provide update regarding registration and final call from the CEC. we have been waiting since months. As other affiliating institutions and organizations has already announced the result and provided the certificates of Jan-June 2020 semester. please look into the matter and do necessary.	extremely in distress; waiting since months; look into the matter and do necessary
Enrolled candidates of India's largest e-course/virtual programmer/course, request The National Coordinator (CEC), please resolve the issue and initiate the process for the final examination and certification. Please do necessary.	resolve the issue and initiate the process
Please initiate the registration process so that we can get certificate from your course. We are tight on time as universities will issue results.	tight on time
We are unable to receive feedback link and certificate also till today. Pls do kindly the needful.	unable to receive feedback link and certificate also till today
It's a splendid journey in taking the course. Now many queries are being floated regarding examination. In this point of time, a big silence from the team. At least some reply or message from the team of Academic writing is highly appreciated.	floated regarding examination; big silence from the team; at least some reply

Kindly go for registration of final examination or see for an alternative. As I am going through the statement by various learners, many have opted this course as an alternative to their respective University courses and their degree is pending. Please expedite the process at MHRD level and give justice to one and all. Linger the process is not at all good for anyone. We are losing the interest too.

see for an alternative, justice to one and all; going through the statement by various learners; Linger the process is not at all good for anyone; losing the interest too.

I have chosen and registered the course instead of university subject. I am final year student. Now, my degree is on hold. Please take the exam or provide us grades based on the performance and quizzes.

registered the course instead of university subject; My degree is on hold

6.1.3 Recommended model for interaction based on CoI in asynchronous learning.

Table 34 describes the seven principles along with the addition of modified (underline) recommended principles so eight in total principles for asynchronous discussion in MOOCs based on the literature survey and current interaction state in the learning process. The framework was established with seven essential principles of good practice based on the CoI model including social, cognitive, and teaching presence during online learning (Fiock, 2020), and it can be adopted by researchers, facilitators, and MOOC designers.

Table 34 Recommended framework based on CoI and eight principles for asynchronous interaction

Eight principles	Recommendation	CoI
Learner-instructor contact	Providing short videos based on particular topics.	SP
	Reflecting on learner-instructor interaction.	CP
	<u>Dividing the content and discussion weekly.</u>	TP
Cooperation among learners	<u>Providing bonus scores based on relevant participation in discussion.</u>	SP
	Using a tracking mechanism for discussion participation.	SP
	Adding learners' views and similar comments to match similar ideas.	CP
	Opportunities for higher-order experiential learning to enhance learner engagement.	CP
	<u>Adequate discussions according to existing modules within some fixed time frame, such as a weekly response.</u>	TP
Active learning	Making learner participation mandatory for course scores.	SP
	<u>Providing extra benefits for those learners who actively participate in the discussion forum and share innovative ideas.</u>	SP
	Asking open-ended questions to encourage participation	CP
	<u>Providing discussion summaries that identify steps in the knowledge-creation process.</u>	CP

	<u>Creating a graphical representation of scores, including assignment and discussion participation scores, to achieve cognitive behavior.</u>	CP
	Model high-order thinking using FAQ	CP
	Developing open-ended critical thinking discussion questions	CP
	Providing course schedules and plans with due dates.	TP
Prompt feedback	Personalized feedback through mentor module.	SP
	Developing learning modules to enhance active learning.	CP
	Providing relevant one-to-one and group feedback within a fixed time duration.	CP
	Providing modules for both public and private interactions with learners.	TP
	Timely response by facilitators.	TP
	Weekly graded assignments.	TP
Time on task	Instead of a text-based announcement, use a video walkthrough.	SP
	<u>Providing benefits of online discussion in the learning process.</u>	SP
	Not adding redundant on-screen text.	CP
	Aiding assignment and quiz-related posts to support skill development and convergent thinking.	CP
	Designing course modules for clarity and consistency.	TP
	<u>Making discussion forums with learner centered approach.</u>	TP

		<u>Announcing due dates or deadlines.</u>	TP
		Providing online learning resources so materials are one click away.	TP
Community expectations	high	Explaining the potential of learner-to-learner interaction	SP
		Modeling, supporting, and encouraging diverse points of view in online discussion.	CP
		Developing learning modules with opportunities for active learning.	CP
		<u>Availability of facilitators depending upon the number of learners.</u>	TP
		<u>Making guidance instructions for assignments clear.</u>	TP
Respect ways of learning	diverse	Introducing the rules for the course and discussion forum.	SP
		Allowing learners to form multiple perspectives for learning.	SP
		Providing a discussion platform for open-ended questions.	CP
		Developing general learning modules.	CP
		<u>Providing modules for both one-to-one and group interaction with the barrier of non-relevant questions.</u>	TP
		<u>Design discussion forum using learner centered approach.</u>	TP
<u>Design based on classified posts</u>		<u>Cluster of similar question posts to reduce instructor tasks.</u>	SP
		<u>Segregation of reply posts to acquire frequent knowledge by learners.</u>	CP

<u>Providing clear and classified categories of posts in discussion forums.</u>	TP
<u>Search options such as a drop-down box to find posts relating to specified indicators.</u>	TP
<u>Analyzing posts to set the priority of queries.</u>	TP

6.2 From Study 2

Figure 28 describes the technology acceptance model (TAM) used to validate the design model (Cheung & Vogel, 2013). TAM was adopted in 1989 to explore the adoption of technology with two variables-perceived Usefulness and Perceived Ease of Use (Fred D. Davis, 1989). The model has been widely used to adopt E-learning tools and technology (Abdullah & Ward, 2016). In this study, perceived usefulness defines the user's belief in using the redesigned discussion forum for improvement of the learning process, while Perceived Ease of Use refers to the easiness of using the redesigned discussion forum. Later a proposed conceptual model also showed the significant relationship between Perceived Ease of Use and Perceived Interaction that affect learners' intention of using discussion forums (I. F. Liu et al., 2010). Further, the interaction among learners and instructors leads to the positive behavioral intention of using discussion forums and MOOCs resulting in a high-quality learning environment. Therefore, five hypotheses were proposed based on TAM:

H1: Perceived usefulness will positively influence attitudes toward online discussion forums.

H2: Perceived ease of use will positively influence attitudes toward online discussion forums.

H3: Perceived ease of use will positively influence perceived usefulness.

H4: Attitudes toward online discussion forums will positively influence intention to use.

H5: Intention to use online discussion forums will positively influence system usage.

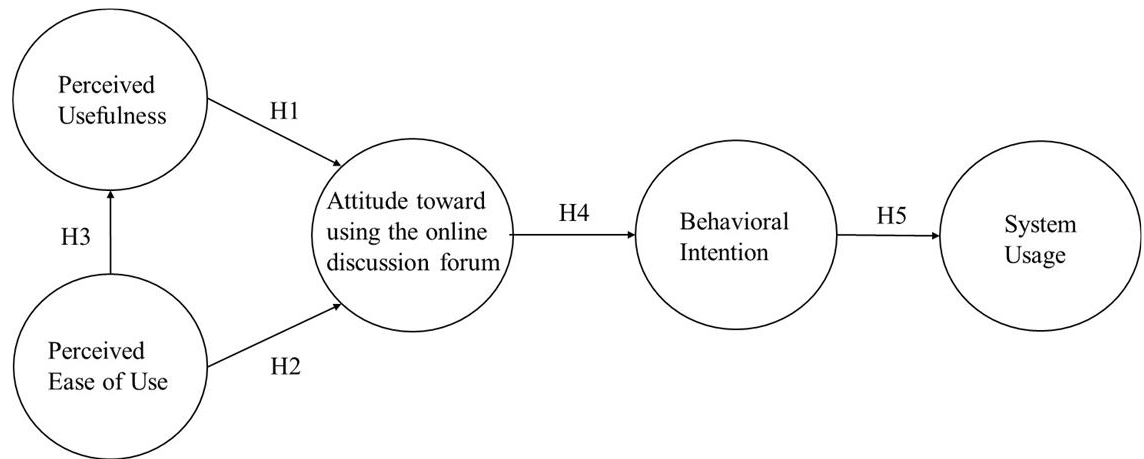


Figure 28 Technology Acceptance Model (Cheung & Vogel, 2013)

Through the navigation experiment, Study 2 investigated perceived demerits of discussion forum design, perceived merits of discussion forum design, and design ideas to implement based on learners' perspectives that improve the quality of the learning process in MOOCs. The result from Study 2 revealed that adopting design factors reduces the time taken while exploring the discussion forum by learners. For instance, the categorization of posts and search features were found to be useful tools while exploring discussion forums. Although the search option was available in the existing discussion forum, however, participants encounter difficulty while typing the correct keyword to search a post and end up with a scrolling feature which was more troublesome in discussion forums.

The participant who took the maximum time while navigating questions typed several combinations of keywords which shows that the user or learner cannot judge which keyword was suitable for searching the post. Therefore, the classification of posts aids or solves the confusion of learners while exploring discussion forums. Several design ideas were recommended by participants which can enhance the interactivity

with the system. The Education MOOCs designers can adopt the findings from study 2 to enhance the interactivity among learners and instructors. Education designers need to pay more attention to user interactivity in online learning to encourage learners and instructors both.

Figure 29 describes the user feedback in the existing and redesigned discussion forum of MOOC.

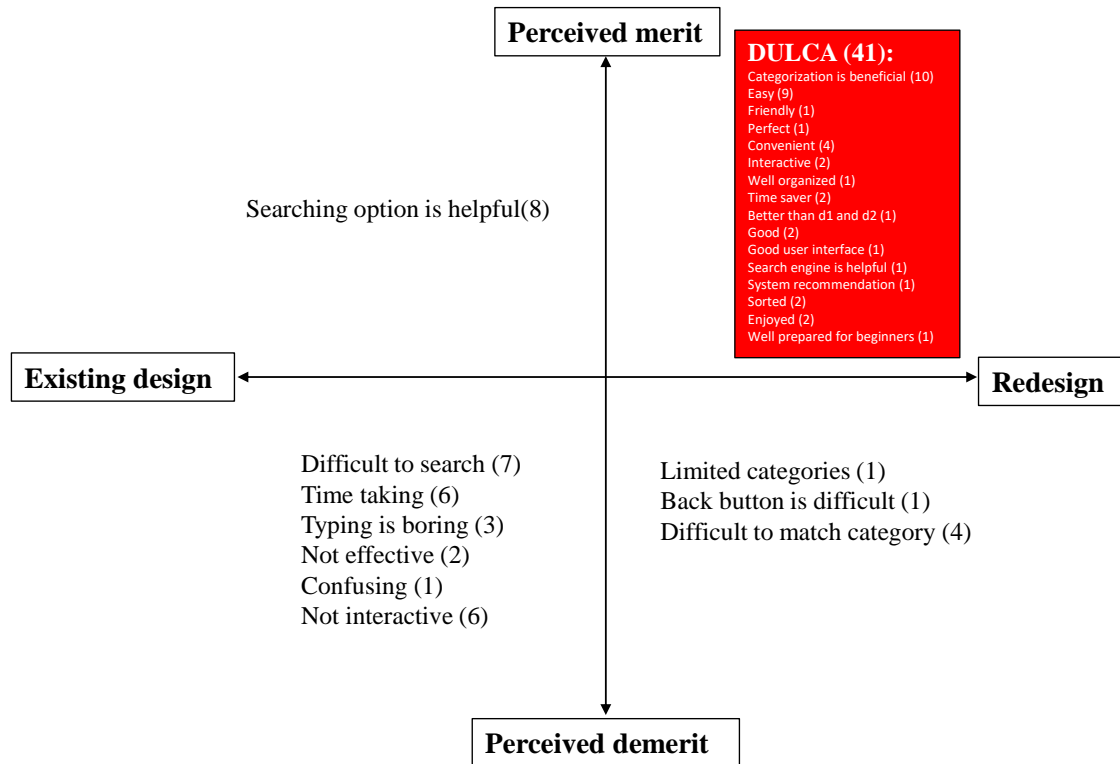


Figure 29 User feedback in existing and redesigned discussion forum of MOOC

The frequency of merits or positive feedbacks for the redesigned discussion forum (D3) was 41 and the frequency of negative feedbacks was 6 from participants. However, in the case of an existing discussion forum, the positive feedbacks were only 8 and negative feedbacks were 25 based on perceived usefulness by participants in the navigation experiment conducted in study 2 as shown in Table 35. Furthermore, a chi-square test was conducted to support the significance of redesigned discussion forum in enhancing the perceived usefulness and ease of use. The association between the design of discussion forum and comments showed extremely statistically significant

results with a two-tailed p value of less than 0.0001. Figure 30 describes the impact of DULCA for enhancing interactions among learners and instructors in MOOCs.

Table 35 Contingency table of feedbacks for the design of discussion forum

	Negative feedbacks	Positive feedbacks	Total
Existing design	25	8	33
Redesigned (D3)	6	41	47
Total	31	49	80

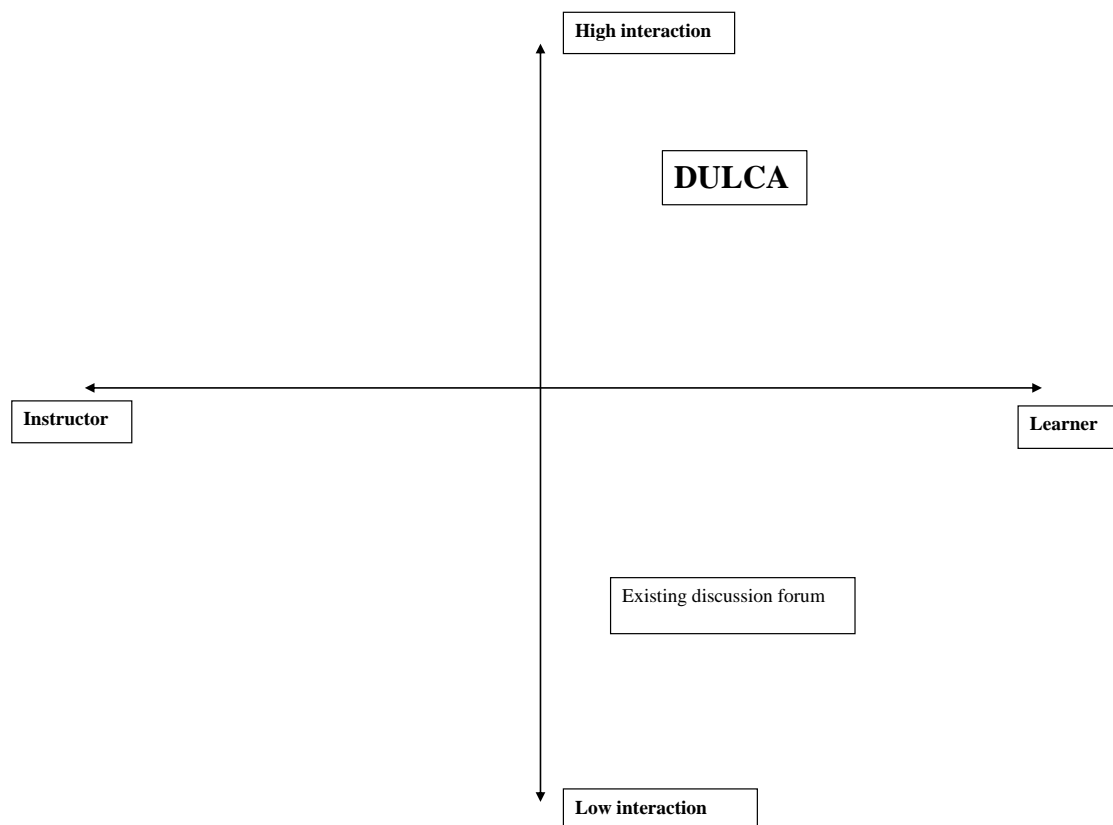


Figure 30 Impact of DULCA for interactions among learners and instructors

6.3 Contribution to Knowledge Science

All scientific research is set up intending to contribute to the body of knowledge or a theory in the domain of research. To achieve this knowledge contribution, the research study encounters two phases that majorly revolve around scientific research. The first phase is the search for understanding and the second phase is for knowing. Improving the current education system, decision making and policy development in the field of education are other factors that contribute to educational research.

The research study contributed the majority to educational design research (EDR). EDR focuses on educational problems in real-world situations with two primary goals for the improvement of education. The first one is to develop knowledge through understanding the concepts, and the second one is to develop solutions through acquiring skills and expertise. EDR is considered a powerful approach because it addresses real needs through the development of a solution to a problem, while also generating knowledge for future development. EDR features the collaboration between stakeholders (eg, researchers, educational designers, instructors, and learners) to simultaneously develop both new theoretical insights of learner's motivational behaviour and practical solutions to serious teaching and learning challenges (McKenney & Reeves, 2021). The Design Research suggests researchers and practitioners the opportunity to produce interventions of real value with tools, approaches, theories, and products tested in the field and proven to be effective. In this research, we focused on the real problem of interaction among learners and instructors in the discussion forum of MOOCs and provides concise information on emerging learning technologies. We implemented several tools- Voyant tools, Atlas.ti; approaches- UCD and LCD; theories- CoI and ICAP framework and products- google forms, google groups, WIX, and TAM to approve the system design effectiveness. EDR extends theoretical knowledge through data collection and analysis.

The process of EDR systematically follows three main phases with multiple time repetitions till achieving the desired goal:

1. Analysis- In this doctoral study, we analyzed three cases to analyze the whole structure of the discussion forum with different perspectives using various tools and education models.
2. Design- The study adopted educational design using UCD and LCD approaches to find a better solution. Further, the existing design and adopted design were compared for a better learning process and interaction between instructors and learners.
3. Evaluation- Three most crucial statistical factors were measured according to the literature review. In addition, qualitative data were collected to evaluate and validate the redesigned discussion forum.

Figure 31 describes the Design based research (DBR) model adopted in 2008 (Amiel & Reeves, 2008). The goal of DBR is to enhance understanding about the nature of learning and what facilitates it. The following characteristics are followed in DBR approach (McKenney & Reeves, 2021):

1. Continuous cycle of design, evaluation, and redesign.
2. Real- life learning settings.
3. Aimed at both testing and refining theories and advancing practice.
4. Characterized by mixed-methods studies.
5. Involves designers, researchers and practitioners with different expertise who interact frequently to guide the design, conduct and reporting of DBR.

This doctoral study provides a pathway to follow for solving educational design research.

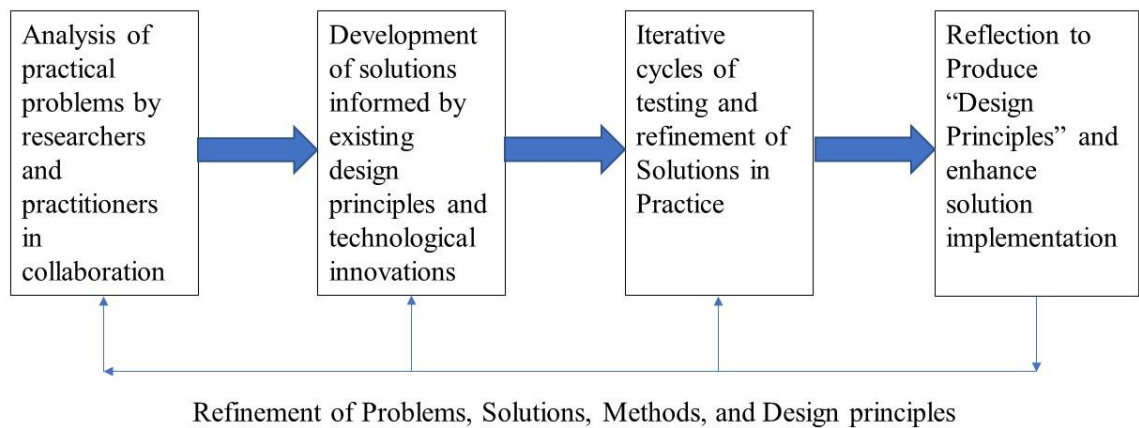


Figure 31 Design-based research (Amiel & Reeves, 2008)

6.4 Limitations and future research

6.4.1 Study 1

This research study faced four limitations that can be accomplished in future studies. Firstly, this research study focused deeply on the classification of discussion forum posts, but we did not match up the performances of learners in the examination according to their participation in the discussion forum.

Secondly, in study 1, the small size of the dataset allowed us to identify limited features which were used to categorize various posts in the discussion forum. Although in Case II, this work offers valuable initial insights into the differences of discussions in practical and theoretical courses, despite the relatively limited data sample of 296 query subjects. In the future, more MOOCs and a high number of posts can be analyzed. This research has also raised questions regarding the need for further investigation of different types of online courses. For example, a significant difference in content-related queries was observed in theoretical and practical course discussions and large randomized controlled trials of the t-SNE tool could also potentially provide more definitive evidence while using Voyant tools. Future investigation can be performed to find the reason behind low CR posts in theoretical course as compared to practical course through instructor interview or analyzing the course structure.

Thirdly, in the academic writing course, the internal assessment was based on participation in the discussion forum. However, we could not identify those learners and posts that were considered for the reward. Also, we could not determine the exact frequency of each category because there were mixture of CR and NCR post in several post. Additionally, one of the limitations of carrying out the work in Case III was that we considered only one MOOC because of its popularity. However, the recommendation framework for maintaining the CoI approach can be applied to all the Swayam courses and MOOCs themselves. In a further study, learners' performance based on their participation in the discussion forum can also be measured.

Lastly, for future research, we recommend analyzing discussion forum data across additional MOOCs and different offerings of the same MOOCs. This approach will help differentiate between how the role of the instructor and the MOOC platform impacts participation. While our study 1 glanced at the nature of participating in discussion forums through quantitative metrics more, it is important to consider that the educational value of discussions may not depend on the size of the discussion thread. We suggest exploring the actual contents of discussion forum data for the quality of conversation with other educational models. We also recommend investigating methods of eliciting in-depth discussions about the course content covered in MOOCs.

6.4.2 Study 2

Study 2 has three primary limitations. First, although this research study was especially focused on the learner-centered approach which eventually can aid in the instructor's task. However, this doctoral study raised a question regarding the fundamental reasons behind the unbalancing in learner side and instructor side in discussion forum. Further investigation can be done by the educational research community through instructor interview or facilitator approach to enhance the research study which support both instructor and learner at the same time. Secondly, we were not able to experiment with real users of MOOCs or specifically SWAYAM users because of COVID-19 border restrictions. We were also not able to reach SWAYAM facilitators which can be a future approach and improve the design ideas of asynchronous discussion forums according to real situations.

Finally, study 2 provides a good set of data that can be used for further analysis. For instance, the set of keywords used by participants while searching posts can be analyzed further.

Publications

1. Scholarly Journals

1. Neha, Kim, E., “Identifying content-related and non-content-related queries in online discussion forums using Voyant Tools”. In: International Journal of Information and Education Technology. (In press), 7 pages.

2. Conference proceedings

1. Neha, Kim, E., “Designing Discussion Forum in SWAYAM for Effective Interactions Among Learners and Supervisors”. In: Stephanidis C., Antona M., Ntoa S. (eds) HCI International 2020 – Late Breaking Posters. HCII 2020. Communications in Computer and Information Science, vol 1294. Springer, Cham.
2. Neha, Kim, E., “Investigating Responsible Factors for Interaction between Learners and Instructors in the Discussion Forum of MOOC”, 2021 9th International Conference on Information and Education Technology (ICIET), pp. 204-207, doi: 10.1109/ICIET51873.2021.9419599.
3. Neha, Kim, E., “A Classification Method of the Learners’ Queries in the Discussion Forum of MOOC to Enhance the Effective Response Rate from Instructors”. In: Stephanidis, C., Antona, M., Ntoa, S. (eds) HCI International 2021 - Posters. HCII 2021. Communications in Computer and Information Science, vol 1421. Springer, Cham.
4. Neha, Kim, E., “Bridging the gap between the learners and the educational designer for learning experiences in the discussion forum of MOOC”, 8th International Conference on Education (IAFOR).

5. Neha, Kim, E., “Relevant Interaction among Learners and Instructors in Asynchronous Academic Writing Course”, 2023 11th International Conference on Information and Education Technology (ICIET), 7 pages.

3. Conference presentations

1. 22nd International Conference on Human-Computer Interaction, Copenhagen, Denmark, “Designing discussion forum in SWAYAM for effective interactions among learners and supervisors”, (Poster) 19-24 July 2020.
2. 9th International Conference on Information and Education Technology, Okayama, Japan, “Investigating responsible factors for interaction between learners and instructors in the discussion forum of MOOC”, (Oral) 27-29 March 2021.
3. 23rd International Conference on Human-Computer Interaction, Washington, USA, “A classification method of the learners’ queries in the discussion forum of MOOC to enhance the effective response rate from instructors”, (Poster) 24-29 July 2021.
4. 6th International Conference on Education And Distance Learning, Rome, Italy, “Identifying content-related and non-content-related queries in online discussion forums using Voyant Tools”, (Oral) 21-23 July 2022.
5. 29th Japan Society for Global Education National Research Conference, Kyoto organized by Japan Association of Global Education, “Evaluation of the effectiveness of self-activation method to improve academic courses and discussion”, (Oral) 6 August 2022.
6. The 8th IAFOR International Conference on Education, Honolulu, Hawaii, USA, “Bridging the gap between the learners and the educational designer for learning experiences in the discussion forum of MOOC”, (Oral) 05-08 January 2023.

7. 11th International Conference on Information and Education Technology (ICIET 2023), Fujisawa (Kanagawa), Japan, “Relevant Interaction among Learners and Instructors in Asynchronous Academic Writing Course”, (Accepted for Oral presentation) 18-20 March 2023

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Appendices

Appendix 1

Manual for the experiment

(All the information will be used for research purpose only.)

Material provided:

This experiment is related to asynchronous discussion forum in massive open online courses.

1. I will provide you three different design of educational discussion forum as mentioned below:

a.) D1- Google groups discussion forum (Discussion forum that is created on google groups).

b.) D2- Google forms discussion forum (Discussion forum that is created on google forums).

c.) D3- Proposed discussion forum (Discussion forum that is created on WIX software).

2. I will give you a hard copy of question sheet consisting of six questions taken from provided discussion forum.

3. I will also provide a soft copy of answer sheet (word file).

Procedure:

Participant:

Step 1: You need to look questions from question sheet (one by one)

Step 2: You need to answer on soft copy of answer sheet only by just copy and paste function from provided discussion forum. The task is about navigating questions and answers.

Note: If you are using google groups discussion forum, then you can use search option by typing combination of maximum three words and you need to highlight those three keywords that you used while searching answers.

Step 3: In the end, you need to fill a google survey form with some 11 basic questions.

Observer:

We will record the time taken, no. of clicks or scroll while navigating the questions using a python programming during this experiment.

Programming code used for tracking clicks and scrolls

```
from pynput import mouse

file_name = "output.txt"

file_name = input("Enter output file name: ")

def on_move(x, y):

    print('Pointer moved to {0}'.format(

        (x, y)))

def on_click(x, y, button, pressed):

    print('{0} at {1}'.format(

        'Pressed' if pressed else 'Released',

        (x, y)))

    if pressed:

        with open(file_name, 'a') as f:

            f.write(f'Pressed at ({x}, {y}) \n')

    # if not pressed:

    # Stop listener

    # pass

    # return False
```

```

def on_scroll(x, y, dx, dy):

    print('Scrolled {0} at {1}'.format(

        'down' if dy < 0 else 'up',

        (x, y)))

    with open(file_name, 'a') as f:

        f.write('Scrolled {0} at {1} \n'.format('down' if dy < 0 else 'up', (x, y)))

with open(file_name, mode='w') as f:

    pass

# Write header

print(f'*****
***** \n')

print(f'This program records mouse events like clicks, scrolls and movement. \n')

print('The output is written both to the terminal screen as well as a text file :- \n')

print(f'*****
***** \n')

# Collect events until released

with mouse.Listener(

    on_move=on_move,

    on_click=on_click,

    on_scroll=on_scroll) as listener:

    listener.join()

```

Programming code for output of number of clicks and scrolls

```
file_name = input("Enter file name: ")

with open(file_name, 'r') as f:

    lines = f.readlines()

    clicks = 0

    scrolls = 0

    for line in lines:

        if "Pressed" in line.split():

            clicks = clicks + 1

        if "Scrolled" in line.split():

            scrolls = scrolls + 1

    print(f'No of clicks = {clicks}, No of scrolls = {scrolls}.')
```

Response form:

Email*

Your email

Country

Your answer

Gender

Male

Female

Prefer not to say

Age

21-25

25-30

30-35

35-40

40-45

>45

Degree

Masters

Ph.D

Are you already familiar with asynchronous discussion forum?

Yes

No

May be

Time taken for completing the question sheet (t1, t2, t3)?

Your answer

Number of clicks while searching answers (c1, c2, c3)?

Your answer

Number of scrolls while searching answers (s1, s2, s3)?

Your answer

Keywords used for searching answers?

Your answer

Feedback and Suggestion (using discussion forum d1, d2, d3) :

Appendix 2

Time taken by all recruited participants

t1	t2	t3
387	371	201
398	272	233
769	196	210
309	206	227
232	206	118
476	388	231
391	206	192
495	281	308
354	166	136
662	285	371
566	254	243
364	206	263
555	165	191
362	178	220
278	138	150
652	350	240
664	231	239
647	378	290
369	145	190
340	162	149
336	112	156
407	186	158
294	142	159
408	154	202
289	147	106
286	122	291
369	286	169
728	497	369

Clicks clicked by each participant while navigating questions:

c1	c2	c3
88	79	80
55	47	57
130	51	85
76	41	93
91	61	58
110	72	93
190	52	64
79	69	91
80	25	65
95	26	67
87	56	81
67	33	74
95	46	68
59	30	53
75	53	93
63	33	105
87	35	50
60	33	67
79	34	63
63	52	72
42	34	47
82	69	44
55	32	86
92	39	82
70	24	41
71	48	69
80	48	63
90	65	78

Scrolls done by each participant while navigating questions in the experiment.

s1	s2	s3
5	573	64
7	709	107
330	443	98
44	586	140
6	410	59
54	265	85
120	486	145
60	304	127
10	772	44
185	273	51
31	239	100
29	353	72
185	101	81
14	229	57
41	236	87
8	370	84
9	309	98
4	244	186
63	341	205
4	118	58
0	187	82
28	81	343
37	84	76
0	549	94
3	283	67
1	435	283
8	240	72
8	271	88

Data for Group 1 (G1)

t1	t2	t3	c1	c2	c3	s1	s2	s3
769	196	210	130	51	85	330	443	98
476	388	231	110	72	93	54	265	85
354	166	136	80	25	65	10	772	44
662	285	371	95	26	67	185	273	51
555	165	191	95	46	68	185	101	81
362	178	220	59	30	53	14	229	57
278	138	150	75	53	93	41	236	87
652	350	240	63	33	105	8	370	84
664	231	239	87	35	50	9	309	98
340	162	149	63	52	72	4	118	58
336	112	156	42	34	47	0	187	82
408	154	202	92	39	82	0	549	94
728	497	369	90	65	78	8	271	88

Data for Group 2 (G2)

t1	t2	t3	c1	c2	c3	s1	s2	s3
232	206	118	91	61	58	6	410	59
391	206	192	190	52	64	120	486	145
566	254	243	87	56	81	31	239	100
407	186	158	82	69	44	28	81	343
289	147	106	70	24	41	3	283	67
286	122	291	71	48	69	1	435	283
369	286	169	80	48	63	8	240	72

Data for Group 3 (G3)

t1	t2	t3	c1	c2	c3	s1	s2	s3
387	371	201	88	79	80	5	573	64
398	272	233	55	47	57	7	709	107
309	206	227	76	41	93	44	586	140
495	281	308	79	69	91	60	304	127
364	206	263	67	33	74	29	353	72
647	378	290	60	33	67	4	244	186
369	145	190	79	34	63	63	341	205
294	142	159	55	32	86	37	84	76

Set of Keywords typed by learners while searching questions:

admit card; published conference; marks assignment posted (website); requirement thesis research paper; certificate; exam test link
download admit card, conference proceedings journals; second subjective assignment; requirement, phd, thesis, link, certificate, webinar, mock, test, link
download admit card; conference proceedings; marks subjective assignment; research paper review paper (phD research review); link certificate webinar; exam test link (mock test link)
Card; published; marks subjective; phD; 20 and 24; mock
Download admit card; published conference proceedings; assignment posted website; phD review paper; certificate webinar 20; exam test link
Download admit card; published research; marks second subjective assignment; requirment Ph.D. thesis; certificate of webinar; mock test link
admit (admit card); conference proceedings (journals); assignment (second subjective assignment); ph.D thesis; certificate (certificate of webinar); exam (exam mock test)
download admit card; conference proceedings journals; second subjective assignment; requirement phD thesis; link certificate webinar; exam mock test

Admit Card; Conference Proceedings; second subjective assignments; phd thesis; 20 may; Mock test
admit card; conference published journals; marks second assignment; requirement phd; webinar may; mock
Download admit card; conference proceedings; marks website; PhD thesis; link certificate webinar; mock test link
download admit card; published journals; second subjective assignment; requirement phd; certificate of webinar; exam mock test
download admit card; published conference journals; marks second subjective; requirement phd thesis; link certificate; webinar; exam mock test
download, admit card; conference proceedings journal; second subjective assignment; requirment Ph.D. thesis; certificate webinar held; exam mock test
Admit card; conference; thesis; certificate link may; test link mock
admit card; conference publish journals; second subject assignment (marks second subjective assignemnt); Link certificate webinar; exam mock link
download admit card; conference published journals; second subjective assignment; requirement thesis paper; link certificate may; mock exam
download Admit card; published conference journals; when assignment posted; requirement phD thesis; link certificate webinar; mock test link
download admit card; conference journals; marks subjective assignment; requirement phd thesis; webinar 20 24; mock link
download admit card; published conference; marks subjective assignment; requirement phd thesis; webinar certificate; mock link exam
download, admit card; research conference proceedings; second subjective assignment; requirment Ph.D. thesis; link certificate webinar; mock test link
how download admit; research journals published; posted website marks; requirement phD; certificate webinar may; exam mock
admit card; research journals published; second subjective marks; requirement phD link webinar certificate may; exam mock
download admit card; research journals proceedings; marks assignment website requirement thesis paper; certificate webinar may; mock test link
download admit card; published conference; second subjective; website; requirement phD thesis; 20 and 24 may; exam mock

download admit card conference proceedings second subjective assignment requirement PhD thesis certificate of webinar exam mock link
download admit card; conference proceedings journals; marks second assignment; requirement PhD thesis; link certificate webinar; exam mock test
admit card; conference proceedings; second subjective assignment; requirement research paper review; link certificate webinar; exam mock test