frontiers | Frontiers in Education

TYPE Systematic Review
PUBLISHED 28 February 2024
DOI 10.3389/feduc.2024.1345205

OPEN ACCESS

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RECEIVED 28 November 2023
ACCEPTED 14 February 2024
PUBLISHED 28 February 2024

CITATION
Loh HS, Martins van Jaarsveld G, Mesutoglu C and Baars M (2024) Supporting social interactions to improve MOOC participants' learning outcomes: a literature review.
Front. Educ. 9:1345205.
doi: 10.3389/feduc.2024.1345205

Supporting social interactions to improve MOOC participants' learning outcomes: a literature review

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Introduction: The need for more scalable, accessible and affordable education, coupled with technological advancements in information sharing technology and collaborative platforms has led to the growth of MOOCs (massive open online courses). The growth of MOOCs has resulted in learning becoming increasingly distributed, affordable and flexible compared to traditional classroom education, allowing individuals in disadvantaged groups to access high quality educational materials. However, new challenges emerge, most notably with MOOCs' low completion rates. Among the reasons for a low completion rate, lack of interaction with peers is cited as a major reason, yet, interventions to promote social interaction has received relatively less attention. From a constructivist perspective, social interactions among peers are essential in helping individuals learn. This systematic literature review aimed to understand social interaction interventions in MOOC settings. This includes constructs measured as learning outcomes and how they were measured.

Methods: Literature articles were sourced from multiple databases and filtered for inclusion using the PRISMA process and its four phases. Twenty articles were included in the final review.

Results: Results of the review showed that social interactions fall into three categories: discussion forums, learning groups and one-to-one interactions with peers. Learning outcomes investigated were grouped into four categories: knowledge, social engagement, learning engagement and learner experience.

Conclusion: Across the studies, there were clear positive effects of social interaction on learning outcomes. Intervention strategies include sending prompts for individuals to use discussion boards and also grouping learners by homogeneity based on their learning engagement. However, more experimental studies are necessary to bolster the evidence of a causal impact of social interactions. Also, further research should be done to understand potential mediating factors that contribute to the success of implementing social interactive elements in MOOCs.

KEYWORDS

MOOC, social interaction, social learning, collaborative learning, learning outcomes

1 Introduction

The evolution of information communication technology has changed the landscape of many fields, education being one of the many. Individuals now have access to an increasing quantity of information from a vast array of sources. More online learning platforms have popped up and virtual classrooms are becoming more commonly used. Cloud storage has made resource sharing easier and as the internet and information communication technologies continue to grow, higher education institutes have also been adapting to this trend of digitalisation. The digitalisation of higher education has also appeared in the form of Massive Open Online Courses (MOOCs), an increasingly popular means of learning.

MOOCs are online courses created by universities, organisations or industry experts for potential learners interested in a topic area (Liyanagunawardena et al., 2013). Across university sites and platforms like edX, Udemy, and Coursera, thousands of MOOCs are currently available for free. From subjects like arts and humanities to computing, from nutrition to business management, participants can sign up for MOOCs from any part of the world, often for free. Classes come in the form of video lectures, documents and assignments. Since only a digital device is required, learning is also made highly convenient for participants.

A combination of factors has driven this popularisation of MOOCs, including the advancements in file sharing and video conferencing technology (Al-Samarraie, 2019) and education institutions' desire to reach a wider audience (Boggs et al., 2021). Additionally, a declining number of educators worldwide (University of Technology Sydney, 2023) implies a need to have reusable materials and instructional methods that can cater to students' learning needs without necessarily increasing the number of educators. MOOCs appear to provide the answer to this issue.

In higher education, MOOCs are generally followed in two ways. First, participants rely entirely on the MOOCs for learning content, however, there are still peer discussions about the content and assignments of the MOOCs. Students also receive support from educators. MOOCs are also used in a blended learning approach where students get their preliminary knowledge from MOOCs before doing seminars and taking assessments that are not part of the MOOC. A variation of the blended learning approach sees MOOC content used only as supporting materials to what has already been provided to students (Holotescu et al., 2014; Manli, 2014). For small university programmes where there are limited courses and educators, Andersen et al. (2019) propose using MOOCs to supplement students' education, noting that educators should still have scheduled sessions for students to clarify doubts. Assessing students' knowledge can be done via presentations at certain checkpoints of a MOOC and a final project for students to work on based on the MOOC materials.

MOOCs present multiple benefits for educators and participants. For educators, MOOCs are a scalable way to teach since learning content can be reused and their time spent does not increase as learners attending the MOOC increases (Pérez-Sanagustín et al., 2017). The extra time and effort can be channelled into improving learning materials. And since MOOCs take place in an online environment, data from participants' learning behaviours and progress can be obtained for learning analytics to optimise learning (Urrutia et al., 2017; Onah et al., 2018). For MOOC participants, having the flexibility to complete course deliverables based on their schedule is highly valued (Shapiro et al., 2017). With traditional courses in schools, students are locked into a study after enrolment but with MOOCs, students can dive into a domain and explore course materials without having the pressure of committing to finish it (Shapiro et al., 2017).

Despite the multiple benefits associated with learning in MOOC setting, historically high dropout rates have been a cautioning point of MOOCs being unable to live up to traditional learning environments. Initial studies on MOOC participant behaviour and completion rates have the median completion rate for courses to be around 10–13% after accounting for participants who became inactive shortly after signing up (Onah et al., 2014; Jordan, 2015; Reich and Ruipérez-Valiente, 2019). Reich and Ruipérez-Valiente (2019) commented on the likely possibility of MOOC platforms catering towards more affluent individuals in higher education, courses becoming less affordable and less accessible for most individuals if participant achievement rates remain low. Participant attrition has been linked to language-related barriers (Gomez-Zermeno and De La Garza, 2016), participant motivation (Wang and Baker, 2015; Xiong et al., 2015), and unmatching expectations (Eriksson et al., 2016), to name a few factors. Remedies have been suggested such as adding subtitles in English or a native language, profiling learners and having different retention strategies for participants with differing motivations (Xiong et al., 2015). Another cause of attrition was a lack of interaction and participants feeling a sense of isolation (Xiong et al., 2015; El Said, 2016). While discussion forums exist on MOOC platforms, understanding how to promote higher-quality online social interaction might play a role in improved completion rates.

A key difference between learning via a MOOC and learning in a traditional setting is the social environment learners are exposed to. In traditional learning environments, social interactions between students have been shown to foster beneficial learning outcomes such as more understanding of content, higher accuracy when quizzed and greater confidence in their knowledge (Tullis and Goldstone, 2020). In online learning contexts, interaction has been shown to result in benefits such as higher engagement with course content (Sunar et al., 2017; De Felice et al., 2021). However, multiple studies point to learners having difficulty with social interaction and a lack of it when learning online (Baber, 2021; Wut and Xu, 2021; Azmat and Ahmad, 2022; Ivanec, 2022). This finding supports the conclusion by Aldowah et al. (2019) that MOOCs lacking social support, social presence and peer interaction results in high participant dropout rates. Researchers agree that participants' feelings of isolation must be addressed and promoting peer engagement can play a role in increasing participants' learning success with the MOOC course (Wang et al., 2018; Aldowah et al., 2019; Williams et al., 2019). Therefore, this review aims to address this issue by presenting a timely synthesis of research done on ways social interactions between peers have been implemented in MOOCs.

1.1 Literature review

1.1.1 MOOCs

MOOCs have experienced substantial growth since 2011 (Onah et al., 2014). A relatively recent investigation by Reich and Ruipérez-Valiente (2019) concluded that while total MOOC enrolments have increased compared to the early years, completion rates have remained

low. Research has looked at attrition factors from multiple different perspectives. For course factors, longer courses, older courses and courses using peer grading (as opposed to auto-grading) were associated with lower completion rates (Jordan, 2015). Self-paced MOOCs—as opposed to MOOCs with fixed dates for assignment submissions positively predicted higher student satisfaction, arguably because it gives students more autonomy in their learning (Hew et al., 2020). For factors related to learner contexts and characteristics, participants with higher levels of education were found to have higher self-regulated learning sub-processes and higher self-efficacy, both of which are associated with MOOC completion (Hood et al., 2015). Additionally, the likelihood of completion was higher for students with prior experience with MOOCs, and participants with a higher self-reported commitment such as participants who specified the number of hours they intended to spend (Greene et al., 2015). Courses that emphasised active learning with assessments that went beyond knowledge recall and that allowed students to apply what they had learnt were associated with higher satisfaction (Hew et al., 2020). Joo et al. (2018) highlighted students' perception of a MOOC's usefulness and its perceived ease of use to have a positive influence on satisfaction with the course which was associated with continuance with the MOOC. On a related note, Jung and Lee (2018) focused on learning engagement, finding it to be a mediator between some of the previously mentioned variables—self-efficacy, perceived usefulness and ease of use—and learning persistence. In summary, previous research has put forward strong explanations to explain attrition rates, attributing them to course factors (e.g. course length, grading system, flexibility), learner characteristics and perceptions of course usefulness.

Research and practice have invested greatly to understand MOOC attrition rates from multiple perspectives but an area of investigation that has received less attention is the impact of social factors. There are inconclusive findings as to whether social interaction play a huge role in learning in MOOC contexts. For example, Hew (2014) found the quality of peer interaction to be highly rated as important by participants from three top-rated MOOCs. However, a contrasting finding was made by Gameel (2017), concluding that participants' course satisfaction did not increase when provided opportunities for discussion on forums as they found it to be chaotic, often going off-top and overwhelming. This lack of clarity calls for a need to synergise research on the impacts of social interaction on MOOC learning outcomes and how to promote it.

To understand the effects of social interaction on MOOCs, it is necessary to understand the types of social interaction that happen in MOOCs. Interactions usually take place on discussion forums that are often built into the MOOC platform (Mayende et al., 2017). However, Veletsianos et al. (2015) showed that social interactions can happen beyond the confines of discussion forums, with learners sharing their experiences with family or discussing course content with individuals who might be friends or other learners enrolled in the same MOOC. There also seem to be different degrees of connection with some learners preferring to post messages on discussion boards and others directly reaching out to other learners through forums or social media to form closer connections (Veletsianos et al., 2015). It is thus important to recognise that different forms of social interactions can exist when promoting them in MOOC settings. Investigating these differences and their impact on participants' learning outcomes is imperative should educators want MOOCs to stay relevant in education.

1.1.2 Social interaction in online learning environments

Multiple prominent learning theories can be used as starting points to understand how social interaction potentially impacts learning. Social Learning Theory (Bandura, 1978) proposes that individuals learn behaviours through modelling behaviours of others, such as peers or teachers. In an example context of problem-solving, an individual learns via observation and imitation of another's methods before later applying the method to a similar problem.

Constructivism emphasises learning to be an active process and knowledge to be constructed by learners (Piaget, 1964; Narayan et al., 2013). According to Piaget (1964), the construction of knowledge happens through assimilation—fitting new experiences such that they are consistent with existing mental schemas, and accommodation—revising existing mental schemas to be consistent with new experiences and information. The second form of constructivism, social constructivism, proposes a similar idea, but individuals learn in a social setting by sharing their knowledge and assimilates and accommodates new information according to what was shared in that group.

This idea of learning from others has similarities with Siemens' theory of Connectivism (Siemens, 2005) where learning occurs when networks are formed between information sources. Knowledge is the result of connecting ideas and concepts from an array of sources which could be expanding on pre-existing ideas. Thus, having a diverse number of information sources and being able to tap into them is critical in learning and acquiring knowledge.

The three theories highlight key complementary areas that are necessary for learning. From Connectivism, the importance of connecting with different individuals is highlighted. The different individuals are information sources where we can observe and imitate others, as posed by Social Learning Theory. Information gained through observation and interaction with others leads to active reflection of new knowledge and revision of pre-existing knowledge, as proposed by Constructivism. Salomon and Perkins (1998) and Vygotsky (1978) emphasised the importance of social interaction and collaboration in an individual's learning process as learning is social in nature. Through interaction with others, students are exposed to a variety of thinking processes which promote learning. Knowledge is more effectively and efficiently developed in a social context as the construction of one's knowledge can be built on the understanding of peers (Brown et al., 1989) and problems or concepts that are too difficult for the individual become solvable with the assistance and guidance of others (Vygotsky, 1978).

In the context of MOOCs, courses should ideally incorporate elements of the above outlined in the theories: connecting participants, discussions to promote sharing of different opinions and approaches towards learning topics and support structures for participants to learn from and guide one another.

With regard to learning outcomes, multiple different indicators of MOOC learner success have been outlined. While course completion or dropout rates seem to be the metric of assessment for interventions (Jordan, 2015; Xiong et al., 2015), other researchers have chosen to focus on other metrics such as final grades (Deng et al., 2019) or learning engagement as measured by a rating score or motivation (Ramesh et al., 2014) or engagement as measured by completion of course activities (Coffrin et al., 2014). Other outcomes studied were learners' satisfaction or behavioural indicators, for example,

participation in discussion forums (Wintrup et al., 2015). Similarly, with different types of social interactions, a variety of constructs and metrics of assessment can be used to measure its effects, each possibly showing a different effect on attrition rates.

1.2 The current study

This review aims to synthesise research on how social interactions in MOOCs can be supported in an effective way considering participants' learning outcomes. The secondary aim of this review is to summarise the learning outcomes that were investigated in these studies on social interactions in MOOCs. Therefore, we have reviewed how learning outcomes were measured and what metrics were used. Dropout and completion rates in MOOCs are a common evaluation metric used by researchers (Onah et al., 2014; Jordan, 2015). However, dropout and completion rates are but a proxy for measuring change in constructs such as motivation, learning engagement and knowledge attained, to name a few. With each construct, there might be multiple ways of measuring them. For example, learning engagement could be operationalised in multiple ways such as self-ratings, duration of time spent on learning materials or the number of learning content viewed.

The main research question posed in this systematic review is: how can social interaction be supported effectively to improve MOOC participants' learning outcomes? Two sub-questions were addressed to answer the main research question. (A) What are ways in which MOOCs have incorporated social interactions? (B) What learning outcomes have been investigated with regard to social interactions and how are they measured?

Identifying effective methods of implementing interaction elements from past MOOCs can guide MOOC designers on appropriate ways of integrating peer interaction into the MOOCs so participants can have more fruitful learning experience. By also summarising the constructs and measurement metrics used along with suggestions for social interaction implementation ideas, future MOOC designers will not only be able to integrate social learning elements but also select appropriate evaluation methods to match the social interaction elements implemented.

2 Method

A systematic literature review method was used to identify empirical articles related to MOOC courses incorporating social interaction elements. The PRISMA framework (D Moher et al., 2009, p. 8) and recommendations by Cooper (2015) were used to ensure a systematic way to identify and assess the quality of the articles. Figure 1 presents the four phases of the PRISMA framework: identification, screening, eligibility and inclusion.

In phase 1, the identification phase or literature search stage (Cooper, 2015), a literature search was conducted from 3rd May to 13th May 2023. Literature was sourced from the following databases: Scopus and ERIC. Additional studies included were identified from the reference list of research papers. The database search was limited to title, abstract and author keywords. Keywords used were 'MOOC', 'massive open online course' and words relating to 'social' like 'peer' and group'. An asterisk was used as a wildcard at the end of a keyword to include different forms of the word and broaden the search (e.g., interact* also searches for 'interaction' and 'interactions'). The databases were searched using the following query:

'("MOOC*" OR "Massive Open Online Course*") AND ("social" OR "group*" OR "peer" OR "communit*") AND ("influence" OR "learning" OR "interaction" OR "communication" OR "learning outcomes) NOT "review"'.

The search yielded 180 records. The records were then screened for duplicates. 39 duplicate items were removed.

In phase 2, the screening phase or data evaluation phase (Cooper, 2015), the title and abstracts were screened for the remaining 141 articles and filtered with the following inclusion criteria: (1) articles must be written in English; (2) articles must be about MOOCs; (3) articles must explore or examine the role of social interactions between learners; (4) articles must indicate learning outcome variables (5) research that are empirical in nature. No restriction was made on the types of empirical studies included as there was a limited sample of studies in this area. Thus, correlational and experimental studies were all included. 93 articles were filtered out as they did not meet the inclusion criteria.

In phase 3, the method, results and discussion sections of remaining 48 articles were filtered for and excluded using the following criteria: (1) the article did not explore or examine interaction between learners or how the interaction happened was not well defined; (2) the article did not report participants' learning outcomes clearly; (3) the research was not in a MOOC context; (4) the articles were opinion pieces or reviews; (5) the full-text articles were not available online; (6) articles are not peer reviewed. The filtering resulted in 28 articles being excluded and 20 articles being selected for the literature review.

In the phase 4, in the inclusion or analysis and interpretation stage (Cooper, 2015), the researchers worked collaboratively to ensure consistency and agreement. Descriptive information of the selected articles were extracted and organised as displayed in Table 1. Table 2 was also constructed to answer the two research questions—the ways in which MOOCs have incorporated social interactions, and the learning outcomes that have been investigated and measured. After multiple rounds of reading the articles, they were first sorted by the type of social interaction that was implemented in the MOOC. Then, four main categories of learning outcomes were identified and for each article, it was noted if any of the learning outcomes were included as an evaluation metric in some form.

3 Results

In this section, a descriptive overview of the included studies will first be reported. Then, the findings of the selected studies will be synthesised in three sub-sections: (a) how social interaction takes place in MOOCs; (b) constructs researched in MOOCs with social interactions and how the constructs they were measured; (c) an overarching synthesis of the findings, answering the main research question of how social interaction can be supported more effectively to improve MOOC participants' learning outcomes.

Of the 20 studies selected for this review, 14 were published relatively recently; within the last 5 years at the time of writing. Most ($n = 14$) MOOCs were between 4 to 8 weeks in duration. MOOCs varied and included topics like business and entrepreneurship,

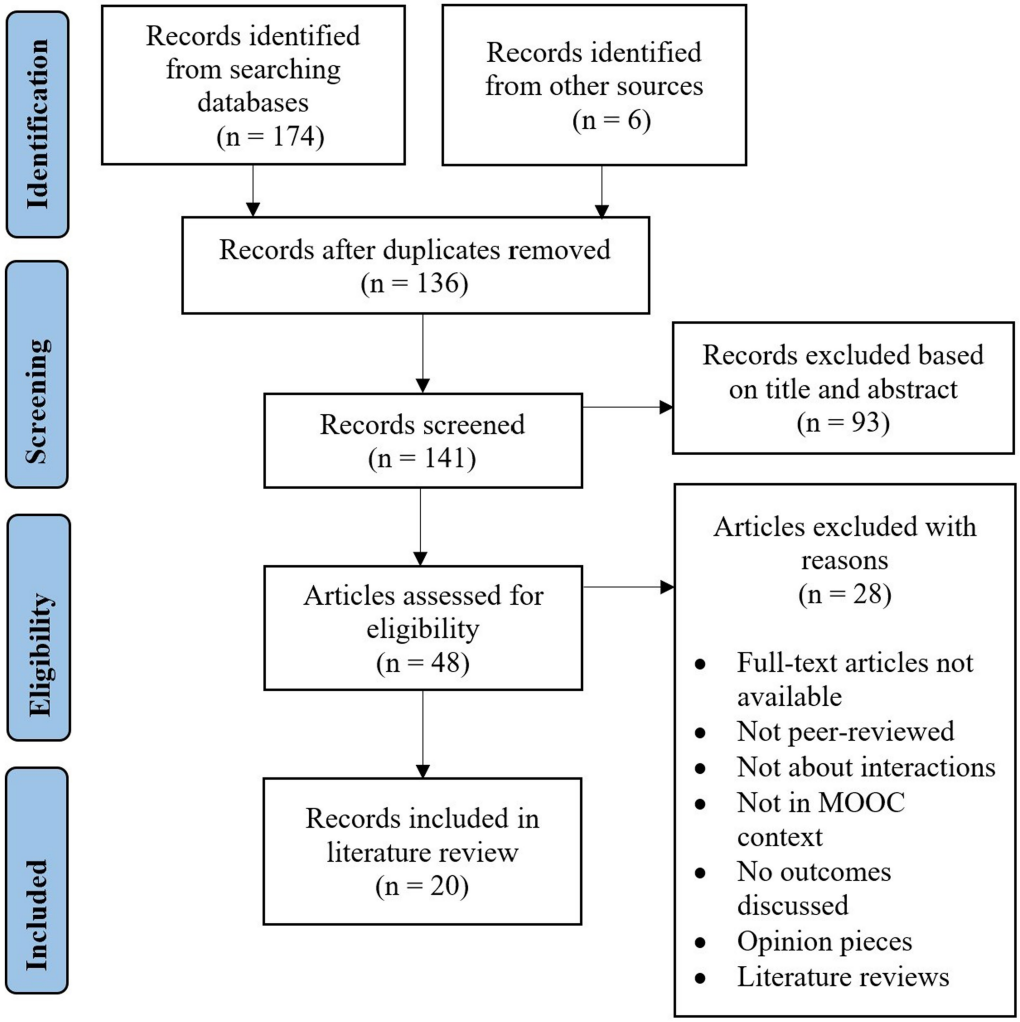

FIGURE 1
PRISMA diagram of article selection process.

education planning, improving creativity, health care, and programming, to name a few. For study design, seven were case studies, four were mixed-method, six were experimental and three were correlational.

3.1 Sub-RQ1: social interaction in MOOCs

Comparing and contrasting the type of interactions in the 20 articles selected for the review, how social interactions are incorporated in MOOCs can be grouped into three categories differing in degrees of interpersonal closeness: (1) discussion forums (2) groups (3) peer (one-to-one interaction). A distinction must be made between the 'discussion forum' and 'group' categories since discussion forums can be viewed as a large group containing all individuals in the MOOC. The 'group' category contained studies with individuals who were matched with peers whom they interacted with regularly. The difference in interpersonal closeness between interacting individuals was the main criterion used to separate the two categories.

The research by Zhang et al. (2017) included three studies. Experiments 1 and 2 were focused on social interactions in discussion forums while experiment 3 focused on social interactions between peers. Thus, the study by Zhang et al. (2017) was counted in both the 'discussion forum' and 'group' categories.

Of the nine studies researching social interaction on discussion forums, five studies investigated the relationship between discussion forum posting and a variety of outcomes including co-construction of knowledge (Kellogg et al., 2014), motivation (Barak et al., 2016), dropout rate, participation rate (Sunar et al., 2017), content understanding (Gillani and Eynon, 2014), social engagement and content engagement (Shi et al., 2019). Four studies differed slightly from the rest. Zhang et al. (2017) looked at prompts to promote social interaction on discussion forums while Xu et al. (2019) compared the difference between on-topic and off-topic posting on learning outcomes. On topic posts were posts and messages that were relevant to the course content while off topic posts were posts that had no relation to course content. Anderson et al. (2020) researched how social media affected learning experiences by encouraging

TABLE 1 Descriptive information of included articles.

Authors	Year	Study design	MOOC topic / title	MOOC duration
Anderson et al.	2020	Case study	School for Health and Care Radicals	5 weeks
Barak et al.	2016	Mixed-methods	Nanotechnology and Nanosensors	10 weeks
Bouchet et al.	2017	Experimental	Project management	2–3 months
Gamage	2021	Mixed-methods	Object-Oriented Programming in Java	6 weeks
Gamage and Whiting	2021	Experimental	Creative problem solving	4 weeks
Gillani and Eynon	2014	Case study	Business strategy	6 weeks
Kellogg et al.	2014	Mixed-methods	Planning for the Digital Learning Transition in K-12 Schools	6 weeks
Krasny et al.	2018	Case study	Environmental Education: Transdisciplinary Approaches to Addressing Wicked Problems	–
Mayende et al.	2017	Case study	Success - Unleash Yourself	8 weeks
Pin-ju and Chen	2022	Case study	An Introduction to Marketing	6 weeks
Razmerita et al.	2020	Correlational	Social Entrepreneurship	12 weeks
Sanz-Martínez et al.	2019	Experimental	How to translate economy and finance texts from Spanish to English	8 weeks
Shi et al.	2019	Correlational	Literature and Mental Health	6 weeks
Su et al.	2016	Case study	Computer networks	20 weeks
Sunar et al.	2017	Case study	Developing Your Research Project	8 weeks
Wichmann et al.	2016	Experimental	Computer-mediated communication in teaching and learning	14 weeks
Xu et al.	2019	Correlational	Educational data mining and the analysis of big data in education	8 weeks
Yang and He	2022	Mixed-methods	Quadratic function in math for grade-10 students	–
Zhang et al.	2017	Experimental	Business operations strategy	5 weeks
Zhang et al.	2016	Experimental	Creativity, Innovation, and Change	6 weeks

participants to share knowledge and have discussion through social media tools such as Facebook and Twitter. Yang and He (2022) evaluated the effectiveness of a tool simulating a pseudo-synchronous atmosphere in bridging learners.

Of the 10 studies included in the group category, three studies examined how groups can be optimally created (Wichmann et al., 2016; Zhang et al., 2016; Sanz-Martínez et al., 2019) by considering participants' communication preferences and interaction with course content. Two studies examined learning groups led by volunteers (Krasny et al., 2018; Gamage, 2021). Two studies researched different tools with affordances that enhanced collaboration and learning outcomes in groups (Su et al., 2016; Gamage and Whiting, 2021). Mayende et al. (2017) investigated learner experiences and ways in which groups were beneficial. Pin-Ju and Chen (2022) studied communication differences between face-to-face and online group discussions. Razmerita et al. (2020) researched how learners' attitudes and communal influence shape their engagement in collaboration and impact learning and behaviour.

In the peer category, the two included studies were one by Bouchet et al. (2017) which looked at ways in which peers can be matched up and experiment 3 by Zhang et al. (2017) examining the effect of prompting students to have one-to-one peer discussions.

3.2 Sub-RQ2: learning outcomes and methods of assessment in MOOCs

In this section, the categories identified previously will be collapsed so the most and least common outcomes investigated can be identified. The learning outcomes will first be grouped into general categories before focusing on the different ways they were operationalised and measured. Table 2 displays a summary table of learning outcomes examined by each study.

3.2.1 Knowledge

Almost half of the included articles ($n = 9$) evaluated participants' knowledge as a learning outcome. This included some scoring via tests or assessments aimed at gauging whether content of the MOOC was understood and applied by the participants. Evaluation methods also included self-reports and interviews. The most common method of assessing participants' knowledge being the use of quiz scores and final grades, as was done by Gillani and Eynon (2014), Zhang et al. (2017) and Xu et al. (2019). Such metrics are built into most MOOC platforms (e.g. Coursera), making it an easy metric to use for evaluation. The link between interacting on discussion boards and final course grades is unclear. Gillani and Eynon (2014) concluded that they are significantly related while Zhang et al. (2017) found no

TABLE 2 Learning outcomes examined by each study.

	Authors	Year	Learning outcomes			
			Knowledge	Social engagement	Learning engagement	Learner experience
Discussion forum						
	Anderson et al.	2020	x			x
	Barak et al.	2016				x
	Gillani and Eynon	2014	x			
	Kellogg et al.	2014		x		
	Shi et al.	2019		x	x	
	Sunar et al.	2017			x	
	Xu et al.	2019			x	
	Yang and He	2022		x		x
	Zhang et al. (study 1 & 2)	2017	x			
Groups						
	Gamage	2021		x		
	Gamage and Whiting	2021		x		x
	Krasny et al.	2018		x		x
	Mayende et al.	2017				x
	Pin-ju and Chen	2022				x
	Razmerita et al.	2020				x
	Sanz-Martínez et al.	2019		x	x	x
	Su et al.	2016	x	x		
	Wichmann et al.	2016	x		x	
	Zhang et al.	2016	x			
Peer						
	Bouchet et al.	2017		x		
	Zhang et al. (study 3)	2017	x		x	

significant relationship. Xu et al. (2019) reported that participants who contributed to on-topic or a mix of on-topic and off-topic posts in discussion forums made up a higher proportion of students with non-zero final grades as compared to students with off-topic posts only. With one-to-one interaction between peers, Zhang et al. (2017) found that it led to an improvement in quiz scores. However, the results must be interpreted with caution as only a small fraction of the total students invited had these interactions.

Another method of assessment is a pre- and post-course survey such as the one used by Anderson et al. (2020). In their research, survey items used a Likert scale, measuring components that the course aimed to improve (e.g. purpose and motivation, theoretical understanding, ability to connect with others and support change initiatives). A quantitative analysis showed no significant difference between pre- and post-survey for most components assessed. However, there was a significant relationship between participation as part of a team and scores for the component of 'maintaining collaborative relationships'.

Qualitative methods such as interviews were also used. In the research by Anderson et al. (2020), participants volunteered to do a semi-structured telephone interview with researchers. From the interview data, participants mentioned that being in groups enhanced their perseverance during the learning.

Participants could also be scored on tasks like in the research by Su et al. (2016) where they tested a new social searching tool that enabled students to share their problem-solving and searching process. Participants were assigned searching tasks and assessed on their searching process and searching abilities. A coding scheme was used to score relevant processes like 'specifying search terms', and 'evaluating the search result'. Results of the study showed that the problem-solving abilities of students improved and students were able to learn search strategies from other students.

Written submissions were also a method of assessing participants' knowledge. The research by Zhang et al. (2016) focused on a MOOC about creativity and innovation where participants did creative exercises on their own and submitted reflections but were not graded on them. Wichmann et al. (2016) had participants submit assessments as a group and assessed knowledge by counting the number of domain concepts included in the text. In their study investigating grouping participants by learning engagement homogeneity, significant

differences were found for different grouping homogeneity and the number of concepts included in text submissions.

3.2.2 Social engagement

Social engagement during a MOOC was an outcome measured by about half of the selected articles ($n = 9$). Included in this category are quantitative or qualitative social engagement measures related to participants' interaction with peers. A common measurement of a participant's social engagement was the frequency of messages posted on discussion boards or messages sent in a group. Shi et al. (2019) tracked the number of comments that participants made each week in the course. Other researchers like Yang and He (2022) used a survey for participants to self-report their social engagement, having participants indicate how regularly they used the social interaction tool provided to them.

In group settings, Krasny et al. (2018) surveyed and interviewed group community leaders to check the number of meetings and the attendance rate of participants. Sanz-Martínez et al. (2019) compared groups formed based on different homogeneity levels and compared them based on active participants in the group, messages posted by each participant and the number of students that participated in the collaborative assignments. A case study by Bouchet et al. (2017) tested a peer recommender system widget. Social engagement measurements used were participants who opened the widget at least once, participants who opened a discussion thread at least once and participants who sent at least one message to a discussion thread. In a similar case study by Su et al. (2016), to evaluate the effectiveness of a tool in aiding interaction and learning within a group, sharing time and sharing frequency were recorded to indicate the proportion of members that used the tool. Groups were identified as 'collaborative' or 'individual' based on these metrics.

Another way in which researchers looked at social engagement was by collecting participants' forum posts and messages and categorising them before analysis. Yang and He (2022) researched social presence by using a scheme to group posts into different categories: emotional expression, open communication, group cohesion, co-presence, and relationship development. Gamage and Whiting (2021) researched a similar topic of social presence but in groups. They labelled behaviours with different indicators according to the Communities of Inquiry model. Examples include an affect indicator for emotional content and an interactive indicator for acknowledgement or questions by peers. To analyse messages for knowledge building, Gamage (2021) used the Epistemic Network Analysis, a framework that categorised a conversation as 'cognitive task', 'social task', 'social non-task' or 'cognitive-non-task'. Analysis of conversations in CollabSpace (which incorporated a grouping framework) showed a strong association between social tasks and non-social tasks, and also non-social tasks and cognitive tasks. This indicated social presence being influential to learning in the community. Kellogg et al. (2014) used the Interaction Analysis Model to measure the extent to which social engagement resulted in co-construction of knowledge. Discussion threads were categorised into five different phases with the fifth being most indicative of knowledge not only being co-constructed but able to be applied by participants. Results from the research showed that participants' interactions were mainly in the first phase (providing observations, opinions or examples that support or extend prior statements). Some interactions reached Phase 2 (identifying areas of agreement or disagreement) and Phase 3 (exploring common ground in views and seeking to integrate ideas), however, few interactions went beyond this phase.

3.2.3 Learning engagement

A few articles measured participants' learning engagement during the MOOC as an outcome ($n = 4$). Learning engagement measures included participant's activity relating to course materials, tasks or assignments. In the research by Shi et al. (2019) and Sunar et al. (2017), steps were basic learning items in each week of the course, which could include articles, images or videos. For each week of the course, the step visit rates—the number of participants who visited at least one step—as well as completion rates—the number of learners that completed at least one step were recorded. In both research, findings show that participants who contributed to discussion threads completed more steps than passive participants.

The other studies that included learning engagement as an outcome variable were studies in group contexts examining the effects of grouping participants by learning engagement homogeneity. Wichmann et al. (2016) measured the quantity of text contributed by each participant in a group and the quantity of text submitted by the whole group to determine group productiveness while Sanz-Martínez et al. (2019) measured learning engagement by looking at the number of groups that completed tasks and submitted assignments. Results from both studies suggest that homogeneous grouping of students led to more learning engagement as measured by assignment text quantity, task completions and assignment submissions.

3.2.4 Learner experience

The other learning outcomes evaluated by researchers could be encompassed in the broad category of learner experience. This category included participants' perception of the grouping structure, satisfaction with the MOOC and their motivation. Approximately half of the selected articles ($n = 9$) had explored learner experience as an outcome.

Surveys were the most commonly used method to gather participants' learning experiences. The focus of survey items varied considerably between different researchers. Sanz-Martínez et al. (2019) and Razmerita et al. (2020) asked participants to rate their satisfaction with their group and group collaboration experiences with a Likert scale. Gamage and Whiting (2021) and Mayende et al. (2017) looked at participants' perceptions of different aspects of group learning by asking them if they agreed or disagreed with statements like, "Our team was effective," "Our team was supportive" and "I received positive feedback." Learners were also asked what the group helped with, from questions about motivation, understanding the content, and technical support. The case study by Yang and He (2022) involved participants being provided with a learning tool and survey questions centred around ease of use and if the learning tool fostered the social presence of others and a sense of belongingness. The survey by Gamage and Whiting (2021) was similar except that questions were gauging participants' sense of belonging with a six-item scale. Participants were asked if being in the group made them feel understood, connected, welcomed, if they felt that they were respected by others, and if they were happy in the group.

Participants' learning experience was also collected using interviews. Pin-ju and Chen (2022) recorded interviews with participants and held focus group meetings. Anderson et al. (2020)

held a semi-structured interview with volunteers. The interviews allowed participants to elaborate more on their experiences and for researchers to reflect on aspects that were potentially outside the researchers' considerations. Additionally, in the research by Anderson et al. (2020), the qualitative data showed a contrast to the quantitative evaluations. Interviewees expressed that support and encouragement were felt from interactions with other participants and that they had a sense of shared purpose with others.

Another outcome related to learner experience was participants' motivation, as examined by three studies. All three studies used surveys. Krasny et al. (2018) also interviewed group leaders to understand their motivations for volunteering. Barak et al. (2016) compared pre and post-course motivation ratings, finding that participants working alone on the final project had relatively low means for motivation to learn as compared to participants working in groups of four or five. Barak et al. (2016) conclude that participants' motivation increases in small groups as these small-group discussions stimulate interest in the learning content. This effect of group learning on motivation is echoed by Mayende et al. (2017) however they attribute motivation gain to peers frequently interacting in the group, providing feedback and exhibiting high commitment to making progress in the MOOC.

3.3 Main research question: how can social interaction be supported in MOOCs?

In this section, we synthesise findings from the literature on how we can support social interaction in MOOCs. The findings will be broken down into different categories of interaction levels discussed above: discussion forums, groups, and one-to-one interactions with peers.

3.3.1 Supporting social interactions on discussion forums

From the studies above, sending prompts for participants to use discussion forums has been shown to be effective in encouraging the use of it (Zhang et al., 2017). There are consistent findings to support the benefits of social interactions on discussion forums including a higher completion rate of MOOC learning activities, course completion and higher course grades (Gillani and Eynon, 2014; Manli, 2014; Zhang et al., 2017; Shi et al., 2019). There is also evidence to suggest that discussions move beyond the phase of sharing information and statements of agreement, with participants co-constructing knowledge by expressing dissonance over understanding of learning materials (Kellogg et al., 2014; Manli, 2014).

Participating in both on and off-topic discussions early in the MOOC increases participants' course engagement (Sunar et al., 2017; Xu et al., 2019). Thus, MOOC designers can encourage participants to participate in off-topic chats initially, so connections are built between individuals that can serve as a vital source of support as the MOOC progresses and gradually encourage on-topic discussion as the course progresses. For off-topic chats, participants can introduce themselves and their interests, which could help them find matching participants with mutual interests. On-topic posts that can be encouraged include sharing notes, asking questions and answering other participants' questions.

MOOC learning is asynchronous which can lead to participants feeling isolated. To remedy this, MOOC designers can look into tools such as Danmaku, a tool tested by Yang and He (2022) to foster a pseudo-synchronous learning environment where participants feel as if they are watching lectures with their peers at the same time. The study's results highlight the tool's usefulness in facilitating deeper connectedness with peers and promoting help-seeking interactions which can serve participants well in overcoming difficulties with course materials.

3.3.2 Supporting social interactions in groups

The research detailing strategies for supporting social interactions in learning groups is grouped into three broad categories: (1) optimal grouping methods; (2) leader-led groups; and (3) assistive tools.

Regarding grouping participants, from the studies reviewed, grouping participants based on their learning and social engagement leads to better learning outcomes as compared to grouping by communication preferences. MOOC administrators can group participants 2 to 3 weeks into the course and not at the beginning course. From the beginning of the course, data should be collected on participant's engagement with the MOOC, including their page views, submitted assignments and the number of forum messages. Expected learning outcome gains from this method of grouping include higher group productivity and assignment quality (Wichmann et al., 2016), increased peer interactions and increased satisfaction with collaboration (Sanz-Martínez et al., 2019). Not grouping participants at the outset has the added benefit of allowing the initial drop-off in participants to level off before the formation of groups, decreasing the chance of learners being demotivated by inactive group members.

MOOC designers and administrators can also consider leader-led groups with volunteers. Krasny et al. (2018) invited volunteers who had previously completed the course while Gamage (2021) and Gamage and Whiting (2021) assigned individuals who indicated their interest as a leader during the grouping process. Social presence was felt in leader-led groups and participants also mentioned feeling a sense of belonging (Gamage, 2021; Gamage and Whiting, 2021). Individuals who had completed the MOOC and volunteered to lead groups assisted in dividing tasks and learning content among participants, facilitated meeting sessions and explained difficult topics (Krasny et al., 2018).

With regards to assistive tools, MOOC designers can look into tools such as PeerCollab, a community-building tool used by Gamage and Whiting (2021) that creates communities in forum spaces. Gamage and Whiting (2021) suggested that most MOOC discussion forums are populated with cognitive presence but limited in social presence. A tool like PeerCollab can help learners find community groups with shared learning goals and engage in leader-driven community activities.

Another tool that MOOC designers can look into is a social searching system that Su et al. (2016) did a case study on. The tool is akin to a group search diary and activity log, helpful for tasks where participants are searching and evaluating information. Also, it is especially helpful for participants who are limited to asynchronous collaboration. In the system, there is a search window, group history, search suggestions, a web annotation tool, and a discussion room. Participants can discuss their searching and problem-solving process and view their peers' activity history. A social collaborative tool like this being integrated into a MOOC platform would allow MOOC

participants to not only interact but also learn and collaborate more seamlessly.

3.3.3 Supporting one-to-one peer interactions

While one-to-one peer interactions are not focused on as frequently, the experimental research by Zhang et al. (2017) shows some evidence that discussions with a peer improve participants' quiz scores and completion of course activities. However, the study's findings are limited as only a small proportion of overall participants followed through after indicating their desire and being matched with a peer for a discussion. A possible explanation is that more effort is required to coordinate a meeting with a peer as compared to using the discussion forum. Another potentially related issue is participants' fear of judgement preventing them from reaching out to their peers, as noted by Bouchet et al. (2017). More research is necessary to understand how one-to-one interactions with peer affects learning outcomes and overcoming barriers to one-to-one interactions.

4 Discussion

This review set out to examine studies done on social interaction in MOOC contexts to understand how to effectively promote social interactions among MOOC participants. Two sub-questions were posed to help answer the main research question. The first question was, what are ways in which MOOCs have incorporated social interactions? To conclude, our results showed that the types of social interaction differed in interpersonal closeness. Interpersonal closeness ranged from most to least number of individuals that could participate in a discussion topic. For example, in discussion forums there are usually a large number of participants which makes the interpersonal closeness less, whereas in one-to-one interactions the interpersonal closeness would be high. Interactions usually occurred in the form of messages in discussion forums (Gillani and Eynon, 2014; Kellogg et al., 2014; Manli, 2014; Barak et al., 2016; Sunar et al., 2017; Zhang et al., 2017; Shi et al., 2019; Xu et al., 2019; Anderson et al., 2020; Yang and He, 2022), in groups (Su et al., 2016; Wichmann et al., 2016; Zhang et al., 2016; Mayende et al., 2017; Krasny et al., 2018; Sanz-Martínez et al., 2019; Razmerita et al., 2020; Gamage, 2021; Gamage and Whiting, 2021; Pin-Ju and Chen, 2022) or one-to-one with another peer (Bouchet et al., 2017; Zhang et al., 2017).

The second question sub-question was what learning outcomes have been investigated with regard to social interactions and how are they measured Our results showed that the learning outcomes investigated in the studies that were reviewed fall into four broad categories: knowledge, social engagement, learning engagement and learner experience. For knowledge, researchers operationalised it using quiz scores (Zhang et al., 2017), final course grades (Gillani and Eynon, 2014; Zhang et al., 2017; Xu et al., 2019), self-reported ratings (Anderson et al., 2020), assessments (Su et al., 2016) and written text submissions (Zhang et al., 2016). Social engagement was measured by the number of messages posted on discussion boards, in groups, and participant attendance rates in group meetings (Krasny et al., 2018). Messages and interactions were also categorised and analysed for themes such as group cohesion, co-presence, emotional content (Gamage and Whiting, 2021; Yang and He, 2022), on-task relatedness (Gamage, 2021; Gamage and Whiting, 2021) and co-construction of knowledge (Kellogg et al., 2014). For learning engagement, researchers looked at the number of activities viewed and completed by participants in the duration of the course (Sunar et al., 2017; Shi et al., 2019), and the quantity and quality of text in written assignments (Zhang et al., 2016). Learner experience was mainly centred around participants' satisfaction with different aspects of working in groups (Sanz-Martínez et al., 2019; Razmerita et al., 2020) and the degree to which they felt connected with other group members (Mayende et al., 2017; Gamage and Whiting, 2021; Yang and He, 2022). Additionally, participants' motivational outcomes were also collected (Barak et al., 2016; Mayende et al., 2017; Krasny et al., 2018).

Based on our review we can conclude that multiple favourable learning outcomes can be expected when MOOCs include some element of social interactions among peers. Outcomes include improving participants' quiz scores (Gillani and Eynon, 2014; Zhang et al., 2017; Xu et al., 2019) and building students' problem solving process (Su et al., 2016). Social interaction was also related to a higher number of domain concepts included in participants' written text assessments (Wichmann et al., 2016). Participants who were active on discussion boards interacted more with course materials (Sunar et al., 2017; Shi et al., 2019). When grouping of participants were effective, participants completed more tasks, submitted more assignments and turned in assignments of higher quality (Wichmann et al., 2016; Sanz-Martínez et al., 2019). Social interaction in groups stimulated interest in course materials (Barak et al., 2016) and were also a source of motivation to persevere in the MOOC (Barak et al., 2016; Mayende et al., 2017; Anderson et al., 2020).

Concerning our first research question on the type of social interaction in MOOCs, this review substantiates the existing literature's findings that social interactions usually happen in discussion forums but also occur outside of it (Veletsianos et al., 2015). The findings of this review extend this insight by extracting unique implementations of social interaction in discussion forums as well as other forms of effective online social interaction. When designing a MOOC to include social interactive elements, MOOC designers can use this categorisation as a starting point to identify the type of interaction they which to promote. For each of the categories, different strategies can be applied to promote interactions between participants.

This review is intended to help MOOC designers and administrators know how to support peer interactions and thus, the recommendations for each category of interaction will be summarised. For discussion forums, MOOC administrators can send messages via email or via the MOOC platform to encourage learners to use discussion forums (Zhang et al., 2017). Messages in the prompt could include getting learners to share what they have learned after watching a lecture, ask questions about assignments and answer others' questions (Zhang et al., 2017; Shi et al., 2019; Xu et al., 2019). Especially at the start of the course, designers should also encourage learners to participate in off-topic discussions so learners can potentially form connections that can serve to motivate and assist them later in the course. Alea et al. (2023) showed that students' exchanging their personal stories in an online course contributed to the teaching and learning outcomes. To continue, tools such as Danmaku can also be considered as it creates a pseudo-synchronous learning environment and foster deeper connectedness among peers. Tools that also offer discussion prompts present a wide range of perspectives to the participants and encourage active participation (Gao et al., 2013; Lieu et al., 2022).

Should MOOC designers choose to implement a grouping structure in the course, participants can be grouped based on their learning engagement for the first few weeks of the course or so (Sanz-Martínez et al., 2019). A homogeneous group seems to be the most effective overall at bringing about a range of different learning outcomes (Wichmann et al., 2016; Sanz-Martínez et al., 2019). Groups with volunteers taking on a leadership role are also effective in community building and for participants to overcome difficulties (Krasny et al., 2018; Gamage, 2021). However, from the studies done, recruitment of volunteers for a leadership role might not be scalable (Gamage, 2021), casting doubt on the viability of having volunteers as group leaders. One strategy to attract participants to volunteer could be to communicate the positive features associated with a leading role, e.g., offering a hands-on facilitation experience, ownership in directing a discussion (Hew, 2015). Assistive tools to look into include PeerCollab for creating community groups in MOOC forums and a social search tool like the one studied by Su et al. (2016) which provides participants with a seamless collaboration experience.

With promoting one-to-one peer interactions, there is insufficient research in this review for recommendations to be made. While benefits for peer interaction were noted (Zhang et al., 2017), more apparent issues that should be tackled first are learners having a fear of judgement (Bouchet et al., 2017), possibly explaining their not being open to interaction (Bouchet et al., 2017) and a low number of participants not following through on contacting their peers after being matched up (Zhang et al., 2017). Future research should delve more into reasons for this fear of judgement and how barriers to peer interaction can be removed.

Concerning the second research question on the type of learning outcomes investigated in relation to social interaction in MOOCs, the findings in this review align with constructivist theories of learning which propose that interactions among peers are integral to learning (Vygotsky, 1978; Salomon and Perkins, 1998). That is, from the review of the studies, multiple favourable learning outcomes can be expected when MOOCs include some element of social interactions among peers. Elements can include encouraging discussion board use (Zhang et al., 2017), grouping participants according to engagement metrics (Wichmann et al., 2016; Sanz-Martínez et al., 2019), and using tools with extra affordances (Su et al., 2016; Gamage and Whiting, 2021; Yang and He, 2022). This conclusion is supported across all categories of interaction, however, one-to-one peer interaction requires more research support.

Salomon and Perkins (1998), Vygotsky (1978) and Brown et al. (1989) proposed that the construction of knowledge is effectively built on the understanding of peers. This sentiment is evident in multiple studies selected for this review, including the one by Kellogg et al. (2014) where some co-construction of knowledge between participants was found and also the study by Mayende et al. (2017) where participants indicated that the groups helped them understand course content. Siemen's theory of Connectivism which emphasised tapping on information sources for learning was exemplified by Krasny et al. (2018) where participants who had previously completed the course were recruited to be group leaders. The group leaders fostered a supportive environment between peers, facilitated discussions and scaffolded participants' learning when course materials were challenging. The results from answering this second research question helps MOOC designers identify the learning outcomes that they wish to target and the existing ways of evaluating these outcomes.

There are some limitations to this review. Firstly, although researchers worked collaboratively to ensure consistency and agreement in the analyses of the selected studies, the selection was done by one of the researchers and no interrater reliability score was calculated. It is recommendable to have two researchers perform the selection and analysis of the studies in a review to avoid bias and ensure objectivity. Secondly, while there is strong evidence that social interaction is related to a multitude of favourable learning outcomes, it is arguable that there is insufficient evidence to conclude that there is a causal effect of social interaction on learning outcomes. Only about a quarter of the studies selected ($n=6$) in this review were experimental in research design. It is possible that participants who achieve favourable outcomes seek out social interactions or that there is an unknown third variable influencing both learning achievement and tendency to seek social interaction (DeVries et al., 2018). Ideas for future rese arch include experimental studies manipulating what individuals post on discussion forums and their frequency of posting to better discern their effects on learning outcomes. With learning groups, experimental research manipulating different activities in group settings can be done to identify which specific activities and group processes contribute most to learning outcomes. The results of those studies will build upon what has been discovered in this review, helping MOOC designers know what exactly to prompt learners to post and also how to proceed after creating an optimal grouping of participants.

Evidence also suggests that other factors mediate the relationship between social interaction and learning outcomes. These factors include learning group identification, immersive experience and satisfaction of relatedness needs (Fang et al., 2019). Previous research in a non-MOOC setting has shown evidence of social closeness affecting learning outcomes like satisfaction (Feng et al., 2022). With the categories of interaction in this study differing in degrees of closeness, perhaps it is worth investigating whether these different categories of interaction have differential impacts on the above-mentioned mediating factors. Recommendations for future research are to carry out comparative studies for the different categories of interaction and investigate if there are differences in feelings of group identification, immersiveness of a MOOC, and satisfaction of relatedness needs.

Finally, while this review show that interactions at different levels are effective, promoting all three might not be ideal as a participant could then be spending too much time on interactions. If a lack of time is cited as a common reason for dropout (Onah et al., 2014), then MOOC designers should be cautious not to overdo the promotion of interactions as this could lead to a diminishing return on beneficial learning outcomes. The suitable type of interaction to promote in a MOOC may depend on factors such as course length, course difficulty and course topics. For example, with a shorter course length, a discussion forum might suffice for satisfying relatedness needs and feelings of social immersion. Future research should look into understanding how these factors could potentially mediate the effects of different social interactions on learning outcomes. This is likely to help MOOC designers pick the best type of social interaction to promote for MOOCs with specific characteristics.

In conclusion, in a MOOC learning context, interactions among participants have been shown to have a variety of beneficial learning outcomes such as knowledge gained, learning and social engagement and learner experience. MOOC designers should consider strategies

to promote peer interactions at different levels, in discussion forums, in learning groups, or in facilitating one-to-one peer interactions. While actionable steps have been outlined in this review, more research can be done to optimise the proposed strategies to maximise the benefits of social interactions for participants in MOOCs.

Data availability statement

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

Author contributions

HL: Conceptualization, Formal analysis, Investigation, Writing – original draft, Writing – review & editing. GM: Writing – original draft, Writing – review & editing. CM: Writing – original draft, Writing – review & editing. MB: Conceptualization, Writing – original draft, Writing – review & editing.

Funding

The author(s) declare that no financial support was received for the research, authorship, and/or publication of this article.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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